MORPHEUS – Policy Brief No. 3
Occurance of pharmaceutical substances in selected WWTPs and recipient waterbodies in the South Baltic

Summary

A comparative analysis of pharmaceutical occurrence at selected WWTPs and recipient waterbodies in the coastal regions Skåne (Sweden), Mecklenburg (Germany), Klaipėda (Lithuania) and Pomerania (Poland) showed that concentrations of pharmaceuticals in wastewater treatment plants (WWTPs) inlets strongly depend on the consumption rate of population in each model area.
The distribution of the pharmaceuticals loads in the South Baltic four coastal regions was partly determined by the differences in the annual volume of treated wastewater in the investigated 15 WWTPs. Knowledge on pharmaceutical concentrations in WWTPs and receiving water bodies along with consumption patterns in model regions will aid in prioritization processes and making wiser investments in advanced treatment technologies to remove relevant pharmaceuticals from the local wastewater and the aquatic environment.

Key findings

1. Almost all pharmaceuticals detected in 15 WWTPs influents. Higher concentrations in WWTPs effluents during winter than in summer

Almost all pharmaceuticals were detected in influent at all 15 WWTPs or 99.5% (224 out of 225 analyses), whereas their detection in treated wastewater is lower, accounting for almost 93% (209 out of total 225 analyses). However, in effluent higher concentrations prevail in winter season (in 144 out of total 209 cases).
This could possibly be explained by increased use of medications during the winter and decreased wastewater treatment processes/reduced pollutants removal efficiencies during the cold period.

Compound	Number of cases with identified higher seasonal concentrations at 15 WWTPs			
	Inlet concentrations		Outlet concentrations	
	summer	winter	summer	winter
Atenolol	11	4	2	13
Azithromycin	2	13	2	13
Carbamazepine	12	3	12	3
Ciprofloxacin	2	13	9	5
Clarithromycin	5	10	2	13
Diclofenac	6	9	4	11
Erythromycin	14	1	9	5
Estrone	7	8	5	8
Ibuprofen	5	10	1	5
Metoprolol	7	8	2	13
Naproxen	5	10	4	11
Oxazepam	9	5	5	9
Paracetamol	7	8	1	12
Propranolol	4	11	0	15
Sulfamethoxazole	11	4	7	8
∑ seasonal detection	107	117	65	144
Seasonal detection, %	48	52	31	69
Total detection, number	224 of 225		209 of 225	
Total detection, %	99.5		92.9	

2. Anti-inflammatory drugs dominate in WWTPs influents and effluents

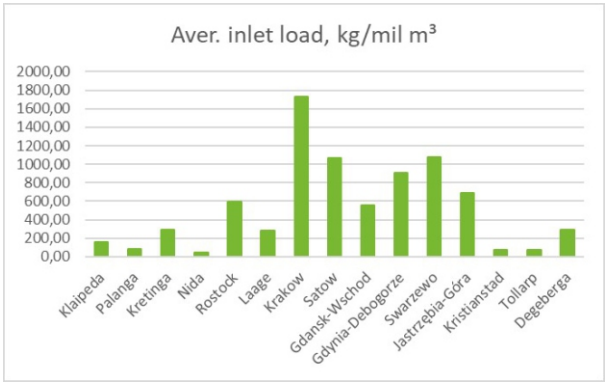
The total average annual influent chemical load of 15 pharmaceuticals at 15 WWTPs reached almost 54 tons. Ibuprofen form the highest load in all WWTPs inlets, reaching almost 50 000 kg or 90 % of the total load. The second highest compound was Paracetamol, which contributed 2164 kg or 4 % of the total load. The total average annual effluent chemical load of 15 pharmaceuticals at 15 WWTPs reached close to 0,6 ton. The highest average load of 178 kg or 30 % of total load in WWTPs effluents was calculated for Diclofenac followed by Azithromycin, Metoprolol and Carbamazepine.

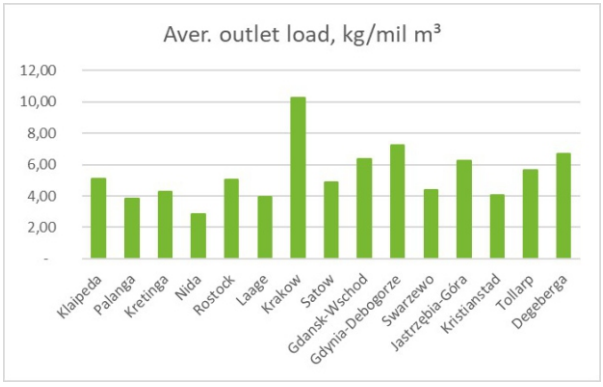
3. The removal rates at the WWTPs are compound-specific

Pharmaceuticals reduced > 90 % are Paracetamol, Ibuprofen and Estrone (except Tollarp WWTP (SE)), between 70-90 % are Ciprofloxacin (except Nida WWTP (LT)), Atenolol, Naproxen (except Nida and Tollarp WWTPs), Azithromycin (except Nida, Jastrzębia-Góra (PL) and Tollarp WWTPs). All other compounds were only removed to a limited extent. Some substances such as Oxazepam and Erythromycin even showed a negative reduction, which has been observed many times in other investigations.
For example, the three highest average removal efficiency of Diclofenac was at Swarzevo WWTP (PL) 73.0 %, Satow WWTP 69.2 %, and Laage WWTP (DE) 65.5 %, while at Tollarp WWTP it was negative at -67.6 %.
Average load elimination efficiency for each WWTP showed the best results in Laage and Kretinga WWTPs, reaching about 75 % removal of all pharmaceuticals load entering the wastewater treatment plants.

4. Pharmaceutical loads are highly variable in the inlets of investigated WWTPs

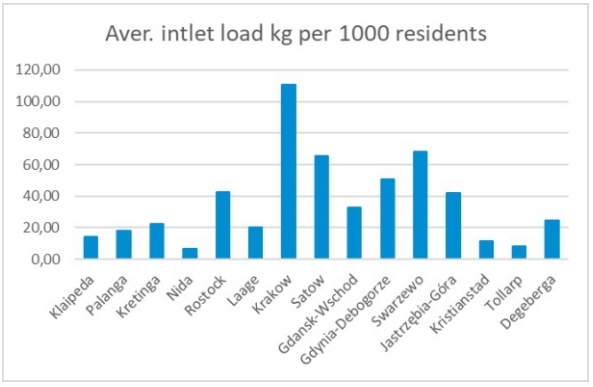
Inlet pharmaceutical loads expressed as kg per one million m³ of wastewater in different WWTPs was characterized by high variability, ranging from 50.0 kg in Lithuania (Nida WWTP) to 1730 kg in Germany (Krakow WWTP). The outlet load values were more homogenous ranging only from 2.83 kg to 10.25 kg per one million m³ of treated wastewater.

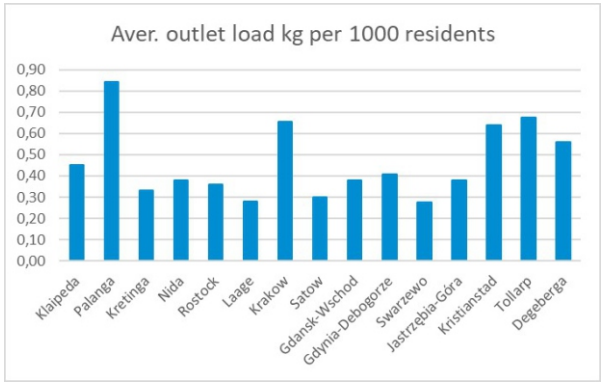




The average outlet value of all outlet loads of all 15 WWTPs was 5.39 kg pharmaceuticals per one million m³ of treated wastewater in WWTPs surrounding the South Baltic Sea.

Additionally, the average inlet loads per 1000 residents were calculated and varied between 8.41 kg in Nida WWTP to 110.46 kg in Krakow WWTP. Outlet loads in kg per 1000 residents varied less and ranged between 0.28 kg to 0.84 kg. Therefore, using actual number of residents most likely will give a better comparison between WWTPs than will volume of treated wastewater.



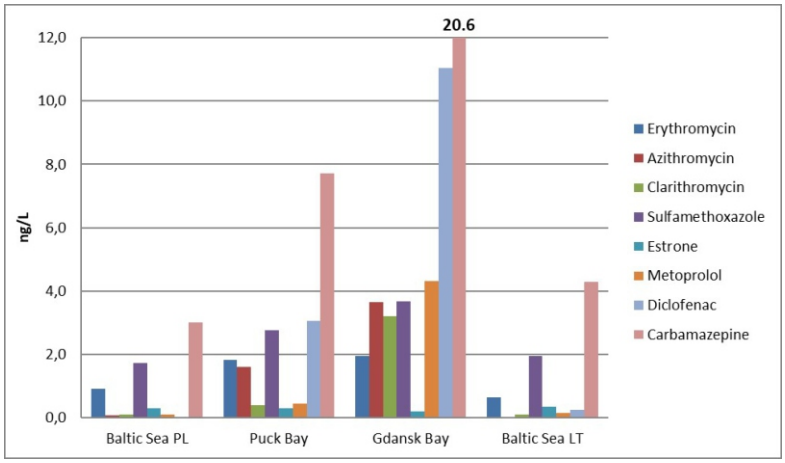


The average outlet loads for all 15 WWTPs was 0.46 kg per 1000 residents.

Country wise, it was 0.50 kg in Lithuania, 0,40 kg in Germany, 0.36 kg in Poland and 0.62 kg in Sweden.

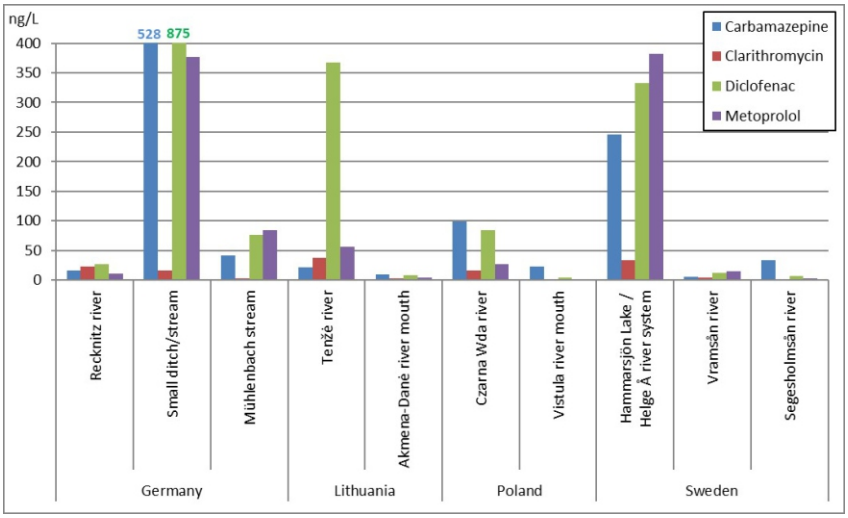
5. Status of receiving water bodies

The concentration of pharmaceuticals in the waterbodies depends on different factors like consumption rate of the medicines in the area, size of the WWTP, removal efficiency of the WWTP, water flow of the receiving rivers.
Chemical analysis of pharmaceuticals in marine water samples taken in Polish and Lithuanian parts of the Baltic Sea revealed that Gdansk Bay near the outlet of Gdansk-Wschod WWTP was characterized by the highest amounts of investigated compounds.



Average concentrations of pharmaceuticals in marine samples taken in summer 2017

In all the investigated rivers/streams/ditches the upstream concentrations of pharmaceuticals were much lower in comparison to the downstream. Downstream concentrations of pharmaceuticals in receiving rivers also depend on the flow of the river.



Average concentrations (summer and winter) of Carbamazepine, Clarithromycin, Diclofenac and Metoprolol in rivers, streams or ditches in Germany, Lithuania, Poland and Sweden downstream of the WWTPs

Knowing more about the concentrations of pharmaceuticals in the environment would allow environmental risk assessments to be improved and measures to be more focused, especially if monitoring could be extended to better cover certain parts of the environment that is known to be vulnerable. In this monitoring it is important to consider cooperation with stakeholders and foresee possible policy options to mitigate such impacts.
Monitoring results are highly relevant in prioritization at which WWTPs society should start to take action for the introduction of an advanced/fourth wastewater treatment step, and by linking these monitoring data to consumption, current treatment technologies and chemical load estimations we can better understand were the environmental impact is most pronounced.

Contact: vlangas@hotmail.com, g.garnaga@aaa.am.lt, sergej.suzdalev@apc.ku.lt, erland.bjorklund@hkr.se