Supplementary Information – SI

to

An analysis of catchment factors associated with heavy metal export into the Baltic Sea and Nature-Based Solutions aimed at its limitation

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Table SI1a. Loads of heavy metals entering the Baltic sea with riverine flows during the period 2012-2021. Data collected from HELCOM 2021a, 2021d, 2024

Country	Catchment area [km^2]	Heavy metal	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Average	Average
			[kg/km^2]	[kg/km^2]	[kg/km^2]	[kg/km^2]	[kg/km^2]	[kg/km^2]	[kg/km^2]	[kg/km^2]	[kg/km^2]	[kg/km^2]	[kg/km^2/year]	[t/year]
ES	45227	Cd	0.0197	0.001	0.0008	0.0008	0.0002	0.0079	0.0005	0.0009	0.0017	0.0037	0.00372	**0.17**
		Cr	0.116	0.01	0.007	0.018	0.001	0.023	0.009	0.017	0.029	0.063	0.029	**1.33**
		Cu	1.826	0.721	0.197	0.501	0.716	0.631	0.2	0.525	0.297	0.411	0.603	**27.25**
		Hg	0.0037	0.0009	0.0008	0.0136	0.0019	0.002	0.0006	0.0002	0.0006	0.0016	0.003	**0.12**
		Ni	0.504	0.158	0.113	0.156	0.284	0.242	0.134	0.32	0.274	0.228	0.241	**10.91**
		Pb	0.183	0.041	0.017	0.045	0.019	0.04	0.008	0.03	0.023	0.037	0.044	**2.00**
		Zn	2.77	0.41	0.25	2.61	4.4	1.4	0.32	1.74	1.99	1.55	1.744	**78.88**
FI	301250	Cd	0.0086	0.0056	0.0061	0.0086	0.0055	0.0052	0.004	0.0062	0.0094	0.0062	0.007	**1.97**
		Cr	0.401	0.293	0.247	0.396	0.229	0.215	0.185	0.189	0.293	0.224	0.267	**80.49**
		Cu	0.82	0.547	0.463	0.689	0.494	0.451	0.377	0.467	0.669	0.505	0.548	**165.15**
		Hg	0.0015	0.001	0.0011	0.0009	0.0006	0.0006	0.0005	0.0005	0.0009	0.0008	0.001	**0.25**
		Ni	1.024	0.653	0.734	1.099	0.783	0.734	0.533	0.726	1.054	0.713	0.805	**242.6**

		Pb	0.132	0.087	0.077	0.125	0.08	0.073	0.064	0.063	0.12	0.082	0.090	**27.2**
		Zn	2.6	1.55	1.81	2.65	1.83	1.61	1.35	1.82	2.71	1.84	1.977	**595.57**
		Cd	0.0048	0.0043	0.0014	0.0062	0.0025	0.004	0.0034	0.0018	0.0026	0.0025	0.003	**0.1**
		Cr	0.074	0.049	0.007	0.089	0.043	0.071	0.046	0.016	0.036	0.037	0.047	**1.36**
		Cu	0.403	0.305	0.134	0.58	0.223	0.328	0.371	0.112	0.159	0.193	0.281	**8.17**
DE	29090	Hg	0.0008	0.0014	0.0001	0.0023	0.0004	0.0005	0.0005	0.0001	0.0002	0.0003	0.001	**0.02**
		Ni	0.183	0.132	0.05	0.615	0.182	0.276	0.36	0.103	0.129	0.146	0.218	**6.33**
		Pb	0.08	0.042	0.015	0.019	0.018	0.035	0.033	0.013	0.034	0.026	0.032	**0.92**
		Zn	1.24	0.92	0.27	3.79	0.52	0.91	0.73	0.39	0.49	0.47	0.973	**28.3**
		Cd	0.0001	0.0002	0.0038	0.0061	0.0102	0.003	0.0066	0.0096	0.006	0.0004	0.005	**0.3**
		Cr	0.002	0.003	0.489	0.079	0.155	0.09	0.018	0.008	0.193	0.011	0.105	**6.77**
		Cu	0.011	0.009	0.456	0.643	0.871	0.993	0.659	0.653	0.683	0.035	0.501	**32.38**
LV	64589	Hg	0.0001	0.0002	0.0001	0.0001	0.0001	0.0097	0.0141	0.0125	0.0024	0.0001	0.004	**0.25**
		Ni	0.004	0.007	0.142	0.266	0.008	0.009	0.006	0.00006	0.00008	0.28	0.072	**4.66**
		Pb	0.003	0.002	0.123	0.077	0.489	0.619	0.337	0.319	0.38	0.021	0.237	**15.31**
		Zn	0.04	0.03	0.53	1.05	0.76	0.96	0.92	0.44	0.83	0.05	0.561	**36.23**
		Cd	no data	no data	0.0003	no data	no data	no data	no data	0.0106	no data	0.0232	0.011	**0.74**
LT	65200	Cr	0.163	0.17	no data	0.234	0.074	0.271	0.194	0.032	0.061	0.106	0.145	**9.45**
		Cu	0.446	0.658	0.001	0.486	0.402	0.803	0.972	0.359	0.317	0.296	0.474	**30.9**

		Hg	no data	0.001	no data	0.0008	0.0006	0.0023	no data	no data	no data	no data	0.001	**0.08**
		Ni	0.212	0.338	no data	0.296	0.338	0.444	0.275	0.12	0.186	0.824	0.337	**21.97**
		Pb	no data	0.002	0.007	0.486	0.19	0.486	0.006	0.04	0.042	0.194	0.161	**10.53**
		Zn	2.22	2.63	no data	4.58	0.76	1.61	9.19	0.09	0.02	0.84	2.438	**158.94**
		Cd	0.0009	0.0009	0.0022	0.0023	0.0015	0.0022	0.002	0.0025	0.0029	0.0012	0.002	**0.58**
		Cr	0.63	no data	no data	0.067	0.088	0.045	0.014	0.014	0.014	no data	0.125	**38.74**
		Cu	0.486	0.369	0.257	0.132	0.177	0.253	0.183	0.167	0.23	no data	0.250	**77.89**
PL	311000	Hg	0.001	0.0023	0.0004	0.0013	0.0001	0.0001	0.0003	0.0002	0.0008	0.0014	0.001	**0.25**
		Ni	0.112	0.273	0.178	0.171	0.184	0.257	0.171	0.171	0.217	0.285	0.202	**62.79**
		Pb	0.033	0.015	0.004	0.03	0.005	0.008	0.008	0.007	0.007	0.021	0.014	**4.29**
		Zn	0.41	0.39	0.08	0.47	0.2	0.28	0.17	0.2	0.43	no data	0.292	**90.88**
		Cd	0.0054	0.0033	0.0037	0.0048	0.0033	0.0039	0.0039	0.0033	0.0041	0.0035	0.004	**1.74**
		Cr	0.178	0.083	0.096	0.102	0.072	0.084	0.096	0.073	0.106	0.09	0.098	**43.38**
		Cu	0.677	0.451	0.506	0.487	0.383	0.378	0.315	0.291	0.372	0.359	0.422	**186.78**
SE	442700	Hg	0.0012	0.0007	0.0007	0.001	0.0007	0.0007	0.0007	0.0007	0.0009	0.0009	0.001	**0.36**
		Ni	0.387	0.228	0.25	0.279	0.222	0.216	0.23	0.216	0.277	0.247	0.255	**112.98**
		Pb	0.137	0.064	0.077	0.082	0.073	0.071	0.069	0.062	0.086	0.043	0.076	**33.82**
		Zn	2.1	1.16	1.25	1.53	1.09	1.03	1.03	0.97	1.25	1.12	1.253	**554.7**

Table SI1b. Loads of heavy metals entering the Baltic sea from direct point sources during the period 2012-2021. Data collected from HELCOM 2021a, 2024

Country	Heavy metal	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Average
		[t]	[t]	[t]	[t]	[t]	[t]	[t]	[t]	[t]	[t]	[t/year]
DE	Cd	0.013	0.013	0.014	0.014	0.013	0.014	0.012	no data	no data	no data	**0.01**
	Cr	0.321	0.307	0.332	0.352	0.328	0.342	0.304	no data	no data	no data	**0.33**
	Cu	0.81	0.842	0.839	0.888	0.827	0.856	0.764	no data	no data	no data	**0.83**
	Hg	0.021	0.02	0.022	0.023	0.021	0.022	0.02	no data	no data	no data	**0.02**
	Ni	1.31	1.24	1.36	1.44	1.34	1.4	1.24	no data	no data	no data	**1.33**
	Pb	0.776	0.736	0.805	0.853	0.794	0.828	0.737	no data	no data	no data	**0.79**
	Zn	10.7	10.2	11.1	11.7	10.9	11.4	10.1	no data	no data	no data	**10.87**
ES	Cd	no data	no data	0.002	0.002	0.002	0.016	0.015	0.014	0.009	0.012	**0.01**
	Cr	0.145	0.085	0.091	0.015	0.004	0.058	0.054	0.057	0.048	0.043	**0.06**
	Cu	0.6	0.42	0.13	0.19	0.18	0.25	0.26	0.357	0.457	0.496	**0.33**
	Hg	0.0002	no data	0.00005	no data	0.0003	0.00005	0.0001	0.0001	0.0001	0.0001	**0.0001**
	Ni	0.33	0.31	0.24	0.22	0.16	0.22	0.23	0.275	0.257	0.186	**0.24**
	Pb	no data	no data	0.004	0.006	0.002	0.032	0.02	0.029	0.02	0.028	**0.02**

	Zn	1.3	0.9	0.7	no data	no data	2	2	2.3	2.24	4.38	**1.98**
FI	Cd	0.08	0.104	0.109	0.098	0.08	0.091	0.093	0.079	0.059	0.064	**0.09**
	Cr	1.652	2.723	2.734	1.996	2.3	2	1.988	1.84	1.8	1.52	**2.06**
	Cu	3	4.36	3.78	3.34	4.54	3.9	3.41	3.62	2.81	3.89	**3.67**
	Hg	0.04	0.036	0.041	0.035	0.012	0.012	0.008	0.0147	0.0172	0.0183	**0.02**
	Ni	4.6	4.11	4.51	4.21	4.1	2.76	3.07	3.66	3.45	4.8	**3.93**
	Pb	0.96	0.63	0.36	0.55	0.25	0.16	0.2	0.183	0.165	0.255	**0.37**
	Zn	26.6	31.6	26.4	21.7	19.9	26.6	25.2	19.3	10.2	10.3	**21.78**
DE	Cd	0.011	0.0003	0.0003	0.052	0.0004	0.004	0.001	0.004	0.004	0.004	**0.01**
	Cr	0.101	0.019	0.026	1.653	0.018	0.169	0.161	0.189	0.157	0.15	**0.26**
	Cu	0.371	0.105	0.123	7.51	0.179	0.644	0.645	0.578	0.623	0.576	**1.14**
	Hg	0.0002	0.0002	0.0002	0.038	0.0002	0.0004	0.0007	0.0009	0.0004	0.0004	**0.00**
	Ni	0.25	0.08	0.17	10.32	0.24	0.43	0.38	0.398	0.354	0.328	**1.30**
	Pb	0.011	0.002	0.004	0.014	0.002	0.014	0.015	0.015	0.018	0.022	**0.01**
	Zn	0.8	0.4	0.4	75.2	no data	3.2	3.1	3.03	3.11	2.99	**10.25**
LV	Cd	0.006	0.015	0.008	0.01	0.03	0.03	0.075	0.027	0.024	0.028	**0.03**
	Cr	0.112	0.189	0.19	0.121	0.119	0.216	0.176	0.165	0.209	0.25	**0.17**
	Cu	0.7	0.57	1.01	0.37	0.39	0.42	0.42	0.433	0.824	0.292	**0.54**
	Hg	0.007	0.012	0.005	0.005	0.006	0.006	0.023	0.0073	0.0071	0.0039	**0.01**

	Ni	0.27	0.48	0.35	0.54	0.51	0.56	0.41	0.368	0.722	0.466	**0.47**
	Pb	0.22	0.14	0.1	0.09	0.18	0.75	0.22	0.169	0.184	0.137	**0.22**
	Zn	2.9	2.1	2.9	2.1	0.8	1.4	2.6	0.848	1.03	1.44	**1.81**
LT	Cd	no data	no data	0	no data	no data	no data	no data	no data	no data	0.001	**0.001**
	Cr	0.033	0.04	0.005	0.001	0.002	0.001	no data	0.005	0.001	0.001	**0.01**
	Cu	0.133	0.143	0.033	0.013	0.011	0.013	0.008	0.013	0.017	0.012	**0.04**
	Hg	0.002	0.0004	0.001	0.0009	0.0007	0.0002	0.0006	0.0003	0.0007	0.0005	**0.00**
	Ni	0.023	0.021	0	0.007	0.008	0.01	0.009	0.017	0.009	0.001	**0.01**
	Pb	0.004	0.08	0.002	0.001	0.001	0.001	0.001	0.002	0.002	0.001	**0.01**
	Zn	0.338	0.418	0.108	0.065	0.065	0.112	0.089	0.145	0.091	0.09	**0.15**
PL	Cd	0.006	0.055	0.002	0.01	0.0002	0.003	0.022	0.01	0.001	0.001	**0.01**
	Cr	0.03	0.15	0.11	0.123	0.133	0.055	0.011	0.004	0.202	0.063	**0.09**
	Cu	0.12	0.54	0.24	0.21	0.03	0.25	0.69	0.086	0.451	0.539	**0.32**
	Hg	0.0006	0.406	0.005	0.034	0.00000005	0.003	0.00002	0.0002	0.0001	0.0001	**0.04**
	Ni	0.13	0.24	0.28	0.26	0.21	0.3	0.06	0.043	1.595	0.391	**0.35**
	Pb	0.06	0.08	0.03	0.07	0.01	0.02	0.0006	0.002	0.173	0.002	**0.04**
	Zn	27.3	3.6	2.9	2.8	3.1	3.3	3.5	1.7	2.89	2.44	**5.35**
SE	Cd	0.022	0.018	0.016	0.343	0.352	0.323	0.338	0.432	0.357	0.292	**0.25**
	Cr	0.47	0.47	0.391	1.146	1.113	1.207	1.721	1.6	1.55	1.61	**1.13**

Cu	5.46	5.96	5.68	8.17	8.07	8.78	8.95	11.9	10.20	11.00	**8.42**
Hg	0.023	0.022	0.023	0.04	0.035	0.035	0.032	0.114	0.034	0.039	**0.04**
Ni	2.89	2.57	2.7	3.67	3.75	4.31	4.41	8.53	4.06	4.7	**4.16**
Pb	0.19	0.19	0.17	1.15	1.06	1.04	1.21	1.45	1.19	1.1	**0.88**
Zn	13.6	12.8	14.8	58	59.3	59	54.3	84.1	50.7	52.1	**45.87**

Table SI2. Demographic and socio-economic data characterizing individual countries of the Baltic Sea catchment area in 2012-2015

Parameter	Unit	Country	Country area [km^2]	2012	2013	2014	2015	References
aquaculture production	t	Denmark	43100	34000	32000	34000	35990	EUROSTAT, 2015b; 2016b; 2017b
		Estonia	45100	1000	1000	1000	798	
		Finland	338400	13000	14000	13000	14879	
		Lithuania	65300	3000	4000	3000	4083	
		Latvia	64600	1000	1000	1000	863	
		Deutchland	357100	27000	25000	26000	26867	
		Poland	312700	33000	no data	36000	33560	
		Sweden	450300	14000	13000	13000	12277	

cereal production	t	Denmark	43100	9460000	9051000	9764000	10023000	EUROSTAT, 2013b; 2014; 2015b; 2016b
		Estonia	45100	994000	876000	1222000	1535000	
		Finland	338400	3687000	4148000	4157000	3683000	
		Lithuania	65300	4657000	4459000	5123000	6067000	
		Latvia	64600	2125000	1949000	2227000	3022000	
		Deutchland	357100	45397000	47757000	52010000	48918000	
		Poland	312700	28544000	28377000	31951000	28003000	
		Sweden	450300	5106000	4994000	5790000	6169000	
municipal waste	t/inhabitat	Denmark	43100	no data	0.747	0.759	0.789	EUROSTAT, 2015a; 2016a; 2017a
		Estonia	45100	no data	0.293	0.357	0.359	
		Finland	338400	no data	0.493	0.482	0.5	
		Lithuania	65300	no data	0.433	0.433	0.448	
		Latvia	64600	no data	0.312	0.281	0.433	
		Deutchland	357100	no data	0.617	0.618	0.625	
		Poland	312700	no data	0.297	0.272	0.286	
		Sweden	450300	no data	0.458	0.438	0.447	
consumption of nitrogen	t	Denmark	43100	187200	193700	187000	203600	EUROSTAT, 2017b
		Estonia	45100	33000	33700	35800	35800	

fertilizers by agriculture		Finland	338400	138900	138100	147400	143500	
		Lithuania	65300	150000	155000	162000	166600	
		Latvia	64600	65200	69700	72900	75800	
		Deutchland	357100	1640400	1648800	1675300	1822800	
		Poland	312700	1094700	1194800	1098500	1003600	
		Sweden	450300	148100	161100	181100	190200	
consumption of phosphate fertilizers by agriculture	t	Denmark	43100	10000	13600	14000	14400	EUROSTAT, 2017b
		Estonia	45100	3000	3100	3800	3700	
		Finland	338400	10600	11200	11800	11000	
		Lithuania	65300	17000	18200	19400	19800	
		Latvia	64600	8600	10700	10200	10600	
		Deutchland	357100	107900	124100	124000	131500	
		Poland	312700	161900	198300	148900	132500	
		Sweden	450300	10400	11800	12100	12500	
number of trucks and road tractors	Numer of cars/1000 inhabitats	Denmark	43100	no data	no data	no data	no data	EUROSTAT, 2018
		Estonia	45100	66	70	73	77	
		Finland	338400	96	no data	101	104	
		Lithuania	65300	46	48	34	35	

	Latvia	64600	37	46	42	43	
	Deutchland	357100	34	35	no data	no data	
	Poland	312700	83	85	88	90	
	Sweden	450300	58	59	60	61	
number of cattle	Denmark	43100	no data	1580000	968000	1600000	HELCOM, 2019; EUROSTAT. 2014; 2016b
	Estonia	45100	no data	260000	242000	300000	
	Finland	338400	no data	900000	847000	900000	
	Lithuania	65300	no data	710000	605000	700000	
	Latvia	64600	no data	410000	605000	400000	
	Deutchland	357100	no data	12690000	1573000	12600000	
	Poland	312700	no data	5590000	5445000	5800000	
	Sweden	450300	no data	1440000	1452000	1400000	
number of pigs	Denmark	43100	no data	12400000	10152000	12700000	HELCOM, 2019; EUROSTAT. 2014. 2016b
	Estonia	45100	no data	360000	282000	300000	
	Finland	338400	no data	1260000	1128000	1200000	
	Lithuania	65300	no data	750000	846000	700000	
	Latvia	64600	no data	370000	282000	300000	
	Deutchland	357100	no data	28050000	2256000	27700000	

		Poland	312700	no data	10990000	10998000	10600000	
		Sweden	450300	no data	1480000	1410000	1400000	
beef	t	Denmark	43100	125400	125200	125600	120600	EUROSTAT, 2013b; 2014; 2015b; 2016b
		Estonia	45100	7200	7600	8900	9600	
		Finland	338400	80400	80400	82300	85800	
		Lithuania	65300	39900	36800	39100	44100	
		Latvia	64600	16400	15700	17000	17400	
		Deutchland	357100	1140000	1106000	1128000	1124000	
		Poland	312700	371000	339000	412700	471000	
		Sweden	450300	135300	135700	142000	144000	
poultry	t	Denmark	43100	148800	160300	143000	134400	EUROSTAT, 2013b; 2014; 2015b; 2016b
		Estonia	45100	no data	no data	no data	no data	
		Finland	338400	107400	111100	113400	117300	
		Lithuania	65300	81800	89800	93300	95800	
		Latvia	64600	24500	26700	28600	29500	
		Deutchland	357100	1428000	1456000	1527000	1511000	
		Poland	312700	1548800	1652000	1804100	2011000	
		Sweden	450300	116300	124800	133700	145800	

pork	t	Denmark	43100	1603700	1589400	1587400	1598700	EUROSTAT, 2013b; 2014; 2015b; 2016b
		Estonia	45100	33400	34600	40600	42400	
		Finland	338400	192800	194500	186100	191900	
		Lithuania	65300	58900	67000	66500	66200	
		Latvia	64600	24000	26200	28200	29300	
		Deutchland	357100	5459000	5474000	5507000	5562000	
		Poland	312700	1695200	1684300	1838500	1906100	
		Sweden	450300	233000	234100	236200	233500	
mutton	t	Denmark	43100	1700	1600	1700	1800	EUROSTAT, 2013b; 2014; 2015b; 2016b
		Estonia	45100	100	100	100	100	
		Finland	338400	900	900	1000	1200	
		Lithuania	65300	100	100	100	100	
		Latvia	64600	300	200	200	300	
		Deutchland	357100	22000	20000	19000	21000	
		Poland	312700	700	600	600	600	
		Sweden	450300	5000	4900	5100	5100	

Table SI3. Values obtained for discriminant analysis

Heavy metal	LD1	LD2
Cd	83.6	-114.5
Pb	8.7	12.5
Hg	713.1	1032.5
Cu	7.1	-11.0
Cr	-0.19	-17.0
Ni	2.7	6.9
Zn	0.52	0.005

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