Input of nutrients: potential to reduce input from point sources

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Eutrophication

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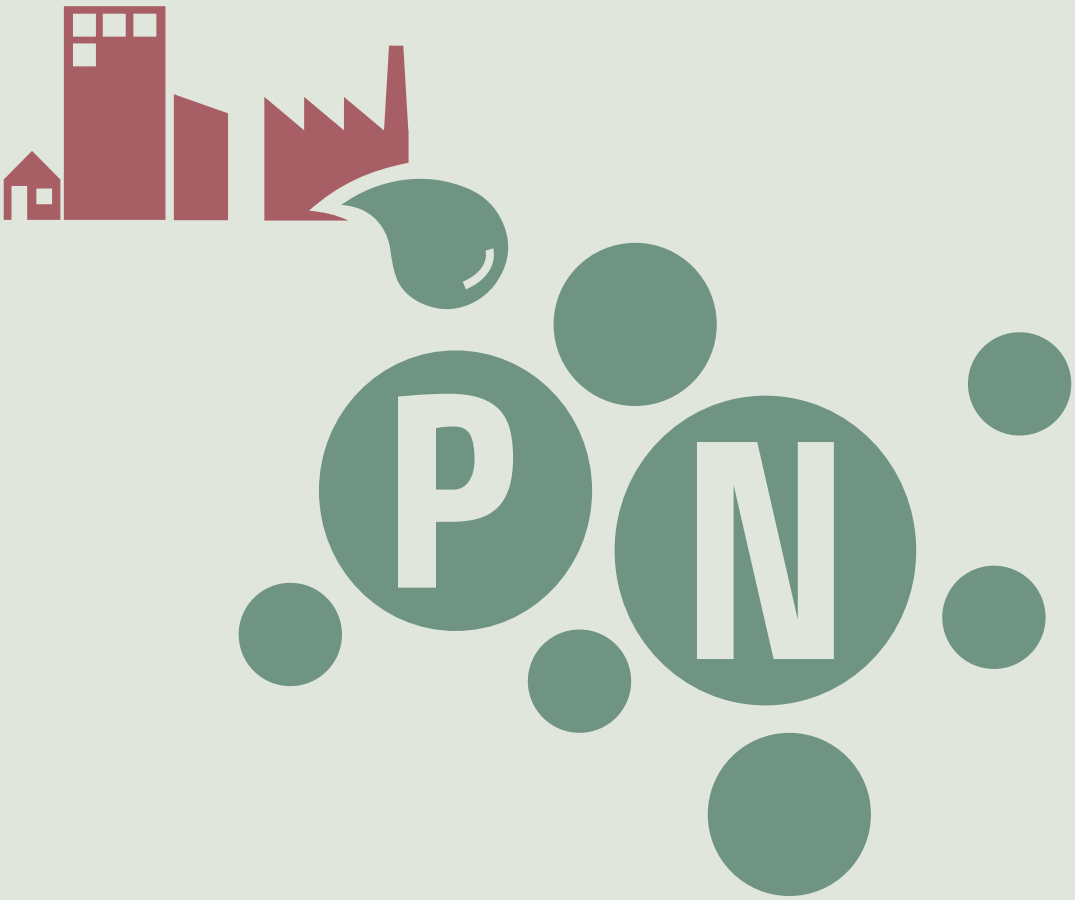

HELCOM

ACTION

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Start date and end date of the project
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Aim of the study

Differences in the flow-normalized annual mean concentrations of discharges from direct point sources will be analysed in order to estimate the relative efficiency of the treatment of water discharges across the region. Inland (indirect) point sources will be assessed in regions where previous HELCOM analyses (HELCOM 2018c) have shown that these are a significant contribution to the total load. This analysis could indicate differences in the potential for measures across the region and variations between similar water treatment facilities in different countries.

To estimate the reduction capacity of municipal wastewater treatment plants (MWWTP) PLC-7 data was collected from the PLC-database. The data includes both treatment plants discharging wastewaters directly to marine wasters and to inland plants. Total phosphorus (PTOT) and total nitrogen (NTOT) loads of individual plants were divided by flows to get concentrations, which were compared to the limit values of the HELCOM recommendation 28E/5 and the EU urban wastewater directive (Table 1). Since the HELCOM limit values are stricter for PTOT than the respective EU values, the comparison was done with HELCOM recommendation values. If calculated concentration was above the limit value, the difference in mg/l was calculated back to tons for the estimation of the remaining reduction potential. Also, retention of nutrients in inland waters was taken into account to get the estimate of the actual reduction potential benefitting the Baltic Sea.

Table 1.
Municipal wastewater treatment requirements according to HELCOM recommendation 28E/5 and the respective requirements of the EU urban wastewater directive. PE = population equivalent.

PE	**HELCOM**				**EU**			
	PTOT		NTOT		PTOT		NTOT	
	mg/l	%	mg/l	%	mg/l	%	mg/l	%
300-2000	2	70	35	30				
2001-10000	1	80	35	30				
10001-100000	0.5	90	15	70-80	2	80	15	70-80
> 100000	0.5	90	10	70-80	1	80	10	70-80

Material and Methods

Data sources and calculation methods

Data of MWWTPs for the year 2017 (PLC-7 data) was collected from the PLC-database. Russia has only aggregated data, and also Swedish data concerning inland MWWTPs was aggregated, but for this study Sweden submitted data of individual plants. The data consisted of altogether 3990 plants (Table 2).

Table 2.
Number of MWWTPs in the PLC-database in 2017 by countries and sub-regions.

COUNTRY	BAP	WEB	KAT	SOU	GUF	GUR	ARC	BOB	BOS	Sum
DE	52	64								**116**
DK	44	319	217	42						**622**
EE					44	13				**57**
FI					162		36	113	83	**394**
LT	556					75				**631**
LV	9				1	28				**38**
PL	1685									**1685**
RU	4				16					**20**
SE	163		120	14				29	101	**427**
Sum	**2513**	**383**	**337**	**56**	**223**	**116**	**36**	**142**	**184**	**3990**

Population equivalent numbers (PE) were mostly missing in the database, but some countries (Denmark, Finland, Germany, Poland and Sweden) could submit this information enabling the classification of plants according PE numbers (Table 1). Since there is a high correlation between wastewater flow and PE (r^2 0.81, n = 1741) in 2017, we used flow to estimate missing PE values according to this formula:

$$PE = \text{flow (m3/a)} * 0.00904 + 4265$$

To be able to estimate the actual loads reaching the Baltic Sea retention in inland surface waters has to be taken into account. For that purpose, MWWTPs were first divided into two categories: direct (zero retention) and indirect (variable retention depending on e.g. distance from sea and lake area). Since there is no estimate of retention of individual plants in the PLC-database other ways of retention were applied: A) for Danish plants 25% NTOT retention and 10% PTOT retention were used (Lars Svendsen personal communication). B) To estimate the retention for other countries MWWTP loads per sub-catchments were summed and the sums were compared with source apportionment figures (MWWTP loads reaching the Baltic Sea) derived from the PLC-7 data. C) Many countries (LT, LV, PL, RU) were lacking MWWTP loads in their source apportionment figures and for those countries published retention estimates were applied (Stålnacke et al. 2015, and Stålnacke Excel spreadsheet with P retention coefficients).

Results

In 2017 the reported sum of MWWTP NTOT load in the PLC-database load was 69 800 t including both indirect and direct loads without retention taken into account (Table 3). Three countries contributed more than 20% of the NTOT loads: Poland 28%, Russia 23% and Sweden 23%.

Loads were divided by country-wise population numbers to get concentrations (mg/l per inhabitants) enabling comparison of waste water treatment (Table 3). Based on this comparison Russia, Finland and Sweden had the highest per capita nitrogen concentrations. Germany and Denmark are known for their efficient nitrogen removal, which was reflected in low per capita nitrogen concentrations in outflowing wastewaters. Estonia, Latvia, Lithuania and Poland had low per capita nitrogen concentrations, which indicates that treatment is at a high level also in those countries.

Table 3.
NTOT load of MWWTPs in 2017.

COUNTRY	BAP	WEB	KAT	SOU	GUF	GUR	ARC	BOB	BOS	Sum	%	Population	Population* connectivity	mg/inhabitant
	t	t	t	t	t	t	t	t	t	t				
DE	543	875								**1419**	**2**	2700000	2484000	571
DK	48	1065	850	1047						**3010**	**4**	5100000	4335000	694
EE					659	87				**746**	**1**	1300000	1066000	700
FI					3932		550	2809	2275	**9566**	**14**	5500000	4510000	2121
LT	1823					163				**1986**	**3**	2900000	2320000	856
LV	119				20	1181				**1320**	**2**	2200000	1672000	789
PL	19903									**19903**	**28**	38500000	27720000	718
RU	525				15506					**16031**	**23**	8400000	6972000	2299
SE	6387		3457	1005				1393	3614	**15855**	**23**	9500000	8265000	1918
Sum	**29348**	**1940**	**4307**	**2052**	**20118**	**1431**	**550**	**4202**	**5889**	**69836**	**100**	**76100000**	**59344000**	

[1)] Russian figures are based on aggregated data.

In 2017 the reported sum of MWWTP PTOT load in the PLC-database load was 4220 t including both indirect and direct loads without retention taken into account (Table 4). Over half of the total municipal phosphorus loads originated from Poland, which also has the biggest population. Finland, Germany, Sweden and Estonia had the lowest per capita PTOT concentrations in outflowing wastewater. Russia had clearly the highest respective PTOT concentrations, which shows that there is still great potential in PTOT reduction.

Table 4.
PTOT load of MWWTPs in 2017.

COUNTRY	BAP	WEB	KAT	SOU	GUF	GUR	ARC	BOB	BOS	Sum	%	Population	Population* connectivity	mg/inhabitant
	t	t	t	t	t	t	t	t	t	t				
DE	37	27								**64**	**2**	2700000	2484000	24
DK	5	108	77	115						**305**	**7**	5100000	4335000	60
EE					31	5				**36**	**1**	1300000	1066000	28
FI					74		9	23	19	**124**	**3**	5500000	4510000	23
LT	136					15				**151**	**4**	2900000	2320000	52
LV	13				3	141				**157**	**4**	2200000	1672000	71
PL	2180									**2180**	**52**	38500000	27720000	57
RU	20				943					**963**	**23**	8400000	6972000	115
SE	104		70	26				11	31	**243**	**6**	9500000	8265000	26
Sum	**2495**	**136**	**147**	**142**	**1051**	**160**	**8.6**	**33.6**	**50.4**	**4223**	**100**	**76100000**	**59344000**	

[1)] Russian figures are based on aggregated data.

If all MWWTPs would follow HELCOM recommendation 28E/5, NTOT loads discharged into inland waters or directly to the Baltic Sea would decrease by 13 600 t (Table 5). The largest reduction potential is in Russia, Finland and Sweden.

Table 5.
NTOT reduction potential in MWWTPs at source.

COUNTRY	BAP	WEB	KAT	SOU	GUF	GUR	ARC	BOB	BOS	Sum	
	t	t	t	t	t	t	t	t	t		%
DE	26	78								**103**	**0.8**
DK		4	3	0						**7**	**0.1**
EE					5					**5**	**0.0**
FI					1326		89	1703	1297	**4415**	**32.5**
LT	119					0				**119**	**0.9**
LV	8				9	207				**224**	**1.7**
PL	1375									**1375**	**10.1**
RU[1)]					4638					**4638**	**34.2**
SE	377		83	104				618	1498	**2680**	**19.8**
Sum	**1904**	**82**	**86**	**105**	**5978**	**207**	**89**	**2322**	**2795**	**13567**	**100**

[1)] Russian figures are based on aggregated data.

If all MWWTPs would follow HELCOM recommendation 28E/5, PTOT loads discharged into inland waters or directly to the Baltic Sea would decrease by 2050 t (Table 6). In Estonia and Sweden there is no potential for further PTOT reductions, whereas the largest possibilities for reductions are in Poland and Russia.

Table 6.
PTOT reduction potential in MWWTPs at source.

COUNTRY	BAP	WEB	KAT	SOU	GUF	GUR	ARC	BOB	BOS	Sum	
	t	t	t	t	t	t	t	t	t		%
DE	11	2.6								**14**	**0.7**
DK	1.0	21	14	29						**65**	**3.2**
EE					0.1	0.0				**0**	**0.0**
FI					3.3		0.2	2.3	3.2	**9**	**0.4**
LT	48					4.9				**53**	**2.6**
LV	7.5				2.3	81				**91**	**4.4**
PL	1250									**1250**	**61.0**
RU[1)]	0.8				573					**573**	**28.0**
SE	0.1								0	**0**	**0.0**
Sum	**1319**	**24**	**14**	**29**	**578**	**86**	**0**	**2**	**3**	**2055**	**100**

[1)] Russian figures are based on aggregated data.

The reduction potential of loads discharged into inland waters would not totally benefit the Baltic Sea, since part of the loads would be retained along the route towards the sea. Approximately 17% of the NTOT reduction potential is lost, because of retention and 42% of the respective PTOT reduction potential (Tables 7 and 8). Thus, NTOT load into the Baltic Sea would decrease by 10500 t and the respective PTOT load by 1210 t, if all MWWTPs would follow HELCOM recommendation 28E/5. Russia, Finland and Sweden comprise together 88% of the NTOT reduction potential, whereas Poland and Russia 86 % of the PTOT reduction potential.

Table 7.

NTOT reduction potential in MWWTPs at sea (taking into account retention in inland surface waters).

COUNTRY	BAP	WEB	KAT	SOU	GUF	GUR	ARC	BOB	BOS	Sum	
	t	t	t	t	t	t	t	t	t		%
DE[1)]	26	78								**103**	**1.0**
DK		3	2	0						**6**	**0.1**
EE					2					**2**	**0.0**
FI					908		89	1526	811	**3334**	**31.8**
LT	84					0				**84**	**0.8**
LV	7				4	148				**158**	**1.5**
PL	951									**951**	**9.1**
RU[1)]					3575					**3575**	**34.1**
SE	83		49	104				653	1387	**2277**	**21.7**
Sum	**1150**	**81**	**51**	**105**	**4489**	**148**	**89**	**2179**	**2199**	**10490**	**100**

[1)] The German data are not well suited for this kind of analysis because the compared dat are based on different minimum sizes of MWWTP (Germany reports currently only indire discharges from MWWTPs > 2000 PE; the German model for the source apportionment considers already MWWTPs >50 PE). Due to the above described discrepancies in the use data for the calculations, the reduction potential of the German MWWTPs were the same at source and at sea.

[2)] Due to aggregation of the data on point sources reported to PLC-7 project, the input reduction potential for point sources in Russia might be overestimated.

Table 8.

PTOT reduction potential in MWWTPs at sea (taking into account retention in inland surface waters).

COUNTRY	BAP	WEB	KAT	SOU	GUF	GUR	ARC	BOB	BOS	Sum	
	t	t	t	t	t	t	t	t	t		%
DE[1)]	11	2.6								**14**	**1.1**
DK	1.0	21	13	29						**63**	**5.2**
EE					0.0	0.0				**0**	**0.0**
FI					2.1		0.2	2.2	2.3	**7**	**0.6**
LT	26					2.1				**28**	**2.4**
LV	4.1				1.2	50				**55**	**4.5**
PL	550									**550**	**45.4**
RU[1)]	0.6				494					**495**	**40.8**
SE	0.1								0	**0**	**0.0**
Sum	**593**	**23**	**13**	**29**	**497**	**52**	**0**	**2**	**2**	**1212**	**100**

[1)] The German data are not well suited for this kind of analysis because the compared dat are based on different minimum sizes of MWWTP (Germany reports currently only indire discharges from MWWTPs > 2000 PE; the German model for the source apportionment considers already MWWTPs >50 PE). Due to the above described discrepancies in the use data for the calculations, the reduction potential of the German MWWTPs were the same at source and at sea.

[2)] Due to aggregation of the data on point sources reported to PLC-7 project, the input reduction potential for point sources in Russia might be overestimated.

Conclusions and recommendations

Even if municipal waste water treatment has improved substantially during the last decades there is still remarkable potential to reduce their nutrient loads: NTOT load into the Baltic Sea would decrease by 10500 t and the respective PTOT load by 1210 t, if all MWWTPs would follow HELCOM recommendation 28E/5. This would correspond to nearly 10% of the BSAP reduction targets. Russia, Finland and Sweden comprise together 88% of the NTOT reduction potential, whereas Poland and Russia 86 % of the PTOT reduction potential.

The uncertainties in estimating reduction potential were partly connected to the comprehensiveness of national nutrient load reporting. During this study many countries updated/corrected their data and it revealed, that there is a need for further checking of possible shortcomings in data reporting.

Russia submitted only aggregated data disabling precise calculations of PE numbers and retention in inland waters. For other countries also only average catchment wise retention values were applied. Better knowledge about location of the plants and retention dynamics would give more reliable estimates of how much of the potential reductions would actually benefit the Baltic Sea. This would be especially important for Polish and Russian plants.

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References

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