

SUPPPORTING INFORMATION FOR:

Chronic toxicity of binary mixtures of six metals (Ag, Cd, Cu, Ni, Pb and Zn) to the great pond snail *Lymnaea stagnalis*

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This material consists of information on the toxicity test experimental design (Figure SI.1), details on metal speciation calculations (Tables SI.1 and SI.2), individual metal toxicity tests analyses based on both total dissolved concentrations and free ion activities (Table SI.3, SI.4 and Figure SI.2), detailed MixTox statistical analyses for each mixture based on both total dissolved concentrations and free ion activities (Tables SI.5, SI.6, SI.7 and SI.8) and predicted versus observed RGR based on free ion activities (Figure SI.3). Finally, the experimental data of all the single metal and mixture toxicity tests carried out in the present study is provided in section 5 (Table SI.9 – SI.24).

1. FIXED-RATIO RAY DESIGN

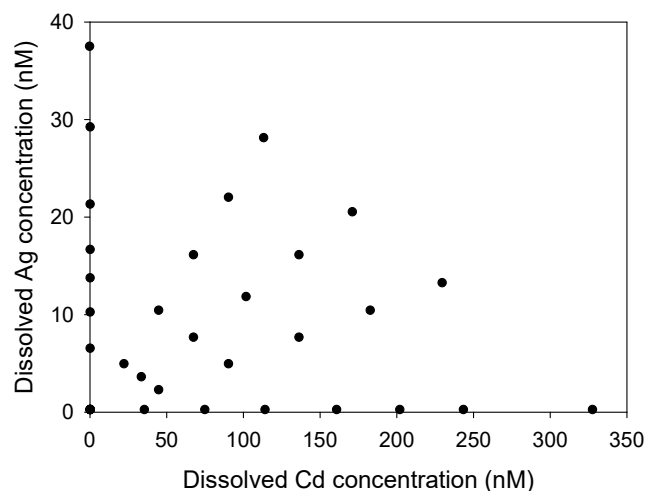


Figure SI.1: Example of the fixed-ratio ray design used for the Ag/Cd mixture.

2. CHEMICAL SPECIATION

Table SI.1: Default and adapted stability constants for carbonate complexes in WHAM VII. Adapted stability constants were from the NIST (National Institute of Standards and Technology) database. Note: no constant is known for Ag.

Metal species	Default stability constant in WHAM VII (log K)	Adapted stability constant (log K)
CdHCO ₃ ⁺	11.83	11.83
CdCO ₃ (aq)	4.37	4.37
CuHCO ₃ ⁺	14.62	12.129
CuCO ₃ (aq)	6.75	6.77
NiHCO ₃ ⁺	13.41	12.42
NiCO ₃ (aq)	5.78	4.57
PbHCO ₃ ⁺	13.23	13.23
PbCO ₃ (aq)	7.2	6.53
ZnHCO ₃ ⁺	13.12	11.829
ZnCO ₃ (aq)	4.76	4.76

Table SI.2: Proportional ranges of each significant metallic form (>0.1%), given within the range of dissolved concentration of each individual metal toxicity test. This speciation was obtained with WHAM VII, using the adapted carbonate constants from Table SI.1. For the free metal ions, proportions are given based on concentration and activity (in brackets).

	Dissolved concentration (nM)	% M ²⁺ concentration (activity)	% M-OH	% M-CO ₃	% M-Cl	% M-SO ₄	% M-DOM
Ag	1.0 - 130	33 - 33 (31 - 31)	< 0.1	< 0.1	65 - 65	0.35 - 0.35	1.1 - 1.1
Cd	6.7 - 340	72 - 75 (54 - 56)	0.32	4.1 - 4.3	5.3 - 5.5	8.1 - 8.5	10 - 6.0
Cu	19 - 170	0.42 - 2.7 (0.31 - 2.0)	0.79 - 5.0	2.6 - 26	< 0.1	< 0.1 - 0.24	95 - 66
Ni	320 - 6500	78 - 80 (58 - 59)	0.59 - 0.61	10 - 11	0.15 - 0.15	6.3 - 6.5	4.9 - 2.0
Pb	5.7 - 370	5.2 - 7.2 (3.9 - 5.3)	5.5 - 7.5	32 - 44	0.16 - 0.21	1.4 - 1.6	56 - 39
Zn	380 - 8000	67 - 73 (50 - 54)	6.6 - 7.1	7.6 - 8.2	0.13 - 0.14	6.3 - 6.8	12 - 5.0

3. SINGLE METAL TOXICITY TESTS: STATISTICAL ANALYSES

3.1 Analysis based on total dissolved concentration

Table SI.3: Parameters of the individual metal concentration-response curves (max, EC50, β) from the individual metal toxicity tests performed for each metal mixture, determined with Eq. 3 and measured total dissolved concentration.

Mixture	Metal 1			Metal 2		
	Max (%)	EC50 (nM)	β	Max (%)	EC50 (nM)	β
Ag/Cd	100 [90 – 110]	29.5 [26.6 – 32.4]	9.61 [0.00 – 19.5]	100 [93 – 107]	198 [159 – 238]	3.65 [0.878 – 6.42]
Ag/Cu	100 [90 – 110]	29.5 [26.6 – 32.4]	9.61 [0.00 – 19.5]	100 [91 – 109]	86.1 [72.9 – 99.3]	4.22 [1.64 – 6.80]
Ag/Ni	100 [89 – 111]	24.7 [20.0 – 29.4]	4.49 [1.21 – 7.76]	100 [87 – 113]	3480 [2840 – 4120]	5.96 [0.0754 – 11.8]
Ag/Pb	100 [95 – 105]	22.2 [19.8 – 24.6]	4.87 [2.82 – 6.91]	100 [92 – 108]	179 [85.6 – 273]	0.798 [0.271 – 1.32]
Ag/Zn	100 [95 – 105]	22.2 [19.8 – 24.6]	4.87 [2.82 – 6.91]	100 [94 – 106]	6230 [5520 – 6950]	3.10 [1.68 – 4.53]
Cd/Cu	100 [94 – 106]	178 [162 – 194]	5.19 [2.88 – 7.49]	100 [94 – 106]	151 [128 – 173]	3.74 [1.59 – 5.89]
Cd/Ni	100 [91 – 109]	195 [168 – 227]	3.95 [1.30 – 6.60]	100 [88 – 112]	3870 [2550 – 5180]	2.05 [0.293 – 3.81]
Cd/Pb	100 [94 – 106]	178 [162 – 194]	5.19 [2.88 – 7.49]	100 [94 – 106]	114 [86.7 – 141]	1.66 [0.983 – 2.34]
Cd/Zn	100 [92 – 108]	173 [148 – 199]	4.93 [1.69 – 8.16]	100 [91 – 109]	5200 [4790 – 5610]	7.76 [2.50 – 13.0]
Cu/Ni	100 [90 – 110]	93.9 [79.1 – 109]	4.88 [1.23 – 8.52]	100 [91 – 109]	3570 [2840 – 4310]	2.71 [1.08 – 4.34]
Cu/Pb	100 [94 – 106]	151 [128 – 173]	3.74 [1.59 – 5.89]	100 [94 – 106]	114 [86.7 – 141]	1.66 [0.983 – 2.34]
Cu/Zn	100 [88 – 112]	86.7 [74.2 – 99.2]	6.79 [0.0708 – 13.5]	100 [91 – 109]	5200 [4790 – 5610]	7.76 [2.50 – 13.0]
Ni/Pb	100 [88 – 112]	3590 [2720 – 4450]	3.40 [0.584 – 6.22]	100 [88 – 112]	135 [72.0 – 199]	1.60 [0.375 – 2.83]
Ni/Zn	100 [91 – 109]	3570 [2840 – 4310]	2.71 [1.08 – 4.34]	100 [94 – 106]	5480 [4620 – 6340]	3.25 [1.41 – 5.09]
Pb/Zn	100 [92 – 108]	179 [85.6 – 273]	0.798 [0.271 – 1.32]	100 [94 – 106]	6234 [5520 – 6950]	3.10 [1.68 – 4.53]

3.2 Analysis based on free metal ion activity

Table SI.4: Parameters of the individual metal concentration-response curves (max, EC50, β) from the individual metal toxicity tests performed for each metal mixture, determined with Eq. 3 and calculated free ion activity.

Mixture	Metal 1			Metal 2		
	Max (%)	EC50 (nM)	β	Max (%)	EC50 (nM)	β
Ag/Cd	100 [90 – 110]	9.11 [8.25 – 9.96]	9.61 [0.00 – 19.5]	100 [93 – 107]	110 [87.6 – 132]	3.59 [0.865 – 6.32]
Ag/Cu	100 [90 – 110]	9.11 [8.25 – 9.96]	9.61 [0.00 – 19.5]	100 [91 – 109]	0.969 [0.683 – 1.25]	2.22 [0.863 – 3.58]
Ag/Ni	100 [89 – 111]	7.62 [6.16 – 9.09]	4.49 [1.21 – 7.76]	100 [87 – 113]	2060 [1680– 2440]	5.91 [0.0755 – 11.8]
Ag/Pb	100 [95 – 105]	6.68 [6.13 – 7.53]	4.87 [2.82 – 6.91]	100 [92 – 108]	8.49 [3.80 – 13.0]	0.747 [0.254 – 1.24]
Ag/Zn	100 [95 – 105]	6.68 [6.13 – 7.53]	4.87 [2.82 – 6.91]	100 [94 – 106]	3330 [2930 – 3720]	3.04 [1.64 – 4.43]
Cd/Cu	100 [94 – 106]	106 [94.1 – 117]	4.75 [2.32 – 7.17]	100 [94 – 106]	2.71 [1.99 – 3.43]	2.06 [0.856 – 3.27]
Cd/Ni	100 [91 – 109]	108 [89.8 – 126]	3.89 [1.28 – 6.49]	100 [88 – 112]	2290 [1500 – 3070]	2.03 [0.290 – 3.78]
Cd/Pb	100 [94 – 106]	98.4 [89.5– 107]	5.11 [2.84 – 7.38]	100 [94 – 106]	5.23 [3.86 – 6.61]	1.51 [0.896 – 2.13]
Cd/Zn	100 [92 – 108]	96.7 [82.6 – 111]	4.89 [1.68 – 8.10]	100 [91 – 109]	2760 [2540 – 2990]	7.59 [2.44 – 12.7]
Cu/Ni	100 [90 – 110]	0.870 [0.739 – 1.00]	1.84 [1.32 – 2.36]	100 [91 – 109]	2110 [1670 – 2550]	2.69 [1.07 – 4.31]
Cu/Pb	100 [94 – 106]	2.71 [1.99 – 3.43]	2.06 [0.856 – 3.27]	100 [94 – 106]	3.79 [2.33 – 5.25]	1.30 [0.662 – 1.93]
Cu/Zn	100 [88 – 112]	0.984 [0.710 – 1.26]	3.52 [0.0531 – 6.99]	100 [91 – 109]	2760 [2540 – 2980]	7.59 [2.44 – 12.7]
Ni/Pb	100 [88 – 112]	2120 [1600 – 2640]	3.38 [0.580 – 6.18]	100 [88 – 112]	6.37 [3.07 – 9.66]	1.45 [0.345 – 2.56]
Ni/Zn	100 [91 – 109]	2920 [2450– 3390]	2.69 [1.07 – 4.31]	100 [94 – 106]	2110 [1670 – 2550]	3.18 [1.38 – 4.98]
Pb/Zn	100 [92 – 108]	3.80 [1.64 – 4.43]	0.747 [0.254 – 1.24]	100 [94 – 106]	3330 [2930 – 3720]	3.04 [1.64 – 4.43]

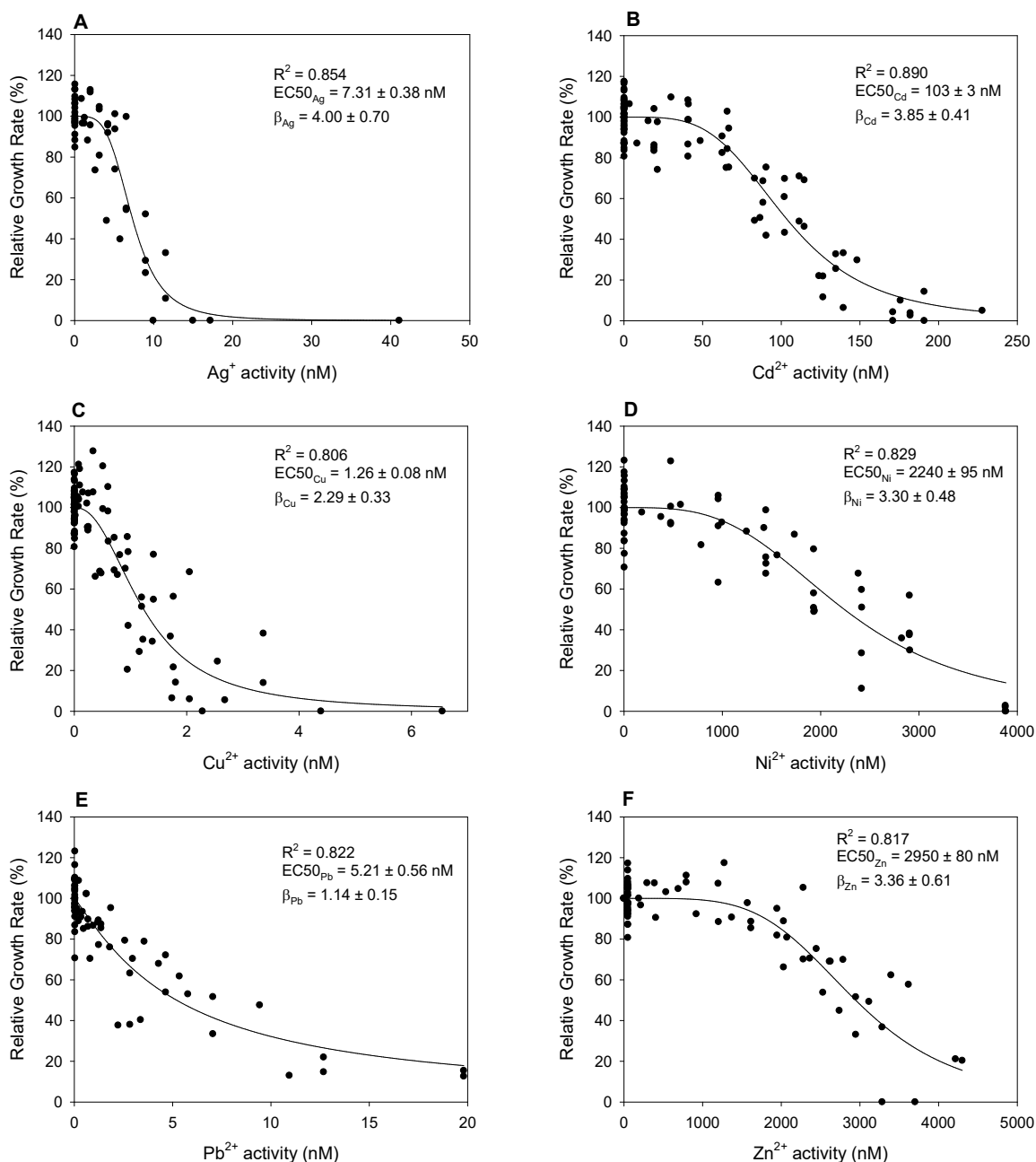


Figure S1.2: Relative growth rate of juvenile *L. stagnalis* as a function of calculated free ion activity, for **A)** Ag, **B)** Cd, **C)** Cu, **D)** Ni, **E)** Pb and **F)** Zn. Regression lines with Eq. 1 are given along with the fitted parameters in each panel. These concentration-response curves were obtained by compiling all the different single metal toxicity tests performed in this study (as detailed in the Results & Discussion of the main manuscript). Each point represents the mean response of 5 snails. Regression lines with Eq. 1 are given along with the fitted parameters in each panel. Relative growth rates as a function of measured total dissolved concentrations are given in Figure 1 of the main manuscript.

4. MIXTURE TOXICITY: DETAILED STATISTICAL ANALYSES

4.1 Analysis based on total dissolved concentration

Table SI.5: Overview of the MixTox statistical analysis for the Concentration Addition (CA) model, based on measured total dissolved concentration. Fitting results of the binary mixture data to the CA model using the whole dataset (both the single metals and the mixture data) (CA_whole dataset) and to the synergy/antagonism CA deviation model (CA_S/A) using the whole dataset. Results of the Chi-squared test between these two tests.

Mixture	CA_whole dataset						CA_S/A						Chi-squared test		
	Max	EC50 _{M1}	β _{M1}	EC50 _{M2}	β _{M2}	SE	Max	EC50 _{M1}	β _{M1}	EC50 _{M2}	β _{M2}	<i>a</i>	SE	Chi-value	Conclusion
	(%)	(nM)		(nM)		(%)	(%)	(nM)		(nM)			(%)	(p-value)	
Ag/Cd	101	32.4	5.62	238	2.55	15	96.5	29.7	8.94	208	3.31	1.67	9.1	35.7 (2.3e-9)	Less than additive
Ag/Cu	97.9	32.4	7.36	98.0	3.06	13	96.3	30.2	9.00	86.6	3.56	0.956	11	8.13 (4.4e-3)	Less than additive
Ag/Ni	108	24.7	2.74	4120	3.17	19	104	23.1	4.16	3600	4.34	1.88	14	19.3 (1.1e-5)	Less than additive
Ag/Pb	103	24.6	5.77	273	1.08	13	105	21.2	4.53	141	0.811	5.74	6.3	55.1 (1.2e-13)	Less than additive
Ag/Zn	102	24.6	4.10	6950	1.83	20	94.8	23.3	5.03	6400	3.76	2.54	9.7	53.9 (2.1e-13)	Less than additive
Cd/Cu	104	194	2.96	173	2.44	15	99.1	194	4.20	138	4.02	1.48	11	22.3 (2.4e-6)	Less than additive
Cd/Ni	95.2	193	5.41	2630	1.27	19	96.2	201	3.94	3920	1.23	-2.07	18	4.93 (0.026)	More than additive
Cd/Pb	97.7	188	4.72	131	1.59	11	97.6	184	4.72	118	1.62	0.566	10	2.91 (0.088)	Additive
Cd/Zn	109	198	1.69	5610	2.50	30	105	164	4.64	5610	2.80	3.54	14	59.7 (1.1e-14)	Less than additive
Cu/Ni	101	101	4.50	3560	2.54	14	100	95.0	5.43	3220	2.73	0.846	13	4.69 (0.030)	Less than additive
Cu/Pb	103	164	3.09	141	1.52	14	103	136	4.06	110	1.66	1.99	12	14.1 (1.8e-4)	Less than additive
Cu/Zn	112	99.2	2.41	5610	2.50	27	105	79.3	4.88	4920	6.48	2.18	16	35.6 (2.5e-9)	Less than additive
Ni/Pb	102	3680	3.13	136	1.40	11	102	3590	3.25	125	1.41	0.456	11	0.753 (0.39)	Additive
Ni/Zn	106	3820	2.90	6340	2.95	16	103	3190	3.54	6070	4.17	1.54	13	17.7 (2.7e-5)	Less than additive
Pb/Zn	99.4	236	1.09	6440	3.43	8.5	99.3	192	1.21	6210	3.52	0.693	8.2	3.08 (0.079)	Additive

Max = Maximum RGR

EC50 = 50% Effect Concentration

β = Slope of the concentration response curve

SE = The mean standard error of the regression

α = Deviation parameter

Table SI.6: Overview of the MixTox statistical analysis for the Independent Action (IA) model, based on measured total dissolved concentration. Fitting results of the binary mixture data to the IA model using the whole dataset (both the single metals and the mixture data) (IA_whole dataset) and to the synergy/antagonism IA deviation model (IA_S/A) using the whole dataset. Results of the Chi-squared test between these two tests.

Mixture	IA_whole dataset						IA_S/A							Chi-squared test	
	Max	EC50 _{M1}	β _{M1}	EC50 _{M2}	β _{M2}	SE	Max	EC50 _{M1}	β _{M1}	EC50 _{M2}	β _{M2}	<i>α</i>	SE	Chi-value	Conclusion on
	(%)	(nM)		(nM)		(%)	(%)	(nM)		(nM)			(%)	(p-value)	mixture
Ag/Cd	97.2	29.2	6.67	205	3.11	9.7	97.0	29.4	6.90	210	3.28	-0.432	9.7	0.258 (0.61)	Additive
Ag/Cu	98.8	28.2	3.91	76.5	3.12	13	99.5	30.2	5.75	76.5	3.14	-1.29	13	2.54 (0.11)	Additive
Ag/Ni	105	22.9	4.35	3710	3.82	14	105	22.6	4.35	3650	3.74	0.333	14	0.133 (0.72)	Additive
Ag/Pb	101	24.8	6.29	178	1.32	9.5	102	23.3	4.61	135	0.880	3.94	7.0	22.3 (2.3e-6)	Less than additive
Ag/Zn	94.1	24.6	4.84	6950	4.31	11	94.6	23.3	4.27	6460	3.91	1.99	10	6.65 (9.9e-3)	Less than additive
Cd/Cu	99.5	194	3.48	128	4.16	11	99.6	194	3.81	131	4.27	-0.564	11	0.818 (0.37)	Additive
Cd/Ni	96.9	164	2.31	2560	1.44	15	89.4	206	4.91	4530	3.61	-6.91	11	24.7 (6.6e-7)	More than additive
Cd/Pb	98.3	178	3.83	104	1.50	11	97.7	183	4.22	119	1.67	-1.29	11	4.70 (0.030)	More than additive
Cd/Zn	105	181	7.10	5610	5.25	15	105	170	4.89	5610	3.19	3.22	14	9.29 (2.3e-3)	Less than additive
Cu/Ni	101	88.9	5.29	2840	2.13	13	101	94.4	6.17	3190	2.43	-1.96	12	5.27 (0.022)	More than additive
Cu/Pb	103	135	4.42	122	1.64	11	104	128	4.06	96.2	1.48	1.55	11	5.05 (0.025)	Less than additive
Cu/Zn	104	80.2	4.16	5390	6.59	17	101	85.1	4.47	5560	13.0	-1.83	17	0.660 (0.42)	Additive
Ni/Pb	102	3550	2.88	112	1.32	12	101	3700	3.13	127	1.40	-0.777	11	0.969 (0.32)	Additive
Ni/Zn	103	3170	3.31	5860	4.98	12	102	3280	3.50	5950	5.09	-0.531	12	0.368 (0.54)	Additive
Pb/Zn	100	195	1.04	6220	3.09	8.0	100	195	1.04	6220	3.10	-0.038	8.0	4.1e-3 (0.95)	Additive

Max = Maximum RGR

EC50 = 50% Effect Concentration

β = Slope of the concentration response curve

SE = The mean standard error of the regression

α = Deviation parameter

4.2 Analysis based on free ion activity

Table SI.7: Overview of the MixTox statistical analysis for the Concentration Addition (CA) model, based on free ion activity. Fitting results of the binary mixture data to the CA model using the whole dataset (both the single metals and the mixture data) (CA_whole dataset) and to the synergy/antagonism CA deviation model (CA_S/A) using the whole dataset. Results of the Chi-squared test between these two tests.

Mixture	CA_whole dataset						CA_S/A							Chi-squared test	
	Max	EC50 _{M1}	β _{M1}	EC50 _{M2}	β _{M2}	SE	Max	EC50 _{M1}	β _{M1}	EC50 _{M2}	β _{M2}	<i>a</i>	SE	Chi-value	Conclusion
	(%)	(nM)		(nM)		(%)	(%)	(nM)		(nM)			(%)	(p-value)	
Ag/Cd	101	9.96	5.63	132	2.60	15	96.5	9.14	8.96	115	3.28	1.67	9.1	35.2 (2.9e-9)	Less than additive
Ag/Cu	96.4	9.41	8.37	1.11	1.90	11	96.5	9.30	8.66	1.04	1.87	0.306	11	0.483 (0.487)	Additive
Ag/Ni	107	9.09	2.71	2440	3.17	19	104	7.07	4.16	2130	4.30	1.89	14	19.3 (1.1e-5)	Less than additive
Ag/Pb	104	7.53	5.42	13.2	0.946	13	103	6.64	4.66	6.62	0.884	5.54	6.6	50.6 (2.3e-12)	Less than additive
Ag/Zn	105	7.53	3.25	3720	1.76	20	94.2	7.23	5.12	3600	3.53	2.43	9.9	52.3 (4.8e-13)	Less than additive
Cd/Cu	98.9	117	3.92	3.15	2.03	12	98.9	110	4.29	2.39	2.33	1.16	11	7.06 (7.9e-3)	Less than additive
Cd/Ni	95.2	107	5.34	1570	1.24	19	96.2	111	3.85	2320	1.20	-2.05	18	4.72 (0.030)	More than additive
Cd/Pb	97.7	104	4.65	6.03	1.46	11	97.7	102	4.66	5.45	1.48	0.525	10	2.22 (0.014)	Additive
Cd/Zn	109	111	1.68	2980	2.44	31	105	91.4	4.61	2980	2.71	3.65	14	60.1 (8.9e-15)	Less than additive
Cu/Ni	103	1.00	2.15	1960	2.43	14	102	1.00	2.36	1830	2.63	0.879	13	3.14 (0.076)	Additive
Cu/Pb	106	2.94	1.71	5.25	1.36	14	103	2.25	2.28	5.25	1.53	2.00	12	9.54 (2.0e-3)	Less than additive
Cu/Zn	112	1.26	0.910	2760	2.44	28	104	0.987	2.59	2540	7.90	3.20	15	45.9 (1.3e-11)	Less than additive
Ni/Pb	102	2180	3.14	6.46	1.28	11	102	2120	3.27	5.86	1.29	0.512	11	0.855 (0.36)	Additive
Ni/Zn	107	2260	2.87	3390	2.90	16	103	1890	3.52	3250	4.09	1.54	13	17.7 (2.5e-5)	Less than additive
Pb/Zn	99.3	12.9	0.968	3450	3.36	8.9	99.1	9.31	1.16	3310	3.50	0.922	8.3	4.77 (0.029)	Less than additive

Max = Maximum RGR

EC50 = 50% Effect Concentration

β = Slope of the concentration response curve

SE = The mean standard error of the regression

α = Deviation parameter

Table SI.8: Overview of the MixTox statistical analysis for the Independent Action (IA) model, based on calculated free ion activity. Fitting results of the binary mixture data to the IA model using the whole dataset (both the single metals and the mixture data) (IA_whole dataset) and to the synergy/antagonism IA deviation model (IA_S/A) using the whole dataset. Results of the Chi-squared test between these two tests.

Mixture	IA_whole dataset						IA_S/A							Chi-squared test	
	Max (%)	EC50 _{M1} (nM)	β_{M1}	EC50 _{M2} (nM)	β_{M2}	SE (%)	Max (%)	EC50 _{M1} (nM)	β_{M1}	EC50 _{M2} (nM)	β_{M2}	α	SE (%)	Chi-value (p-value)	Conclusion
Ag/Cd	97.1	8.99	6.67	113	3.10	9.7	96.9	9.06	6.90	116	3.27	-0.433	9.7	0.261 (0.61)	Additive
Ag/Cu	98.8	8.72	3.93	0.807	1.63	13	99.5	9.06	5.13	0.807	1.69	-1.11	13	2.39 (0.13)	Additive
Ag/Ni	105	7.05	4.35	2200	3.80	14	105	6.93	4.36	2150	3.72	0.384	14	0.177 (0.67)	Additive
Ag/Pb	101	7.53	6.28	8.44	1.24	9.5	101	7.23	4.70	6.37	0.874	4.17	7.2	21.0 (4.6e-6)	Less than additive
Ag/Zn	94.4	7.53	4.82	3720	4.22	11	94.2	7.33	4.26	3720	3.63	1.45	10	5.15 (0.023)	Less than additive
Cd/Cu	99.3	109	3.47	2.20	2.31	11	98.5	113	4.02	2.39	2.40	-1.07	11	1.29 (0.26)	Additive
Cd/Ni	96.7	91.5	2.37	1530	1.43	15	89.4	114	4.88	2680	3.50	-6.71	11	24.1 (9.0e-7)	More than additive
Cd/Pb	98.4	98.6	3.82	4.80	1.38	11	97.8	101	4.15	5.46	1.52	-1.16	11	3.85 (0.050)	Additive
Cd/Zn	105	103	7.34	2980	5.23	16	104	95.0	4.76	2980	3.05	3.60	14	10.3 (1.3e-3)	Less than additive
Cu/Ni	103	1.00	2.36	1730	2.15	13	103	1.00	2.36	1730	2.17	-0.207	13	0.109 (0.74)	Additive
Cu/Pb	104	2.48	2.61	5.25	1.46	12	104	2.14	2.39	5.15	1.38	1.63	11	6.76 (9.3e-3)	Less than additive
Cu/Zn	101	1.22	2.73	2930	12.7	17	105	0.911	2.74	2650	5.64	3.39	16	5.55 (0.019)	Less than additive
Ni/Pb	102	2120	2.94	5.36	1.23	12	101	2180	3.12	5.91	1.28	-0.562	11	0.508 (0.48)	Additive
Ni/Zn	103	1880	3.30	3150	4.90	12	103	1900	3.39	3150	4.98	-0.248	12	0.162 (0.69)	Additive
Pb/Zn	99.5	9.64	1.05	3370	3.15	8.1	100	9.32	0.980	3320	3.05	0.375	8.1	4.63 (0.50)	Additive

Max = Maximum RGR

EC50 = 50% Effect Concentration

β = Slope of the concentration response curve

SE = The mean standard error of the regression

α = Deviation parameter

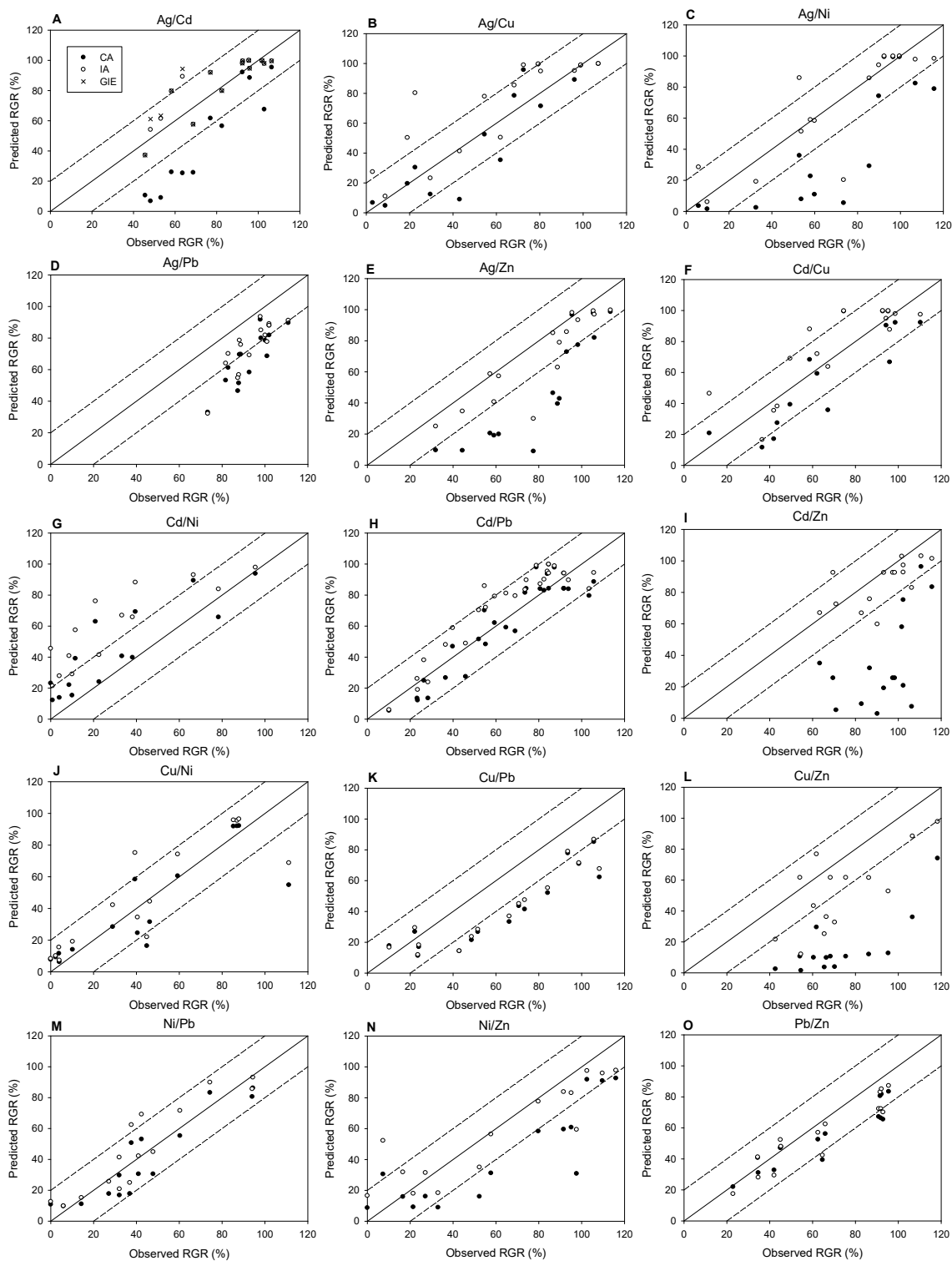


Figure SI.3: Predicted versus measured relative growth rates of juvenile *L. stagnalis* for the 15 binary combination of Ag, Cd, Cu, Ni, Pb and Zn: **A)** Ag/Cd, **B)** Ag/Cu, **C)** Ag/Ni, **D)** Ag/Pb, **E)** Ag/Zn, **F)** Cd/Cu, **G)** Cd/Ni, **H)** Cd/Pb, **I)** Cd/Zn, **J)** Cu/Ni, **K)** Cu/Pb, **L)** Cu/Zn, **M)** Ni/Pb, **N)** Ni/Zn, **O)** Pb/Zn.

Predictions are from the GIE (Greatest Individual Effect, Eq. 1, symbol: x), CA (Concentration Addition, Eq. 2, symbol: ●) and IA (Independent Action, Eq. 3, symbol: o) approaches, based on calculated free ion activities and the individual metal toxicity parameters given in Table SI.4. The full line corresponds to the perfect fit (i.e. strict additivity) and the points above this line represent more-than-additive toxicity, while the points below this line represent less-than-additive toxicity. The dashed lines represent an absolute difference of 20% between the observed and predicted RGR and are drawn for comparison only. The predictions based on total dissolved concentration are given in Figure 2 of the main manuscript.

5. TOXICITY DATASET

In this section, we provide the experimental dataset produced in this study (e.g. average metal concentration and snail initial and final wet weights in each treatment). Table SI.9 gives the data of the six preliminary single metal tests that allowed selecting adequate treatments for the subsequent metal mixture toxicity tests. Tables SI.10 to SI.24 give the data of the 15 mixture toxicity tests, along with the single metal tests which were simultaneously performed.

Table SI.9: Preliminary single metal toxicity tests: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Metal	[Metal] (nM)	[Free ion] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ag	< 0.4*	< 0.1	9.6	240.0	100.0
	2.90	0.89	9.3	305.1	108.5
	3.25	1.00	9.2	205.7	96.5
	4.01	1.24	9.4	210.7	96.5
	4.10	1.26	9.3	226.9	99.3
	5.41	1.67	9.3	158.3	88.2
	8.48	2.61	9.2	98.6	73.5
	13.20	4.06	9.4	45.4	48.8
	18.70	5.76	9.4	33.9	39.8
	32.30	9.95	9.4	9.4	0.0
	48.60	14.98	9.4	9.4	0.0
	55.70	17.18	9.5	9.5	0.0
	133.10	41.08	9.4	9.4	0.0
Cd	0.41	0.22	6.6	126.5	100.0
	6.67	3.57	6.6	152.8	106.4
	15.70	8.42	6.5	85.4	87.1
	28.80	15.51	6.5	118.1	98.0
	55.30	30.06	6.5	166.6	109.7

		89.00	48.62	6.5	88.5	88.3
		118.7	65.1	6.5	59.6	75.1
		157.1	86.6	6.5	28.8	50.5
		184.7	102.0	6.4	38.6	60.8
		223.9	124.1	6.5	12.4	22.0
		266.9	148.3	6.5	15.8	29.7
		315.4	175.7	6.5	8.8	9.9
		407.3	227.8	6.5	7.5	5.0
Cu		< 3.0*	<0.003	7.2	131.4	100.0
		10.40	0.020	7.2	117.4	96.1
		18.90	0.059	7.2	153.1	105.3
		32.40	0.153	7.3	164.3	107.5
		42.10	0.246	7.1	93.8	88.8
		52.80	0.377	7.3	49.7	66.1
		67.50	0.607	7.3	82.2	83.4
		83.10	0.910	7.3	55.8	70.1
		103.80	1.392	7.4	19.9	34.2
		117.00	1.740	7.5	9.0	6.4
		136.10	2.282	7.3	7.0	0.0
		201.40	4.390	7.3	7.3	0.0
		261.70	6.551	7.4	7.4	0.0
Ni		< 12	< 7	7.6	148.8	100.0
		316	182	7.6	140.0	97.6
		648	377	7.6	131.2	95.5
		987	577	7.6	156.7	101.4
		1341	786	7.6	86.2	81.6
		1696	996	7.6	120.5	92.7
		2119	1248	7.5	104.7	88.3
		2417	1425	7.6	111.2	90.0
		2643	1559	7.6	74.8	76.6
		2940	1735	7.7	101.9	86.7
		3281	1939	7.7	33.5	49.3
		4028	2384	7.8	58.1	67.6
		4768	2825	7.8	22.6	35.8
Pb		< 2*	< 0.08	6.7	120.2	100.0
		3.88	0.150	6.7	103.6	94.8
		4.09	0.158	6.7	98.8	93.2
		5.70	0.221	6.7	86.4	88.9
		8.99	0.352	6.7	91.4	90.8
		10.70	0.420	6.7	99.4	93.4
		12.10	0.477	6.7	77.4	85.1

	17.50	0.703	6.5	77.9	86.1
	23.80	0.966	6.5	79.1	86.6
	30.20	1.244	6.6	61.3	77.2
	52.30	2.231	6.6	19.4	37.7
	76.60	3.377	6.5	20.6	40.3
	220.60	10.937	6.5	9.4	13.0
Zn	383	191	6.9	164.0	100.0
	430	215	7.0	149.1	96.6
	587	296	6.8	205.2	107.5
	799	405	6.9	121.8	90.5
	1046	535	6.7	174.2	103.1
	1343	691	6.7	185.2	104.7
	1777	921	6.8	126.9	92.3
	2299	1199	6.8	202.3	107.3
	2993	1571	6.7	147.8	97.7
	3925	2073	6.7	86.5	80.8
	4946	2626	6.7	59.7	69.0
	6362	3397	6.8	49.0	62.3
	8019	4302	6.7	12.8	20.3

***Method detection limit**

Table SI.10: Ag/Cd toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Treatment	[Cd] (nM)	[Ag] (nM)	[Cd ²⁺] (nM)	[Ag ⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	2.5	< 0.4*	1.3	< 0.1	8.6	76.1	88
Ctrl2	4.1	< 0.4	2.2	< 0.1	8.6	112.3	104
Ctrl3	7.3	< 0.4	3.9	< 0.1	8.5	123.6	108
Ctrl4	7.1	< 0.4	3.8	< 0.1	8.5	105.4	102
Ctrl5	4.8	< 0.4	2.6	< 0.1	8.5	139.1	113
Ctrl6	5.0	< 0.4	2.7	< 0.1	8.5	69.3	85
Cd alone	35.7	< 0.4	0.2	< 0.1	8.5	66.5	83
Cd alone	75.1	< 0.4	40.8	< 0.1	8.4	96.3	99
Cd alone	114.4	< 0.4	62.5	< 0.1	8.5	65.2	82
Cd alone	161.1	< 0.4	88.5	< 0.1	8.5	35.6	58
Cd alone	202.2	< 0.4	111.5	< 0.1	8.5	49.0	71
Cd alone	243.7	< 0.4	134.7	< 0.1	8.4	15.8	25
Cd alone	327.8	< 0.4	182.1	< 0.1	8.4	9.2	4
Ag alone	4.5	6.5	2.4	2.0	8.4	88.7	96
Ag alone	3.8	10.2	2.0	3.1	8.5	62.4	81
Ag alone	3.4	13.7	1.8	4.2	8.5	82.0	92
Ag alone	4.4	16.6	2.3	5.1	8.5	85.6	94
Ag alone	1.6	21.3	0.9	6.6	8.5	99.3	100
Ag alone	4.3	29.2	2.3	9.0	8.5	30.6	52
Ag alone	4.5	37.5	2.4	11.5	8.5	11.0	11
Cd/Ag	22.5	4.9	12.1	1.5	8.3	87.9	95
Cd/Ag	45.1	2.3	24.3	0.7	8.3	81.7	93
Cd/Ag	33.7	3.6	18.2	1.1	8.4	103.6	102
Cd/Ag	45.1	10.4	24.3	3.2	8.4	116.3	106
Cd/Ag	90.6	4.9	49.3	1.5	8.4	89.5	96
Cd/Ag	67.7	7.6	36.8	2.4	8.3	81.4	92
Cd/Ag	67.7	16.1	36.8	5.0	8.3	105.6	103
Cd/Ag	136.5	7.6	74.8	2.4	8.3	63.8	83
Cd/Ag	102.0	11.8	55.7	3.6	8.3	55.7	77
Cd/Ag	90.6	22.0	49.3	6.8	8.3	39.7	64
Cd/Ag	183.0	10.4	100.7	3.2	8.3	45.1	69
Cd/Ag	136.5	16.1	74.8	5.0	8.3	34.8	58
Cd/Ag	113.5	28.1	62.0	8.7	8.3	27.2	48
Cd/Ag	229.8	13.2	127.0	4.1	8.3	25.7	46
Cd/Ag	171.3	20.5	94.2	6.3	8.4	31.3	53

* Method detection limit

Table SI.11: Ag/Cu toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Treatment	[Cu] (nM)	[Ag] (nM)	[Cu ²⁺] (nM)	[Ag ⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	4.2	< 0.4*	0.005	< 0.1	8.6	76.1	88
Ctrl2	3.2	< 0.4	0.003	< 0.1	8.6	112.3	104
Ctrl3	2.9	< 0.4	0.003	< 0.1	8.5	123.6	108
Ctrl4	5.4	< 0.4	0.007	< 0.1	8.5	105.4	102
Ctrl5	< 3.0	< 0.4	<0.003	< 0.1	8.5	139.1	113
Ctrl6	6.2	< 0.4	0.009	< 0.1	8.5	69.3	85
Cu alone	21.9	< 0.4	0.08	< 0.1	8.4	109.2	104
Cu alone	40.3	< 0.4	0.24	< 0.1	8.4	78.1	90
Cu alone	58.5	< 0.4	0.48	< 0.1	8.4	44.6	68
Cu alone	76.7	< 0.4	0.81	< 0.1	8.4	55.6	77
Cu alone	94.8	< 0.4	1.23	< 0.1	8.4	20.0	35
Cu alone	116.7	< 0.4	1.81	< 0.1	8.4	11.9	14
Cu alone	145.8	< 0.4	2.68	< 0.1	8.4	9.6	5
Ag alone	8.1	6.5	0.01	2.0	8.4	88.7	96
Ag alone	8.0	10.2	0.01	3.2	8.5	62.4	81
Ag alone	7.6	13.7	0.01	4.2	8.5	82.0	92
Ag alone	3.9	16.6	0.004	5.1	8.5	85.6	94
Ag alone	4.8	21.3	0.006	6.6	8.5	99.3	100
Ag alone	5.9	29.2	0.009	9.0	8.5	30.6	52
Ag alone	6.0	37.5	0.009	11.6	8.5	11.0	11
Cu/Ag	13.9	4.9	0.04	1.52	8.4	118.2	107
Cu/Ag	27.8	2.3	0.12	0.70	8.4	96.1	99
Cu/Ag	20.9	3.6	0.07	1.11	8.3	58.8	79
Cu/Ag	27.8	10.4	0.12	3.23	8.3	49.7	73
Cu/Ag	55.7	4.9	0.44	1.53	8.3	44.7	68
Cu/Ag	41.7	7.6	0.25	2.37	8.3	88.9	96
Cu/Ag	41.7	16.1	0.25	5.00	8.2	60.1	80
Cu/Ag	83.5	7.6	0.96	2.38	8.3	38.4	62
Cu/Ag	62.6	11.8	0.55	3.67	8.3	32.0	55
Cu/Ag	55.7	22.0	0.44	6.84	8.3	14.5	23
Cu/Ag	111.3	10.4	1.66	3.24	8.4	17.4	30
Cu/Ag	83.5	16.1	0.96	5.01	8.3	13.3	19
Cu/Ag	69.6	28.1	0.67	8.74	8.3	33.0	55
Cu/Ag	139.1	13.2	2.47	4.12	8.3	10.3	9
Cu/Ag	104.4	20.5	1.47	6.38	8.4	9.0	3

* Method detection limit

Table SI.12: Ag/Ni toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Treatment	[Ni] (nM)	[Ag] (nM)	[Ni ²⁺] (nM)	[Ag ⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	< 12*	< 0.4*	< 7	< 0.1	6.9	113.8	113
Ctrl2	< 12	< 0.4	< 7	< 0.1	6.9	75.3	97
Ctrl3	< 12	< 0.4	< 7	< 0.1	6.9	121.3	116
Ctrl4	< 12	< 0.4	< 7	< 0.1	6.9	79.8	98
Ctrl5	< 12	< 0.4	< 7	< 0.1	6.9	79.8	99
Ctrl6	< 12	< 0.4	< 7	< 0.1	6.9	46.8	77
Ni alone	813	< 0.4	476	< 0.1	6.8	143.1	123
Ni alone	1625	< 0.4	959	< 0.1	6.8	90.3	104
Ni alone	2438	< 0.4	1444	< 0.1	6.9	79.4	99
Ni alone	3251	< 0.4	1930	< 0.1	6.9	28.9	58
Ni alone	4063	< 0.4	2417	< 0.1	6.9	9.0	11
Ni alone	4876	< 0.4	2904	< 0.1	6.9	17.8	38
Ni alone	6501	< 0.4	3880	< 0.1	6.9	6.9	0
Ag alone	< 12	6.50	< 7	2.01	6.9	113.0	113
Ag alone	< 12	10.22	< 7	3.15	6.9	92.0	105
Ag alone	< 12	13.71	< 7	4.23	6.9	74.7	96
Ag alone	< 12	16.62	< 7	5.12	6.9	84.3	101
Ag alone	< 12	21.27	< 7	6.56	6.9	26.8	55
Ag alone	< 12	29.17	< 7	9.00	6.9	12.2	23
Ag alone	< 12	37.43	< 7	11.54	6.8	15.5	33
Ni/Ag	1084	2.26	637	0.70	7.0	77.4	97
Ni/Ag	542	4.92	316	1.53	7.0	69.8	92
Ni/Ag	813	3.58	476	1.11	7.0	83.3	100
Ni/Ag	2167	4.92	1283	1.53	7.1	65.8	90
Ni/Ag	1084	10.39	637	3.23	7.1	100.4	107
Ni/Ag	1625	7.63	959	2.37	7.1	124.9	116
Ni/Ag	3251	7.63	1930	2.37	7.1	29.8	58
Ni/Ag	1625	16.08	960	5.00	7.1	26.2	53
Ni/Ag	2438	11.79	1444	3.67	7.0	58.5	85
Ni/Ag	4334	10.39	2580	3.24	7.0	43.5	73
Ni/Ag	2167	21.97	1283	6.84	7.0	31.1	60
Ni/Ag	3251	16.08	1930	5.01	7.1	26.7	54
Ni/Ag	5418	13.21	3230	4.11	7.1	9.0	10
Ni/Ag	2709	28.07	1606	8.74	7.1	8.1	6
Ni/Ag	4063	20.48	2417	6.38	7.1	15.8	33

* Method detection limit

Table SI.13: Ag/Pb toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Treatment	[Pb] (nM)	[Ag] (nM)	[Pb ²⁺] (nM)	[Ag ⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	< 2*	< 0.4*	< 0.08	< 0.1	6.9	112.8	106
Ctrl2	< 2	< 0.4	< 0.08	< 0.1	6.9	75.3	91
Ctrl3	< 2	< 0.4	< 0.08	< 0.1	6.9	84.4	95
Ctrl4	< 2	< 0.4	< 0.08	< 0.1	6.9	87.5	97
Ctrl5	< 2	< 0.4	< 0.08	< 0.1	6.9	110.9	106
Ctrl6	< 2	< 0.4	< 0.08	< 0.1	6.9	88.6	97
Ctrl7	< 2	< 0.4	< 0.08	< 0.1	6.9	122.2	110
Ctrl8	< 2	< 0.4	< 0.08	< 0.1	6.9	89.1	98
Pb alone	20.1	< 0.4	0.81	< 0.1	7.0	44.4	70
Pb alone	29.4	< 0.4	1.21	< 0.1	7.0	70.6	88
Pb alone	43.0	< 0.4	1.81	< 0.1	7.0	51.2	76
Pb alone	68.1	< 0.4	2.97	< 0.1	7.0	44.2	70
Pb alone	95.4	< 0.4	4.29	< 0.1	7.0	41.4	68
Pb alone	124.9	< 0.4	5.78	< 0.1	7.0	28.0	53
Pb alone	193.4	< 0.4	9.43	< 0.1	7.0	24.3	48
Ag alone	< 2	6.50	< 0.08	2.01	7.0	130.7	112
Ag alone	< 2	10.22	< 0.08	3.15	7.0	104.8	103
Ag alone	< 2	13.71	< 0.08	4.23	7.0	85.6	96
Ag alone	< 2	16.62	< 0.08	5.12	7.0	48.6	74
Ag alone	< 2	21.27	< 0.08	6.56	6.9	28.6	54
Ag alone	< 2	29.17	< 0.08	9.00	6.9	14.9	29
Ag alone	< 2	37.43	< 0.08	11.54	6.9	6.9	0
Pb/Ag	6.01	4.18	0.23	1.29	7.0	91.6	98
Pb/Ag	12.93	1.89	0.51	0.58	7.0	102.1	102
Pb/Ag	9.44	3.03	0.37	0.94	7.1	130.3	111
Pb/Ag	12.93	8.87	0.51	2.74	7.1	103.0	102
Pb/Ag	27.49	4.18	1.13	1.29	7.1	98.0	100
Pb/Ag	20.09	6.50	0.81	2.01	7.1	93.2	98
Pb/Ag	20.09	13.71	0.81	4.23	7.1	100.4	101
Pb/Ag	43.03	6.50	1.81	2.01	7.1	72.8	89
Pb/Ag	31.29	10.06	1.29	3.11	7.1	71.6	88
Pb/Ag	27.49	18.71	1.13	5.78	7.1	70.6	88
Pb/Ag	59.53	8.87	2.57	2.74	7.1	62.0	83
Pb/Ag	43.03	13.71	1.81	4.24	7.1	80.3	93
Pb/Ag	35.14	23.86	1.46	7.38	7.1	48.3	73
Pb/Ag	77.01	11.27	3.40	3.49	7.1	60.2	82
Pb/Ag	55.32	17.45	2.37	5.40	7.1	69.8	87

* Method detection limit

Table SI.14: Ag/Zn toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Treatment	[Zn] (nM)	[Ag] (nM)	[Zn ²⁺] (nM)	[Ag ⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	< 45*	< 0.4*	< 23	< 0.1	6.9	112.8	106
Ctrl2	107	< 0.4	55	< 0.1	6.9	75.3	91
Ctrl3	< 45	< 0.4	< 23	< 0.1	6.9	84.4	95
Ctrl4	93	< 0.4	48	< 0.1	6.9	87.5	97
Ctrl5	133	< 0.4	68	< 0.1	6.9	110.9	106
Ctrl6	52	< 0.4	27	< 0.1	6.9	88.6	97
Ctrl7	80	< 0.4	41	< 0.1	6.9	122.2	110
Ctrl8	84	< 0.4	43	< 0.1	6.9	89.1	98
Zn alone	2605	< 0.4	1371	< 0.1	7.0	75.0	91
Zn alone	3670	< 0.4	1948	< 0.1	7.0	59.5	82
Zn alone	4434	< 0.4	2364	< 0.1	7.0	44.2	71
Zn alone	5210	< 0.4	2787	< 0.1	7.0	43.5	70
Zn alone	5810	< 0.4	3115	< 0.1	7.0	25.4	49
Zn alone	6728	< 0.4	3618	< 0.1	7.0	31.7	58
Zn alone	7815	< 0.4	4216	< 0.1	7.0	12.1	21
Ag alone	< 45	6.50	< 23	2.01	8.7	130.7	112
Ag alone	138	10.22	70	3.15	8.7	129.8	103
Ag alone	76	13.71	39	4.23	8.7	108.0	96
Ag alone	100	16.62	51	5.12	8.7	60.6	74
Ag alone	144	21.27	74	6.56	8.7	35.9	54
Ag alone	176	29.17	90	9.00	8.7	18.6	29
Ag alone	67	37.43	34	11.54	8.7	8.7	0
Zn/Ag	868	4.18	444	1.30	7.1	139.7	113
Zn/Ag	1737	1.89	905	0.59	7.1	87.3	96
Zn/Ag	1302	3.03	674	0.94	7.1	113.2	105
Zn/Ag	1737	8.87	905	2.76	7.1	113.8	106
Zn/Ag	3473	4.18	1841	1.30	7.1	81.8	93
Zn/Ag	2605	6.50	1372	2.03	7.1	94.0	98
Zn/Ag	2605	13.71	1372	4.27	7.1	69.2	87
Zn/Ag	5210	6.50	2787	2.03	7.1	73.2	89
Zn/Ag	3907	10.06	2077	3.14	7.1	74.9	90
Zn/Ag	3473	18.71	1841	5.83	7.2	32.3	57
Zn/Ag	6946	8.87	3739	2.76	7.2	33.9	59
Zn/Ag	5210	13.71	2787	4.27	7.2	36.1	61
Zn/Ag	4342	23.86	2313	7.43	7.2	55.2	78
Zn/Ag	8683	11.27	4694	3.51	7.3	16.8	32
Zn/Ag	6512	17.45	3500	5.44	7.3	23.3	44

* Method detection limit

Table SI.15: Cd/Cu toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Treatment	[Cu] (nM)	[Cd] (nM)	[Cu ²⁺] (nM)	[Cd ²⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	7.3	3.5	0.012	1.9	9	153.4	99
Ctrl2	4.5	5.1	0.005	2.8	8.7	244	116
Ctrl3	3.9	9.4	0.004	5.1	8.7	133.8	95
Ctrl4	4.3	5.5	0.005	3	8.7	159.5	102
Ctrl5	5.7	4	0.008	2.2	8.7	128.1	94
Ctrl6	5.5	2.4	0.008	1.3	8.7	172.4	104
Ctrl7	6.7	7.6	0.01	4.1	8.7	135.5	96
Ctrl8	6.9	7.4	0.011	4	8.7	127.4	94
Cu alone	24	5.5	0.0790	3	8.2	163.1	104
Cu alone	43	5.8	0.253	3.3	8.3	177.4	107
Cu alone	67	1.9	0.601	1.01	8.3	194.2	110
Cu alone	85	2.4	0.960	1.4	8.3	77.8	78
Cu alone	104	4.1	1.410	2.3	8.3	75.0	77
Cu alone	128	4.9	2.053	2.8	8.4	59.4	68
Cu alone	171	3.6	3.367	2.1	8.4	25.1	38
Cd alone	5.7	40	0.008	21	8.0	130.3	98
Cd alone	4.7	75	0.006	41	8.0	95.2	87
Cd alone	7.0	120	0.011	66	8.1	90.9	84
Cd alone	3.2	151	0.003	83	8.1	60.0	70
Cd alone	6.6	185	0.010	102	8.1	59.8	70
Cd alone	4.5	228	0.005	127	8.2	15.3	22
Cd alone	7.0	307	0.011	171	8.2	9.2	4
Cu/Cd	14	50	0.038	28	6.4	54.1	75
Cu/Cd	28	25	0.123	14	6.4	98.0	95
Cu/Cd	21	37	0.075	21	6.4	91.1	93
Cu/Cd	28	100	0.128	57	6.4	95.3	94
Cu/Cd	57	50	0.443	28	6.5	152.2	110
Cu/Cd	43	75	0.261	43	6.5	108.7	99
Cu/Cd	43	151	0.268	86	6.5	38.6	62
Cu/Cd	85	75	0.972	43	6.5	34.7	59
Cu/Cd	64	113	0.564	65	6.5	101.7	96
Cu/Cd	57	202	0.462	116	6.5	22.5	44
Cu/Cd	114	100	1.673	58	6.5	26.9	50
Cu/Cd	85	151	0.984	87	6.6	44.9	67
Cu/Cd	71	254	0.710	146	6.6	18.7	36
Cu/Cd	142	125	2.491	73	6.6	9.3	12
Cu/Cd	107	190	1.500	110	6.6	21.9	42

Table SI.16: Cd/Ni toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Treatment	[Ni] (nM)	[Cd] (nM)	[Ni ²⁺] (nM)	[Cd ²⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	< 12*	4.7	< 7	2.5	7.3	63.8	84
Ctrl2	< 12	3.9	< 7	2.1	7.3	89.8	97
Ctrl3	< 12	2.1	< 7	1.1	7.3	115.9	106
Ctrl4	< 12	2.3	< 7	1.2	7.3	97.6	100
Ctrl5	< 12	8.6	< 7	4.6	7.3	123.7	109
Ctrl6	< 12	3.8	< 7	2.1	7.4	155.8	117
Ctrl7	< 12	6.7	< 7	3.6	7.4	71.4	87
Ni alone	817	3.6	476	1.9	7.4	82.1	93
Ni alone	1634	8.4	959	4.5	7.4	38.4	63
Ni alone	2450	7.5	1444	4.1	7.4	42.9	68
Ni alone	3267	5.9	1930	3.2	7.4	58.4	80
Ni alone	4084	5.5	2417	3.0	7.4	34.8	60
Ni alone	4901	7.2	2904	3.9	7.4	19.4	37
Ni alone	6534	4.4	3880	2.4	7.4	7.9	3
Cd alone	< 12	35.6	< 7	19.2	7.38	66.9	85
Cd alone	< 12	74.9	< 7	40.8	7.38	60.0	81
Cd alone	< 12	114.0	< 7	62.5	7.38	77.5	91
Cd alone	< 12	160.5	< 7	88.5	7.44	44.2	69
Cd alone	< 12	201.5	< 7	111.5	7.44	26.4	49
Cd alone	< 12	242.9	< 7	134.7	7.44	17.4	33
Cd alone	< 12	326.7	< 7	182.1	7.44	8.0	3
Ni/Cd	1089	22.4	637	12.7	7.32	41.3	67
Ni/Cd	545	44.9	316	25.2	7.32	87.5	96
Ni/Cd	817	33.6	477	18.9	7.3	n.a.	n.a.
Ni/Cd	2178	44.9	1283	25.6	7.3	12.6	21
Ni/Cd	1089	90.2	638	51.1	7.3	20.4	40
Ni/Cd	1634	67.5	960	38.4	7.38	56.4	78
Ni/Cd	3267	67.5	1931	38.7	7.4	10.0	12
Ni/Cd	1634	136.0	960	77.4	7.4	17.6	33
Ni/Cd	2450	101.6	1445	58.1	7.4	20.0	38
Ni/Cd	4356	90.2	2580	51.8	7.4	13.3	23
Ni/Cd	2178	182.3	1284	104.1	7.4	9.3	9
Ni/Cd	3267	136.0	1931	78.0	7.4	7.4	0
Ni/Cd	5445	113.1	3230	65.1	7.4	9.6	10
Ni/Cd	2723	229.0	1608	131.1	7.38	7.6	1
Ni/Cd	4084	170.7	2418	98.0	7.38	8.2	4

* Method detection limit

Table SI.17: Cd/Pb toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate. Note: Two tests were combined for this series, hence the higher n.

Treatment	[Cd] (nM)	[Pb] (nM)	[Cd ²⁺] (nM)	[Pb ²⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	3.1	< 2*	1.7	< 0.08	7.9	185.5	109
Ctrl2	9.5	< 2	5.1	< 0.08	7.8	95.5	87
Ctrl3	5.4	< 2	2.9	< 0.08	7.8	155.3	104
Ctrl4	7.3	< 2	3.9	< 0.08	7.8	141.4	100
Ctrl5	3.5	< 2	1.9	< 0.08	9.0	153.4	99
Ctrl6	5.1	< 2	2.8	< 0.08	8.7	244.0	116
Ctrl7	9.4	< 2	5.1	< 0.08	8.7	133.8	95
Ctrl8	5.5	< 2	3.0	< 0.08	8.7	159.5	102
Ctrl9	4.0	< 2	2.2	< 0.08	8.7	128.1	94
Ctrl10	2.4	< 2	1.3	< 0.08	8.7	172.4	104
Ctrl11	7.6	< 2	4.1	< 0.08	8.7	135.5	96
Ctrl12	7.4	< 2	4.0	< 0.08	8.7	127.4	94
Cd alone	35.6	< 2	19.2	< 0.08	7.8	66.7	74
Cd alone	74.9	< 2	40.8	< 0.08	7.8	178.8	108
Cd alone	114.0	< 2	62.5	< 0.08	7.8	152.2	103
Cd alone	160.5	< 2	88.5	< 0.08	7.8	32.4	49
Cd alone	201.5	< 2	111.5	< 0.08	7.8	27.3	43
Cd alone	242.9	< 2	134.7	< 0.08	7.8	11.0	12
Cd alone	326.7	< 2	182.1	< 0.08	7.8	7.8	0
Cd alone	39.6	< 2	21.4	< 0.08	8.0	130.3	98
Cd alone	74.9	< 2	40.8	< 0.08	8.0	95.2	87
Cd alone	119.8	< 2	65.8	< 0.08	8.1	90.9	84
Cd alone	151.0	< 2	83.2	< 0.08	8.1	60.0	70
Cd alone	185.0	< 2	102.2	< 0.08	8.1	59.8	70
Cd alone	228.4	< 2	126.6	< 0.08	8.2	15.3	22
Cd alone	307.0	< 2	171.0	< 0.08	8.2	9.2	4
Pb alone	3.0	5.9	1.6	0.23	7.8	180.9	109
Pb alone	8.9	17.6	4.8	0.71	7.9	105.3	90
Pb alone	4.5	30.0	2.4	1.23	8.0	105.6	89
Pb alone	5.5	44.1	3.0	1.86	8.0	125.9	95
Pb alone	7.5	59.8	4.1	2.58	8.0	79.3	79
Pb alone	9.5	80.5	5.1	3.56	8.0	78.2	79
Pb alone	9.7	116.5	5.2	5.35	8.0	47.8	62
Pb alone	5.6	15.5	3.0	0.62	8.1	150.7	102
Pb alone	2.4	33.0	1.3	1.37	8.1	93.6	85

Pb alone	2.6	65.2	1.4	2.83	8.1	24.1	38
Pb alone	5.3	102.6	2.9	4.65	8.1	37.9	54
Pb alone	8.8	149.3	4.8	7.05	8.2	21.3	33
Pb alone	4.3	251.6	2.3	12.68	8.2	12.6	15
Pb alone	4.7	372.0	2.5	19.81	8.2	12.8	15
Cd/Pb	20.3	1.3	10.9	0.05	8.0	92.4	85
Cd/Pb	74.9	1.3	40.8	0.05	8.0	99.9	87
Cd/Pb	130.1	1.3	71.5	0.05	8.0	67.4	74
Cd/Pb	36.1	5.9	19.6	0.23	8.0	78.4	79
Cd/Pb	114.0	5.9	62.6	0.24	8.0	87.0	82
Cd/Pb	20.3	17.6	11.0	0.71	8.0	90.9	84
Cd/Pb	74.9	17.6	41.1	0.73	8.0	91.9	85
Cd/Pb	74.9	17.6	41.1	0.73	8.0	112.5	92
Cd/Pb	74.9	17.6	41.1	0.73	8.0	113.1	92
Cd/Pb	130.1	17.6	71.8	0.74	8.0	44.3	59
Cd/Pb	36.1	30.0	19.8	1.25	8.0	67.9	74
Cd/Pb	114.0	30.0	63.0	1.27	8.0	52.1	65
Cd/Pb	20.3	35.2	11.1	1.47	8.1	83.1	81
Cd/Pb	74.9	35.2	41.3	1.50	8.1	39.2	55
Cd/Pb	130.1	35.2	72.1	1.51	8.1	39.8	55
Cd/Pb	49.8	19.3	27.2	0.79	8.4	173.2	106
Cd/Pb	24.8	41.2	13.6	1.75	8.4	162.8	104
Cd/Pb	37.3	30.0	20.4	1.25	8.4	122.8	94
Cd/Pb	100.1	41.2	55.4	1.78	8.3	59.7	69
Cd/Pb	49.8	91.2	27.6	4.12	8.3	25.9	40
Cd/Pb	74.9	65.2	41.5	2.88	8.3	36.6	52
Cd/Pb	151.0	65.2	84.1	2.91	8.3	30.7	46
Cd/Pb	74.9	149.3	41.9	7.11	8.3	17.7	26
Cd/Pb	112.8	105.0	63.0	4.84	8.3	23.7	37
Cd/Pb	202.4	91.2	113.4	4.19	8.3	16.2	23
Cd/Pb	100.1	215.5	56.4	10.72	8.3	18.7	28
Cd/Pb	151.0	149.3	84.8	7.15	8.4	16.4	23
Cd/Pb	254.5	119.3	143.2	5.63	8.4	11.3	10

* Method detection limit

Table SI.18: Cd/Zn toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Treatment	[Cd] (nM)	[Zn] (nM)	[Cd ²⁺] (nM)	[Zn ²⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	4.90	130	2.84	68.9	7.5	53.0	87
Ctrl2	6.70	80	3.89	42.4	7.4	102.7	117
Ctrl3	6.00	127	3.48	67.3	7.5	62.5	94
Ctrl4	7.40	142	4.29	75.3	7.5	67.9	98
Ctrl5	5.20	119	3.02	63.1	7.6	53.6	87
Ctrl6	2.60	50	1.51	26.5	7.5	96.5	114
Ctrl7	2.80	105	1.62	55.7	7.7	80.7	105
Ctrl8	2.80	106	1.62	56.2	7.8	70.1	98
Cd alone	35.7	148	19.7	78.4	7.9	80	104
Cd alone	75.5	109	41.8	57.8	7.9	71.9	99
Cd alone	121.7	113	67.7	59.9	7.9	65.5	94
Cd alone	164.0	50	91.4	26.5	7.8	20.0	42
Cd alone	207.2	57	115.7	30.2	7.9	22.2	46
Cd alone	251.3	64	140.6	33.9	7.9	9.1	6
Cd alone	342.2	142	192.1	75.3	7.8	7.8	0
Zn alone	6.60	3135	3.83	1657	7.8	66.6	96
Zn alone	4.30	3746	2.49	1990	7.8	62.3	93
Zn alone	6.80	4266	3.94	2272	7.8	40.4	73
Zn alone	6.00	596	3.48	318	7.9	31.7	62
Zn alone	7.60	5122	4.41	2739	7.9	26.5	54
Zn alone	6.40	5505	3.71	2948	7.9	29.4	59
Zn alone	4.90	6070	2.84	3258	7.9	74.3	n.a.
Cd/Zn	20.2	2599	11.7	1369	8.0	96.1	111
Cd/Zn	75.5	2569	43.6	1353	8.0	78.2	102
Cd/Zn	132.4	2584	76.4	1361	8.0	64.7	93
Cd/Zn	36.1	2951	20.9	1559	8.0	108.0	116
Cd/Zn	115.6	2997	66.9	1583	8.1	80.4	102
Cd/Zn	20.2	3807	11.7	2023	8.1	80.3	102
Cd/Zn	75.5	3823	43.7	2031	8.1	38.5	70
Cd/Zn	75.5	3761	43.7	1998	8.1	72.0	97
Cd/Zn	75.5	3853	43.7	2047	8.0	73.1	98
Cd/Zn	132.4	3792	76.7	2015	8.0	86.7	106
Cd/Zn	36.1	4664	21.0	2489	8.0	56.2	87
Cd/Zn	115.6	4633	67.2	2473	8.0	39.5	71
Cd/Zn	20.2	5000	11.8	2672	8.1	33.6	63
Cd/Zn	75.5	4969	43.9	2656	8.1	52.1	83
Cd/Zn	132.4	5046	76.9	2697	8.1	61.4	90

* Method detection limit

Table SI.19: Cu/Ni toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Treatment	[Ni] (nM)	[Cu] (nM)	[Ni ²⁺] (nM)	[Cu ²⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	< 12*	6.1	< 7	0.0089	7.0	80.0	93
Ctrl2	< 12	7.6	< 7	0.0128	6.9	107.5	105
Ctrl3	< 12	4.3	< 7	0.0050	6.8	106.3	105
Ctrl4	< 12	6.2	< 7	0.0092	6.8	76.3	92
Ctrl5	< 12	< 3.0	< 7	< 0.0026	6.8	112.0	107
Ctrl6	< 12	6.5	< 7	0.0099	6.8	100.0	103
Ctrl7	< 12	8.1	< 7	0.0142	6.8	79.8	94
Ni alone	817	4.2	476	0.0048	6.9	95.5	101
Ni alone	1634	3.6	959	0.0037	6.9	74.3	91
Ni alone	2450	< 3.0	1444	< 0.0026	6.9	49.8	76
Ni alone	3267	6.7	1930	0.0104	6.9	25.8	51
Ni alone	4084	< 3.0	2417	< 0.0026	6.9	14.4	28
Ni alone	4901	7.5	2904	0.0125	6.9	30.2	57
Ni alone	6534	6.1	3880	0.0089	6.9	7.3	2
Cu alone	< 12	22.4	< 7	0.079	6.8	161.8	121
Cu alone	< 12	42.7	< 7	0.253	6.8	72.7	91
Cu alone	< 12	67.2	< 7	0.601	6.8	88.8	98
Cu alone	< 12	85.5	< 7	0.960	6.8	20.5	42
Cu alone	< 12	104.5	< 7	1.410	6.8	28.6	55
Cu alone	< 12	128.2	< 7	2.053	6.8	8.0	6
Cu alone	< 12	170.9	< 7	3.367	6.8	9.8	14
Ni/Cu	1089	14.2	640	0.057	6.9	66.8	87
Ni/Cu	545	28.5	320	0.146	7.0	65.0	85
Ni/Cu	817	21.4	480	0.098	7.0	69.5	88
Ni/Cu	2178	28.5	1289	0.196	7.0	32.9	59
Ni/Cu	1089	57.0	645	0.525	7.0	127.7	111
Ni/Cu	1634	42.7	967	0.348	6.9	19.4	39
Ni/Cu	3267	42.7	1940	0.413	6.9	23.2	46
Ni/Cu	1634	85.5	971	1.116	6.9	20.0	41
Ni/Cu	2450	64.1	1456	0.734	6.9	14.8	29
Ni/Cu	4356	57.0	2592	0.694	6.9	22.4	45
Ni/Cu	2178	113.9	1298	1.865	6.9	7.7	4
Ni/Cu	3267	85.5	1946	1.231	7.0	9.1	10
Ni/Cu	5445	71.2	3245	1.029	7.0	7.4	2
Ni/Cu	2723	142.4	1624	2.722	7.0	7.8	4
Ni/Cu	4084	106.8	2435	1.812	7.0	7.0	0

* Method detection limit

Table SI.20: Cu/Pb toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Treatment	[Cu] (nM)	[Pb] (nM)	[Cu ²⁺] (nM)	[Pb ²⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	7.3	< 2*	0.012	< 0.08	9.0	153.4	99
Ctrl2	4.5	< 2	0.005	< 0.08	8.7	244.0	116
Ctrl3	3.9	< 2	0.004	< 0.08	8.7	133.8	95
Ctrl4	4.3	< 2	0.005	< 0.08	8.7	159.5	102
Ctrl5	5.7	< 2	0.008	< 0.08	8.7	128.1	94
Ctrl6	5.5	< 2	0.008	< 0.08	8.7	172.4	104
Ctrl7	6.7	< 2	0.01	< 0.08	8.7	135.5	96
Ctrl8	6.9	< 2	0.011	< 0.08	8.7	127.4	94
Pb alone	5.8	15.5	0.008	0.618	8.1	150.7	102
Pb alone	8	33.0	0.014	1.366	8.1	93.6	85
Pb alone	6.7	65.2	0.010	2.834	8.1	24.1	38
Pb alone	6.1	102.6	0.009	4.650	8.1	37.9	54
Pb alone	< 3.0	149.3	< 0.0026	7.052	8.2	21.3	33
Pb alone	6.7	251.6	0.010	12.683	8.2	12.6	15
Pb alone	7.6	372.0	0.013	19.808	8.2	12.8	15
Cu alone	22.4	< 2	0.079	< 0.08	8.2	163.1	104
Cu alone	42.7	< 2	0.253	< 0.08	8.3	177.4	107
Cu alone	67.2	< 2	0.601	< 0.08	8.3	194.2	110
Cu alone	85.5	< 2	0.960	< 0.08	8.3	77.8	78
Cu alone	104.5	< 2	1.410	< 0.08	8.3	75.0	77
Cu alone	128.2	< 2	2.053	< 0.08	8.4	59.4	68
Cu alone	170.9	< 2	3.367	< 0.08	8.4	25.1	38
Pb/Cu	28.5	19.3	0.126	0.878	8.4	174.2	106
Pb/Cu	14.2	41.2	0.040	1.860	8.4	142.6	99
Pb/Cu	21.4	30.0	0.078	1.361	8.4	123.0	94
Pb/Cu	57.0	41.2	0.465	2.010	8.5	189.4	108
Pb/Cu	28.5	91.2	0.144	4.402	8.5	64.5	71
Pb/Cu	42.7	65.2	0.283	3.164	8.5	94.9	84
Pb/Cu	85.5	65.2	1.033	3.346	8.4	69.1	73
Pb/Cu	42.7	149.3	0.321	7.633	8.4	36.7	52
Pb/Cu	64.1	105.0	0.632	5.382	8.4	55.8	66
Pb/Cu	113.9	91.2	1.787	4.867	6.4	12.0	22
Pb/Cu	57.0	215.5	0.578	11.562	6.4	12.7	24
Pb/Cu	85.5	149.3	1.118	8.000	6.4	25.8	49
Pb/Cu	142.4	119.3	2.670	6.560	6.4	8.5	10
Pb/Cu	71.2	289.7	0.911	16.182	6.4	12.5	24
Pb/Cu	106.8	198.2	1.718	11.000	6.4	21.8	43

* Method detection limit

Table SI.21: Cu/Zn toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Treatment	[Cu] (nM)	[Zn] (nM)	[Cu ²⁺] (nM)	[Zn ²⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	8.7	130	0.016	69	7.5	53.0	87
Ctrl2	4.2	80	0.005	42	7.4	102.7	117
Ctrl3	5.8	127	0.008	67	7.5	62.5	94
Ctrl4	6.3	142	0.009	75	7.5	67.9	98
Ctrl5	9.3	119	0.018	63	7.6	53.6	87
Ctrl6	9.0	50	0.017	27	7.5	96.5	114
Ctrl7	4.4	105	0.005	56	7.7	80.7	105
Ctrl8	3.3	106	0.003	56	7.8	70.1	98
Cu alone	25.4	82	0.109	43	7.9	95.8	111
Cu alone	49.8	47	0.361	25	8.6	150.7	128
Cu alone	61.7	<45*	0.539	< 24	7.9	73.8	99
Cu alone	73.4	68	0.747	36	7.9	53.8	85
Cu alone	84.9	123	0.982	65	7.9	12.6	20
Cu alone	96.1	73	1.240	39	8.0	25.3	51
Cu alone	117.9	141	1.802	75	8.0	13.0	22
Zn alone	4.4	3135	0.005	1657	7.8	66.6	96
Zn alone	6.9	3746	0.011	1990	7.8	62.3	93
Zn alone	9.4	4266	0.018	2272	7.8	40.4	73
Zn alone	8.0	596	0.014	318	7.9	31.7	62
Zn alone	3.4	5122	0.003	2739	7.9	26.5	54
Zn alone	4.3	5505	0.005	2948	7.9	29.4	59
Zn alone	3.8	6070	0.004	3258	7.9	n.a.	n.a.
Cu/Zn	28.5	2527	0.311	1338	8.1	115.5	118
Cu/Zn	50.0	2527	0.696	1343	8.2	32.7	62
Cu/Zn	70.8	2605	1.153	1388	8.2	36.3	66
Cu/Zn	34.8	2836	0.436	1507	8.2	151.7	130
Cu/Zn	64.8	2866	1.055	1528	8.2	31.9	60
Cu/Zn	28.5	3768	0.369	2010	8.2	89.6	107
Cu/Zn	50.0	3768	0.798	2014	8.2	27.8	54
Cu/Zn	50.0	3692	0.798	1974	8.2	38.0	68
Cu/Zn	50.0	3692	0.798	1974	8.3	45.0	76
Cu/Zn	70.8	3768	1.292	2018	8.3	36.0	66
Cu/Zn	34.8	4471	0.528	2395	8.3	57.3	86
Cu/Zn	64.8	4611	1.221	2476	8.3	21.7	43
Cu/Zn	50.0	4856	0.883	2608	8.4	40.5	70
Cu/Zn	28.5	4856	0.418	2604	8.4	71.0	95
Cu/Zn	70.8	4956	1.408	2666	8.4	28.5	55

* Method detection limit

Table SI.22: Ni/Pb toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Treatment	[Ni] (nM)	[Pb] (nM)	[Ni ²⁺] (nM)	[Pb ²⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	< 12*	< 2*	< 7	< 0.08	7.02	74.2	109
Ctrl2	< 12	< 2	< 7	< 0.08	7.02	32.4	71
Ctrl3	< 12	< 2	< 7	< 0.08	7.00	100.8	123
Ctrl4	< 12	< 2	< 7	< 0.08	7.02	76.4	110
Ctrl5	< 12	< 2	< 7	< 0.08	7.02	74.7	109
Ctrl6	< 12	< 2	< 7	< 0.08	7.00	42.7	83
Ctrl7	< 12	< 2	< 7	< 0.08	7.04	68.3	105
Ni alone	817	< 2	476	< 0.08	7.02	51.4	92
Ni alone	1634	< 2	960	< 0.08	7.02	69.6	106
Ni alone	2450	< 2	1444	< 0.08	7.04	33.8	72
Ni alone	3267	< 2	1930	< 0.08	7.04	20.2	49
Ni alone	4084	< 2	2417	< 0.08	7.02	21.1	51
Ni alone	4901	< 2	2904	< 0.08	7.02	13.4	30
Ni alone	6534	< 2	3880	< 0.08	7.04	7.0	0
Pb alone	< 12	15.5	< 7	0.62	7.02	64.1	102
Pb alone	< 12	33.0	< 7	1.37	7.04	46.6	87
Pb alone	< 12	65.2	< 7	2.83	7.04	27.6	63
Pb alone	< 12	102.6	< 7	4.65	7.04	33.5	72
Pb alone	< 12	149.3	< 7	7.05	7.02	21.4	52
Pb alone	< 12	251.6	< 7	12.68	7.00	11.2	22
Pb alone	< 12	372.0	< 7	19.81	7.02	9.2	13
Ni/Pb	1089	19.3	638	0.87	7.08	54.7	94
Ni/Pb	545	41.2	317	1.84	7.1	54.4	94
Ni/Pb	817	30.0	477	1.34	7.1	35.5	74
Ni/Pb	2178	41.2	1284	1.95	7.1	26.2	60
Ni/Pb	1089	91.2	639	4.34	7.12	16.1	38
Ni/Pb	1634	65.2	961	3.10	7.12	17.8	42
Ni/Pb	3267	65.2	1933	3.20	7.12	17.3	41
Ni/Pb	1634	149.3	963	7.47	7.1	14.2	32
Ni/Pb	2450	105.0	1448	5.20	7.1	20	48
Ni/Pb	4356	91.2	2583	4.61	7.1	14.2	32
Ni/Pb	2178	215.5	1288	11.24	7.08	12.7	27
Ni/Pb	3267	149.3	1935	7.67	7.06	15.7	37
Ni/Pb	5445	119.3	3234	6.19	7.04	8	6
Ni/Pb	2723	289.7	1614	15.68	7.04	9.6	14
Ni/Pb	4084	198.2	2423	10.51	7.02	7.0	0

* Method detection limit

Table SI.23: Ni/Zn toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Treatment	[Ni] (nM)	[Zn] (nM)	[Ni ²⁺] (nM)	[Zn ²⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	< 12*	144	< 7	71	7.0	80.0	93
Ctrl2	< 12	56	< 7	27	6.9	107.5	105
Ctrl3	< 12	125	< 7	61	6.8	106.3	105
Ctrl4	< 12	< 45	< 7	< 22	6.8	76.3	92
Ctrl5	< 12	102	< 7	50	6.8	112.0	107
Ctrl6	< 12	111	< 7	54	6.8	100.0	103
Ctrl7	< 12	< 45*	< 7	< 22	6.8	79.8	94
Ni alone	817	89	476	44	6.9	95.5	101
Ni alone	1634	86	959	42	6.9	74.3	91
Ni alone	2450	95	1444	47	6.9	49.8	76
Ni alone	3267	100	1930	49	6.9	25.8	51
Ni alone	4084	< 45	2417	< 22	6.9	14.4	28
Ni alone	4901	150	2904	74	6.9	30.2	57
Ni alone	6534	107	3880	52	6.9	7.3	2
Zn alone	< 12	1654	< 7	818	6.9	114.3	107
Zn alone	< 12	2268	< 7	1240	6.9	115.7	108
Zn alone	< 12	3118	< 7	1665	6.8	69.0	88
Zn alone	< 12	4016	< 7	2092	6.8	69.2	89
Zn alone	< 12	4772	< 7	2520	6.8	38.5	66
Zn alone	< 12	5843	< 7	3165	6.8	48.8	75
Zn alone	< 12	7071	< 7	3813	6.8	17.9	37
Ni/Zn	1056	756	623	406	7.1	123.8	110
Ni/Zn	511	1543	302	821	7.1	146.0	116
Ni/Zn	835	1150	493	613	7.1	103.5	103
Ni/Zn	2181	1559	1287	826	7.1	57.1	80
Ni/Zn	1107	3165	653	1669	7.1	85.4	95
Ni/Zn	1687	2283	995	1246	7.1	77.8	92
Ni/Zn	3288	2346	1940	1250	7.1	8.6	7
Ni/Zn	1652	4693	975	2525	7.1	32.1	58
Ni/Zn	2385	3512	1407	1886	7.2	91.9	98
Ni/Zn	4361	3102	2573	1677	7.2	14.6	27
Ni/Zn	2181	6236	1287	3387	7.2	11.1	17
Ni/Zn	3237	4630	1910	2530	7.2	28.1	52
Ni/Zn	5554	4000	3277	2106	7.1	12.4	21
Ni/Zn	2743	7953	1618	4253	7.1	7.1	0
Ni/Zn	4089	5969	2412	3176	7.1	16.8	33

* Method detection limit

Table SI.24: Zn/Pb toxicity test data: Average dissolved metal concentration, WHAM-calculated free ion concentrations, initial and final snail wet weight and relative growth rate.

Treatment	[Pb] (nM)	[Zn] (nM)	[Pb ²⁺] (nM)	[Zn ²⁺] (nM)	Initial wt (mg)	Final wt (mg)	RGR (%)
Ctrl1	< 2*	< 45*	< 0.08	< 23	6.9	112.8	106
Ctrl2	< 2	107	< 0.08	55	6.9	75.3	91
Ctrl3	< 2	< 45	< 0.08	< 23	6.9	84.4	95
Ctrl4	< 2	93	< 0.08	48	6.9	87.5	97
Ctrl5	< 2	133	< 0.08	68	6.9	110.9	106
Ctrl6	< 2	52	< 0.08	27	6.9	88.6	97
Ctrl7	< 2	80	< 0.08	41	6.9	122.2	110
Ctrl8	< 2	84	< 0.08	43	6.9	89.1	98
Pb alone	20.1	167	1.26	86	7.0	44.4	70
Pb alone	29.4	122	1.83	63	7.0	70.6	88
Pb alone	43.0	145	2.65	75	7.0	51.2	76
Pb alone	68.1	184	4.12	95	7.0	44.2	70
Pb alone	95.4	116	5.66	60	7.0	41.4	68
Pb alone	124.9	200	7.26	103	7.0	28.0	53
Pb alone	193.4	79	10.74	41	7.0	24.3	48
Zn alone	< 2	2605	< 0.08	1372	7.0	75.0	91
Zn alone	< 2	3670	< 0.08	1948	7.0	59.5	82
Zn alone	< 2	4434	< 0.08	2364	7.0	44.2	71
Zn alone	< 2	5210	< 0.08	2787	7.0	43.5	70
Zn alone	< 2	5810	< 0.08	3115	7.0	25.4	49
Zn alone	< 2	6728	< 0.08	3618	7.0	31.7	58
Zn alone	< 2	7815	< 0.08	4216	7.0	12.1	21
Pb/Zn	6.0	1737	0.52	906	6.9	84.2	96
Pb/Zn	12.9	868	0.99	445	6.9	76.4	92
Pb/Zn	9.4	1302	0.76	675	6.9	77.6	92
Pb/Zn	12.9	3473	1.13	1842	7.0	79.9	93
Pb/Zn	27.5	1737	2.12	907	7.0	75.7	91
Pb/Zn	20.1	2605	1.65	1373	6.9	77.2	92
Pb/Zn	20.1	5210	1.79	2789	6.9	22.7	45
Pb/Zn	43.0	2605	3.35	1375	6.9	39.1	66
Pb/Zn	31.3	3907	2.61	2080	6.9	35.8	63
Pb/Zn	27.5	6946	2.48	3741	6.9	20.9	42
Pb/Zn	59.5	3473	4.63	1846	6.9	22.6	45
Pb/Zn	43.0	5210	3.61	2791	7.0	17.2	34
Pb/Zn	35.1	8683	3.20	4698	7.0	12.8	23
Pb/Zn	77.0	4342	5.96	2320	7.0	38.4	65
Pb/Zn	55.3	6512	4.65	3505	7.0	17.5	35

* Method detection limit