

# The Estimation of the Wastewater Generation and Pollution Load by the Branches of Industry

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## Introduction

Statistical Office of Estonia conducted a small study with the aim to improve the quality of the data delivered by the Joint OECD/Eurostat Questionnaire on Inland Waters from Estonia, and particularly on the table 7 and 3.2 on wastewater treatment and also on discharged wastewater volumes and wastewater pollutant loads.

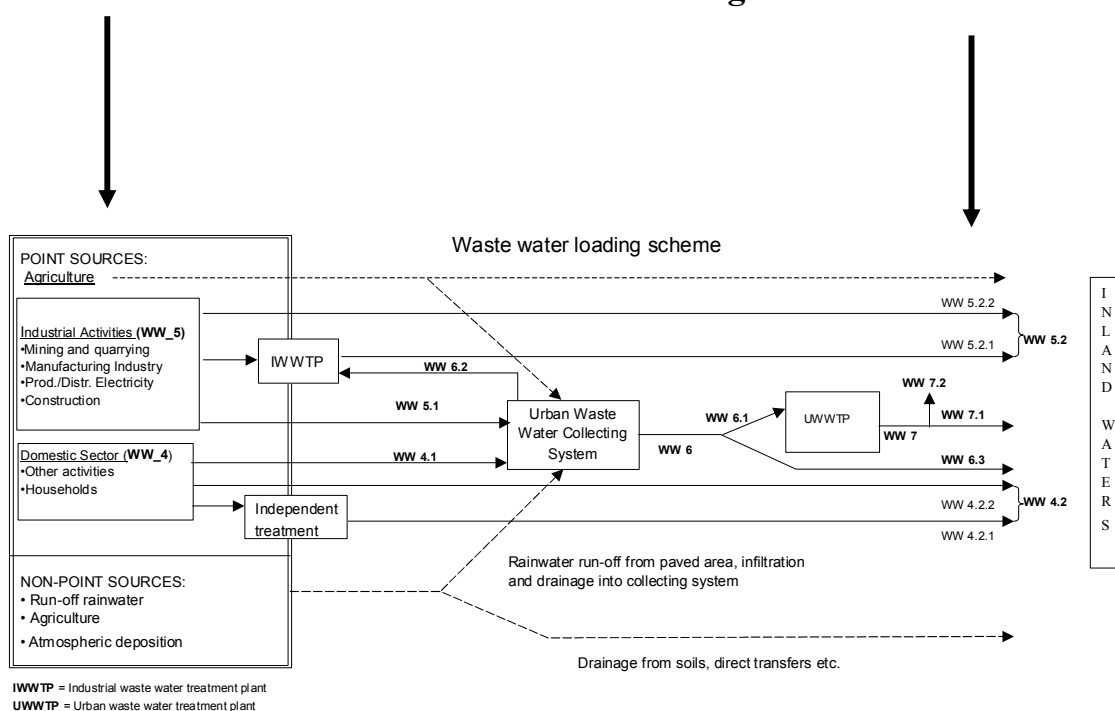
As practically no information existed on wastewater loads generated by the branches of industry in Estonia, the estimations of the wastewater generation on the level of industry groups were made. Factors based on economic indicators were developed and used for the estimation of missing data on wastewater discharge quantities.

As a starting point, the data about wastewater generation were readily available only for the enterprises that discharged wastewater directly to environment (and possessed discharge consent). For others, which deliver their wastewater to wastewater treatment plants, practically no relevant information existed. The survey was carried out to enterprises, which deliver their wastewater to wastewater treatment plants with the focus to identify their water consumption and discharge. As a result the detailed water consumption data on enterprise level were obtained. Data obtained by this survey were used as a starting point for combining economic data with data on water management.

The estimation of pollution (P, N, BOD, suspended solids) of industrial wastewater was performed in two locations of the flow: generation and discharge to environment:

## Generation

## Discharge to environment



The estimations for industry groups (NACE 2-digit grouping level) were made for following parameters: volume, BOD, N, P, suspended solids. The estimations were based on water use data and statistical databases available in Statistical Office (production statistics, environmental expenditure statistics) and Estonian Environment Information Centre of the Ministry of the Environment of Estonia (Wastewater inflow part of the database of wastewater treatment plants reports).

## Wastewater factors

In order to reach full coverage of industrial sector on NACE 2 digit level on water use (by purpose types) and wastewater generation the factors were developed. Wastewater factors should be understood as the ratio between the amount of generated wastewater in m<sup>3</sup> d and net sales in kroons for given branch.

As a first step the quantity relationship between the water use and wastewater generation on NACE 2 digit level were figured out.

Factors based on economic indicators were developed and used for the estimation of wastewater discharge quantities. The estimation of wastewater discharge quantities was based on net sales values. Wastewater factors were calculated according to the formula:

$$F_{ww} = W_t/S$$

Where:

F<sub>ww</sub> — wastewater factor

W<sub>t</sub> — total quantity of wastewater generated

S — total net sale

On the bases of data of enterprises included in Statistical Office survey, the wastewater factors for NACE categories on 2 or 3 digit levels were calculated.

$$F_{ww} = \frac{\sum_{i=1}^n W_{t,i}}{\sum_{i=1}^n S_{i}}$$

Where:

W<sub>t</sub> — total quantity of wastewater generated by i enterprise,

S<sub>i</sub> — total net sale of i enterprise,

N — number of enterprises in given NACE category

For each economic activity group wastewater quantities were summed from the three categories of data: Wastewater quantities on the bases of EEIC database on water use and discharge, Statistical Office survey results and the estimations of missing wastewater quantities based on monetary factor. Details on total estimated quantities of wastewater generated in each NACE category in 2001 are presented in Table 1.

## **Why the factors could not be developed from the basis of enterprises with pollution permission**

For comparison wastewater factors on economic activity level were also calculated just on the basis of the data of enterprise who possessed a discharge consent. The number of such enterprises is low: in several economic activities only few enterprises were possessing pollution consents and some economic activities were not represented at all.

Wastewater factors of enterprises with water permits are 10 times higher than the ones without water permits inside the same economic activity. So, the wastewater quantities could have been heavily overestimated if the factors of the permit owners would have been used for the wastewater generation estimation. So, the reliability of the factors developed from the basis of the data of enterprises having water permits is lower.

Another reason is that quite often these enterprises have unique production type inside NACE category and the estimations based on these enterprises data cannot be applied on other enterprises in this economic category.

For example inside economic activity production of paper and products of paper (NACE category 21), only 2 enterprises produce paper from pulp or recycled paper. These are also the only 2 enterprises with water permits. Other enterprises in the same economic activity (NACE category 21) do not possess water permits and they have completely different production profile as they are producing paper products out of paper. So, the factors derived from the data of the paper mills are not suitable for the estimation of the wastewater production of the paper products fabricators.

Another economic activity with big variability is production of chemicals and chemical products (NACE 24), where one enterprise (big wastewater generation and low net sales) is distorting the picture. The majority of enterprises does not have water permits and produce mainly cosmetics and other domestic chemicals.

Comparison of wastewater factors derived from the data of enterprises with and without water permits is outlined in Table 2.

## **The estimation of the pollution load reaching the environment by source industry groups**

No factors for pollution loads (BOD, N, P, suspended solids) were calculated on economic activities level, because pollution load estimations were based on the quantities of generated wastewater. In fact they would have been the same factors multiplied with average pollution load of wastewater.

The “upside down” approach (i.e. the estimation of the share of every economic activity in total number) was used for the estimation of the share of different NACE categories in the pollution load (N, P, BOD, suspended solids) released into environment by wastewater

The following presumptions were made:

1. All wastewater discharged into environment has the same (average) load of pollutants.
2. Share of pollutants originated from different NACE categories is proportional to the quantity of generated wastewater.

Load of the following pollutants in wastewater was estimated: BOD<sub>7</sub>, suspended solids, total N and total P. These are the most common pollutants for which data were collected and total quantities of these pollutant released into environment with wastewater was known.

Quantities of pollutants in wastewater originating from different NACE categories are presented in Table 3.

### **The estimation of the pollution load generated by industry groups**

Estimations were made on the basis of the influents flows to WWTP. In order to find out the industry wastewater, wastewater generated by households was subtracted from the total wastewater. The basis for the calculation was the expert opinion that in Estonia 1 inhabitant uses as average 127 litres water per day and produces the same quantity of wastewater.

The assumption was made that the nutrients load of households and industry wastewater does not differ drastically and thus the quantities of pollutants were divided between population and industry proportionally to the quantity of treated wastewater.

There are two types of WWTP-s which show different characteristics: URBAN-type WWTP and all other types (including industrial) of WWTP.

For the both types of WWTP's the average concentrations of pollution loads of the inflow were found. Next, the division between the quantities of pollutants in influent flow originating from industry and households was found. The estimated quantities of pollutants and wastewater volumes treated by both types of WWTP were summed. Next table outlines in right side the average pollution load of wastewater from industry and on the left side the division of total pollution between population and industry.

#### Quantities of pollutants in influent

Pollutant	Total influent	From population	From industry	Average pollution load of wastewater from industry per cubic metre
BOD <sub>7</sub> , tons	37 104	14 028	23 076	<b>318</b>
Suspended solids, tons	31 324	12 233	19 090	<b>263</b>
Total N, tons	7 356	2 858	4 497	<b>62</b>
Total P, tons	1 527	589	937	<b>13</b>
Wastewater treated, m <sup>3</sup>		46 558 349	72 561 204	

## **Estimation of the pollution generation by NACE categories**

In order to estimate the pollution load of wastewater generated by NACE categories the total estimated quantities of pollutants originated from industry were divided by NACE categories proportionally to the quantity of generated wastewater.

Following presumption was made:

- 1) Wastewater from all industry branches (NACE categories) has the same pollution load (estimated as described above)
- 2) Cooling wastewater wherever it is generated has the same pollution load (average concentration according to the inflow data of WWTP)
- 3) Sanitary wastewater from of all enterprises has the same pollution load (which was equalized to average concentration of the pollution load of URBAN-type of WWTP influent):

In the Table 4 the pollution load by the sources and categories of wastewater are outlined for the year 2001. Next, the pollution loads by categories of wastewater were summed in order to get the pollution loads by economical sectors. Table 5 outlines the results.

## **Conclusions**

Data about wastewater generation were available only for the enterprises, which discharged wastewater directly to environment (and were possessing a discharge consent). For other enterprises, which deliver their wastewater to wastewater treatment plants, practically no information existed on the quantities of wastewater generation and pollutions loads.

The estimations on the wastewater generation by industry on the NACE 2-digit grouping level were made for following parameters: volume, BOD, N, P, suspended solids. The estimations were based on water use data and statistical databases available in Statistical Office (production statistics, environmental expenditure statistics) and environmental Ministry (database of wastewater treatment facilities).

In order to reach full coverage of industrial sector on NACE 2digit level on water use (by purpose types) and wastewater generation the wastewater factors were developed. Wastewater factors were based on statistical survey data and connected amount of generated wastewater with economical data (net sales) of enterprises.

In addition the estimation of pollution load (P, N, BOD, suspended solids) of industrial wastewater by industry on the NACE 2-digit grouping level in two locations of the flow — generation and discharge to environment — was performed. The pollution loads estimations were made on bases of data from database of wastewater treatment facilities and estimated wastewater generation on the NACE 2-digit grouping level.

The result of the study could also provide the tool for forecasting of water supply demand based on industrial statistics and forecasting.

**Table 1. Generation of wastewater by NACE categories and by enterprise categories**

NACE	Enterprises having water permits	Statistical Office survey	Estimation according to Statistical Office survey	TOTAL
15	5 951 187	399389	17 723	<b>6 368 299</b>
17	2 204 552	53 126	8 052	<b>2 265 730</b>
18	371 625	108 957	11 996	<b>492 578</b>
19	55 870	47 992	1 758	<b>105 620</b>
20	1 198 840	108 990	14 164	<b>1 321 994</b>
21	8 034 998	18 118	101	<b>8 053 218</b>
221	0	8 196	9 868	<b>18 064</b>
222	0	51 827	103 427	<b>155 254</b>
23	529 500		0	<b>529 500</b>
24	1 779 739	2 022 925	68 646	<b>3 871 310</b>
25	15 662	34 661	1 877	<b>52 200</b>
26	981 228	66 894	2 388	<b>1 050 510</b>
27	0	7 092	1 376	<b>8 468</b>
28	20 059	221 006	24 287	<b>265 352</b>
29	49 237	84 567	9 762	<b>143 567</b>
30	0	659	450	<b>1 109</b>
31	0	29 137	12 742	<b>41 879</b>
32	0	106 058	6 769	<b>112 827</b>
33	36 417	85 772	12 446	<b>134 636</b>
34	0	33 742	235	<b>33 977</b>
35	74 800	4 186	3 140	<b>82 126</b>
36	421 219	76 870	17 968	<b>516 057</b>
<b>Total</b>	<b>21 724 935</b>	<b>3 570 164</b>	<b>329 176</b>	<b>25 624 275</b>

**Table 2. Wastewater factors derived from the data of enterprises with and without water permits**

Enterprises without water permits			Enterprises with water permits		
NACE	Number of enterprises	Wastewater factor of category	NACE	Number of enterprises	Wastewater factor of category
15	112	0.177		66	0.796
17	56	0.057		7	0.561
18	132	0.070		1	1.360
19	26	0.087		3	1.210
20	182	0.034		16	0.579
21	13	0.027		2	16.891
221	31	0.018		0	
222	31	0.511		0	
23	0			1	4.627
24	19	1.141		4	342.391
25	43	0.027		2	0.066
26	43	0.083		16	2.328
27	3	0.054		0	
28	132	0.092		2	0.042
29	53	0.081		4	0.323
30	2	0.005		0	
31	20	0.041		0	
32	19	0.092		0	
33	12	0.138		2	1.205
34	9	0.033		0	
35	10	0.064		2	0.394
36	87	0.050		13	0.295

**Table 3. Quantities of pollutants in wastewater originating from different NACE categories, tons**

NACE	BOD7			Suspended solids			Nitrogen			Phosphorus		
	Industrial and sanitary	cooling	total	Industrial and sanitary	cooling	total	Industrial and sanitary	cooling	total	Industrial and sanitary	cooling	Total
15	96.959	0.782	<b>97.741</b>	144.981	2.704	<b>147.685</b>	182.279	0.495	<b>182.774</b>	11.145	0.024	<b>11.169</b>
17	20.320	0.000	<b>20.320</b>	30.384	0.000	<b>30.384</b>	38.200	0.000	<b>38.200</b>	2.336	0.000	<b>2.336</b>
18	3.611	0.000	<b>3.611</b>	5.400	0.000	<b>5.400</b>	6.789	0.000	<b>6.789</b>	0.415	0.000	<b>0.415</b>
19	0.111	0.000	<b>0.111</b>	0.166	0.000	<b>0.166</b>	0.209	0.000	<b>0.209</b>	0.013	0.000	<b>0.013</b>
20	6.449	0.000	<b>6.449</b>	9.643	0.000	<b>9.643</b>	12.124	0.000	<b>12.124</b>	0.741	0.000	<b>0.741</b>
21	36.130	8.307	<b>44.436</b>	54.024	28.728	<b>82.751</b>	67.922	5.260	<b>73.182</b>	4.153	0.257	<b>4.410</b>
221	0.019	0.000	<b>0.019</b>	0.028	0.000	<b>0.028</b>	0.035	0.000	<b>0.035</b>	0.002	0.000	<b>0.002</b>
222	2.117	0.051	<b>2.168</b>	3.165	0.178	<b>3.343</b>	3.980	0.033	<b>4.012</b>	0.243	0.002	<b>0.245</b>
23	9.862	0.000	<b>9.862</b>	14.747	0.000	<b>14.747</b>	18.541	0.000	<b>18.541</b>	1.134	0.000	<b>1.134</b>
24	5.104	12.444	<b>17.548</b>	7.632	43.037	<b>50.669</b>	9.595	7.880	<b>17.475</b>	0.587	0.385	<b>0.972</b>
25	0.057	0.019	<b>0.075</b>	0.085	0.064	<b>0.149</b>	0.107	0.012	<b>0.119</b>	0.007	0.001	<b>0.007</b>
26	2.101	1.118	<b>3.218</b>	3.141	3.865	<b>7.006</b>	3.949	0.708	<b>4.657</b>	0.241	0.035	<b>0.276</b>
27	0.047	0.001	<b>0.048</b>	0.071	0.002	<b>0.073</b>	0.089	0.000	<b>0.089</b>	0.005	0.000	<b>0.005</b>
28	2.980	0.045	<b>3.024</b>	4.455	0.155	<b>4.610</b>	5.602	0.028	<b>5.630</b>	0.342	0.001	<b>0.344</b>
29	0.727	0.011	<b>0.738</b>	1.088	0.037	<b>1.125</b>	1.368	0.007	<b>1.374</b>	0.084	0.000	<b>0.084</b>
30	0.021	0.000	<b>0.021</b>	0.031	0.000	<b>0.031</b>	0.039	0.000	<b>0.039</b>	0.002	0.000	<b>0.002</b>
31	0.026	0.029	<b>0.055</b>	0.039	0.099	<b>0.138</b>	0.049	0.018	<b>0.067</b>	0.003	0.001	<b>0.004</b>
32	0.879	0.048	<b>0.927</b>	1.314	0.167	<b>1.481</b>	1.653	0.031	<b>1.683</b>	0.101	0.001	<b>0.103</b>
33	2.162	0.000	<b>2.162</b>	3.233	0.000	<b>3.233</b>	4.064	0.000	<b>4.064</b>	0.248	0.000	<b>0.248</b>
34	0.266	0.017	<b>0.283</b>	0.397	0.060	<b>0.458</b>	0.499	0.011	<b>0.510</b>	0.031	0.001	<b>0.031</b>
35	0.039	0.026	<b>0.065</b>	0.058	0.088	<b>0.147</b>	0.074	0.016	<b>0.090</b>	0.004	0.001	<b>0.005</b>
36	4.195	0.000	<b>4.195</b>	6.272	0.000	<b>6.272</b>	7.886	0.000	<b>7.886</b>	0.482	0.000	<b>0.482</b>
	<b>194.181</b>	<b>22.897</b>	<b>217.078</b>	<b>290.354</b>	<b>79.184</b>	<b>369.538</b>	<b>365.051</b>	<b>14.498</b>	<b>379.549</b>	<b>22.320</b>	<b>0.708</b>	<b>23.029</b>



**Table 4. Pollution load of wastewater generated, by NACE categories, estimations for 2001**

Quantity of wastewater					Wastewater from industry (excl cooling water)			
NACE	Total	From (excl. water)	industryCooling water	Sanitary	BOD7	Suspended solids	Total N	Total P
15	6 368 299	5 205 582	205 038	957 679	1 655.510	1 369.573	322.668	67.272
17	2 265 730	1 090 942	0	1 174 788	346.948	287.023	67.622	14.098
18	492 578	193 872	0	298 706	61.656	51.007	12.017	2.505
19	105 620	5 971	0	99 649	1.899	1.571	0.370	0.077
20	1 321 994	346 237	0	975 757	110.112	91.094	21.461	4.474
21	8 053 218	1 939 742	2 177 987	3 935 489	616.888	510.340	120.235	25.067
221	18 064	998	0	17 066	0.318	0.263	0.062	0.013
222	155 254	113 653	13 480	28 120	36.145	29.902	7.045	1.469
23	529 500	529 500	0	0	168.395	139.310	32.821	6.843
24	3 871 310	274 022	3 262 832	334 457	87.146	72.094	16.985	3.541
25	52 200	3 059	4 855	44 286	0.973	0.805	0.190	0.040
26	1 050 510	112 787	293 023	644 700	35.869	29.674	6.991	1.458
27	8 468	2 546	140	5 783	0.810	0.670	0.158	0.033
28	265 352	159 972	11 736	93 644	50.875	42.088	9.916	2.067
29	143 567	39 055	2 813	101 699	12.420	10.275	2.421	0.505
30	1 109	0	0	1 109	0.000	0.000	0.000	0.000
31	41 879	1 400	7 503	32 976	0.445	0.368	0.087	0.018
32	112 827	47 195	12 653	52 980	15.009	12.417	2.925	0.610
33	134 636	116 065	0	18 571	36.912	30.536	7.194	1.500
34	33 977	14 262	4 575	15 140	4.536	3.752	0.884	0.184
35	82 126	2 099	6 690	73 337	0.668	0.552	0.130	0.027
36	516 057	225 200	0	290 857	71.620	59.250	13.959	2.910
<b>Total</b>	<b>25 624 275</b>	<b>10 424 157</b>	<b>6 003 325</b>	<b>9 196 793</b>	<b>3 315.153</b>	<b>2 742.565</b>	<b>646.141</b>	<b>134.711</b>

Continues...

	Wastewater from sanitary				Cooling water			
	BOD7	Suspended solids	Total N	Total P	BOD7	Suspended solids	Total N	Total P
15	402.216	280.330	61.854	13.841	0.782	2.704	0.495	0.024
17	493.400	343.882	75.876	16.979	0.000	0.000	0.000	0.000
18	125.454	87.437	19.293	4.317	0.000	0.000	0.000	0.000
19	41.852	29.169	6.436	1.440	0.000	0.000	0.000	0.000
20	409.809	285.622	63.021	14.103	0.000	0.000	0.000	0.000
21	1 652.870	1 151.988	254.181	56.880	8.307	28.728	5.260	0.257
221	7.167	4.995	1.102	0.247	0.000	0.000	0.000	0.000
222	11.810	8.231	1.816	0.406	0.051	0.178	0.033	0.002
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	140.469	97.902	21.602	4.834	12.444	43.037	7.880	0.385
25	18.600	12.963	2.860	0.640	0.019	0.064	0.012	0.001
26	270.768	188.715	41.639	9.318	1.118	3.865	0.708	0.035
27	2.429	1.693	0.374	0.084	0.001	0.002	0.000	0.000
28	39.330	27.411	6.048	1.353	0.045	0.155	0.028	0.001
29	42.713	29.769	6.568	1.470	0.011	0.037	0.007	0.000
30	0.466	0.325	0.072	0.016	0.000	0.000	0.000	0.000
31	13.850	9.653	2.130	0.477	0.029	0.099	0.018	0.001
32	22.251	15.508	3.422	0.766	0.048	0.167	0.031	0.001
33	7.800	5.436	1.199	0.268	0.000	0.000	0.000	0.000
34	6.358	4.432	0.978	0.219	0.017	0.060	0.011	0.001
35	30.801	21.467	4.737	1.060	0.026	0.088	0.016	0.001
36	122.157	85.139	18.786	4.204	0.000	0.000	0.000	0.000
<b>Total</b>	<b>3 862.570</b>	<b>2 692.067</b>	<b>593.993</b>	<b>132.921</b>	<b>22.897</b>	<b>79.184</b>	<b>14.498</b>	<b>0.708</b>

**Table 5. Pollution loads of BOD<sub>7</sub>, suspended solids, total N and total P by economical sectors, tons**

NACE	BOD <sub>7</sub>	Suspended solids	Total N	Total P
15	2 058.509	1 652.607	385.017	81.137
17	840.348	630.905	143.498	31.077
18	187.110	138.444	31.310	6.823
19	43.751	30.740	6.806	1.517
20	519.922	376.716	84.483	18.577
21	2 278.065	1 691.056	379.676	82.204
221	7.485	5.258	1.164	0.260
222	48.006	38.311	8.894	1.877
23	168.395	139.310	32.821	6.843
24	240.059	213.033	46.467	8.760
25	19.591	13.832	3.062	0.680
26	307.755	222.254	49.338	10.810
27	3.239	2.364	0.532	0.116
28	90.249	69.654	15.992	3.422
29	55.144	40.081	8.996	1.975
30	0.466	0.325	0.072	0.016
31	14.323	10.120	2.235	0.496
32	37.308	28.092	6.378	1.377
33	44.711	35.972	8.394	1.768
34	10.912	8.244	1.873	0.404
35	31.494	22.108	4.883	1.088
36	193.777	144.389	32.745	7.114
<b>Total</b>	<b>7 200.620</b>	<b>5 513.815</b>	<b>1 254.633</b>	<b>268.341</b>