Phthalate acid esters (PAEs) concentrations in water and sludge of STEP project partners

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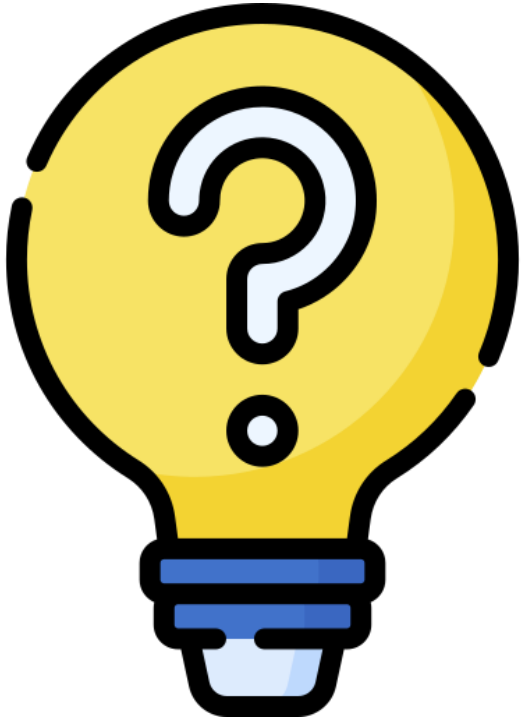
Water Resources And Contamination

Effects of climate change as well as over use and contamination put water resources under substantial pressure. The EU has some restrictions on the use of phthalates in materials and products. Therefore, industries should be prepared for and respond to the life cycle of their products. However, in Eastern European countries, the most organizers of economic activity do not know what types of phthalates are released into water and what their further qualitative and quantitate characteristics are.

Main Study Question

The study had the intention to clarify citizens' and industries' economic activities interactions with pollution of the aquatic environment by PAEs in order to understand why and where are the key sources and tendency of phthalates distribution in the sewage and what managerial solutions to change the situation have existed.



Icons from Flaticon

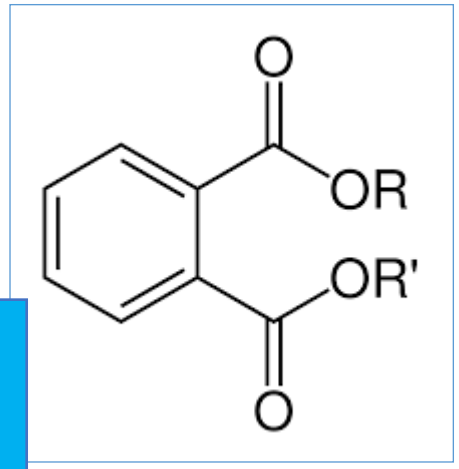
Where Can Phthalates Be Found?

- *wires and cables; electrical cords; flooring, roofing and cladding;*
- *wall coverings and floor tiles; films and sheets;*
- *paints and lacquers, adhesives, clothing,*
- *furniture (PVC flooring),*
- *car and public transport interior (automobile upholstery, leather for car interiors),*
- *cosmetic products,*
- *medical devices (plastic tubing and intravenous storage bags; gloves; teethers),*
- *toys and child care products,*
- *food and packaging material (drinking straws, food containers*

What Properties Do Phthalate Have?

Unique properties ?

- *transparency,*
- *pliability,*
- *plasticity,*
- *strength,*
- *endurance,*
- *longevity*



R-CO-OR’

$C_6H_4(CO_2H)_2$

Increase the flexibility of materials

Plasticizers and additives- cheap and high performance?

Do Phthalates Be Harmful For Environment And Human?

Harmful effect?

PAEs are not chemically bound to the host polymer and exposed on higher temperature can easily migrate in the contact matrix which may lead to the release from life cycle of commercial and domestic products into the environment…

Negative impact to **soil, water, air**
Negative impact **to biota**
Harmful affect to human health “**endocrine disruptors”, carcinogenic, toxic**

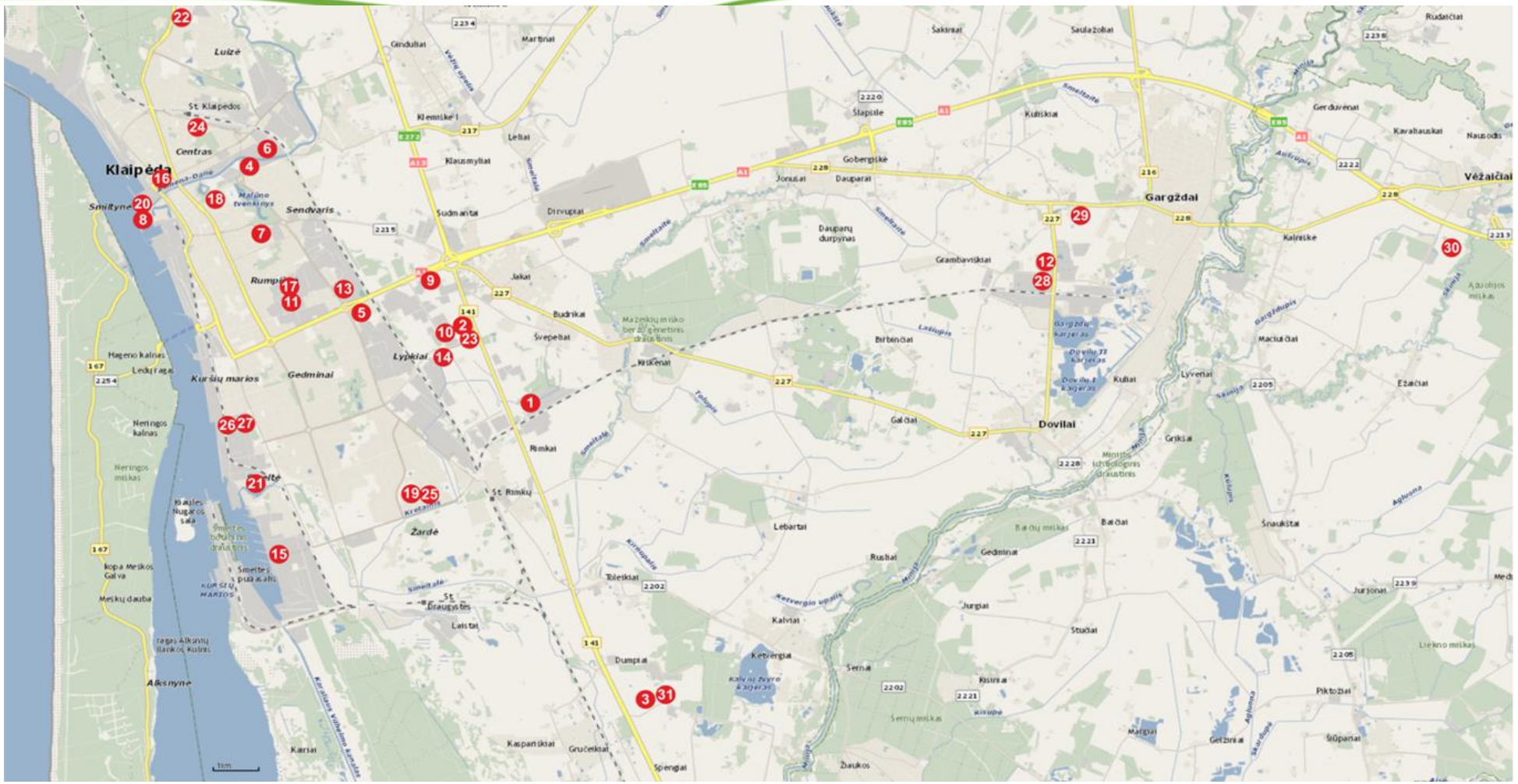
What Way Do Phthalates Come To The Environment?

PAEs eventually can enter the environment through multiple pathways among which are **industrial** and **municipal wastewaters**, land application of **sewage sludge,** and **leaching** after the disposal of industrial and municipal solid **waste.**

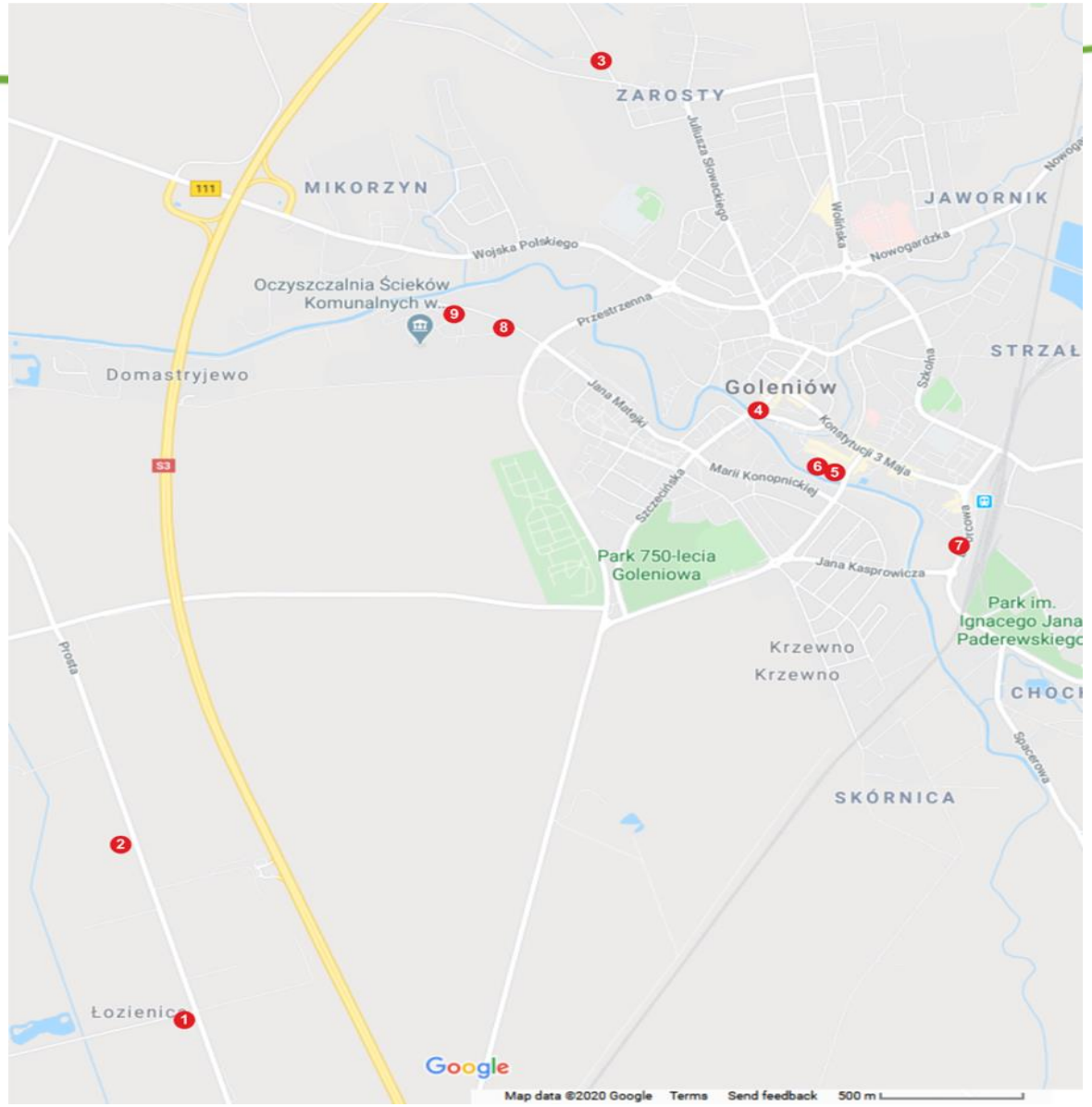
What Kind Of PAEs Were Analysed?

The determining of PAE contamination was based on analysis of dimethyl phthalate (DMP), di-ethyl phthalate (DEP), dipropyl phthalate (DPP), dibutyl phthalate (DBP), diisobutyl phthalate (DiBP), dicyclohexyl phthalate (DCHP) and di(2-ethylhexyl) phthalate (DEHP) in wastewater and sediment samples collected from city sewer systems of Lithuania and Poland, and Denmark for comparison.

Lithuanian (Klaipeda) Sampling's Points



Sampling's Points In Poland (Goleniow)



DEHP – One of the Most Common PAEs

Lithuania. The highest DEHP concentrations of **159** µg/l and 112 µg/l was observed in the truck wash and laundry sampling points respectively. However, the concentrations of DEHP in water samples of Klaipeda and Vezaiciai WWTPs ranged respectively only 0,07 and 0,14 µg/l.

The wastewater treatment plant ensures effective phthalates precipitation at least two times per wastewater cleaning process and phthalates concentrate in the sedimentation.

Based on the statistics, the amount of the plastic waste has tendency to increase over the world (380 million tons in 2015) and taking into account the low DEHP biodegradability in the water, the DEHP concentration is higher than others measured phthalates.

Sludge samples: Decomposed sludge (95,6 mg/kg) > Primary sludge (30,02 mg/kg) > Dried sludge (16,2 mg/kg) > Excess sludge (4,8 mg/kg)

DEHP and DMP in Polish Samples

Poland. The highest contamination with phthalates was observed in sewage pumping station No 6 (Fig. 1), where sewage from supermarket and industrial area are collected before transferring them to the sewage treatment plant (Table 6). The concentration of DMP reached **210** µg/l.

It was found that the total concentrations of seven PAEs in the inlet of the sewage treatment plant reached 22.7 µg/l. The dominant PAEs were DEHP > DEP > DiBP > DBP. DMP, DPP and DCHP concentrations were less than 0.05 µg/l.

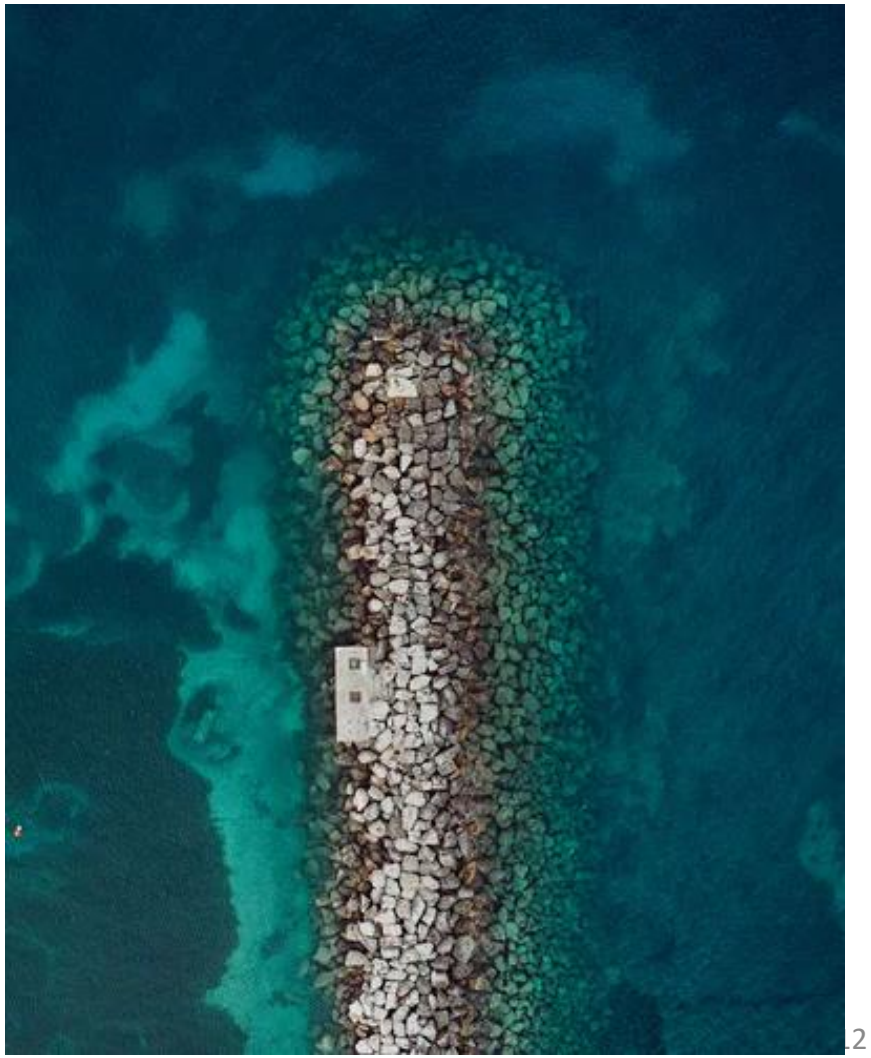
The distribution of PAEs in the water samples from Goleniów was as follow: DMP > DEHP > DEP > DBP and DiBP. DPP and DCHP concentrations were less than 0.05 µg/l.

It is important to state that concentration of DPP and DCHP *in all sampling points were less than 0.05 µg/l* that in accordance with proposition of the other scientists and based on small industrial/domestic sewage proportion at the typical wastewater treatment plant.

Denmark's (Rønne) Samples

The Danish national surveillance programme for the aquatic environment (formerly NOVA in 2003, now NOVANA) has since 1998 included monitoring of trace elements and organic xenobiotics in discharges from the sewage treatment plants (STPs) and other point sources.

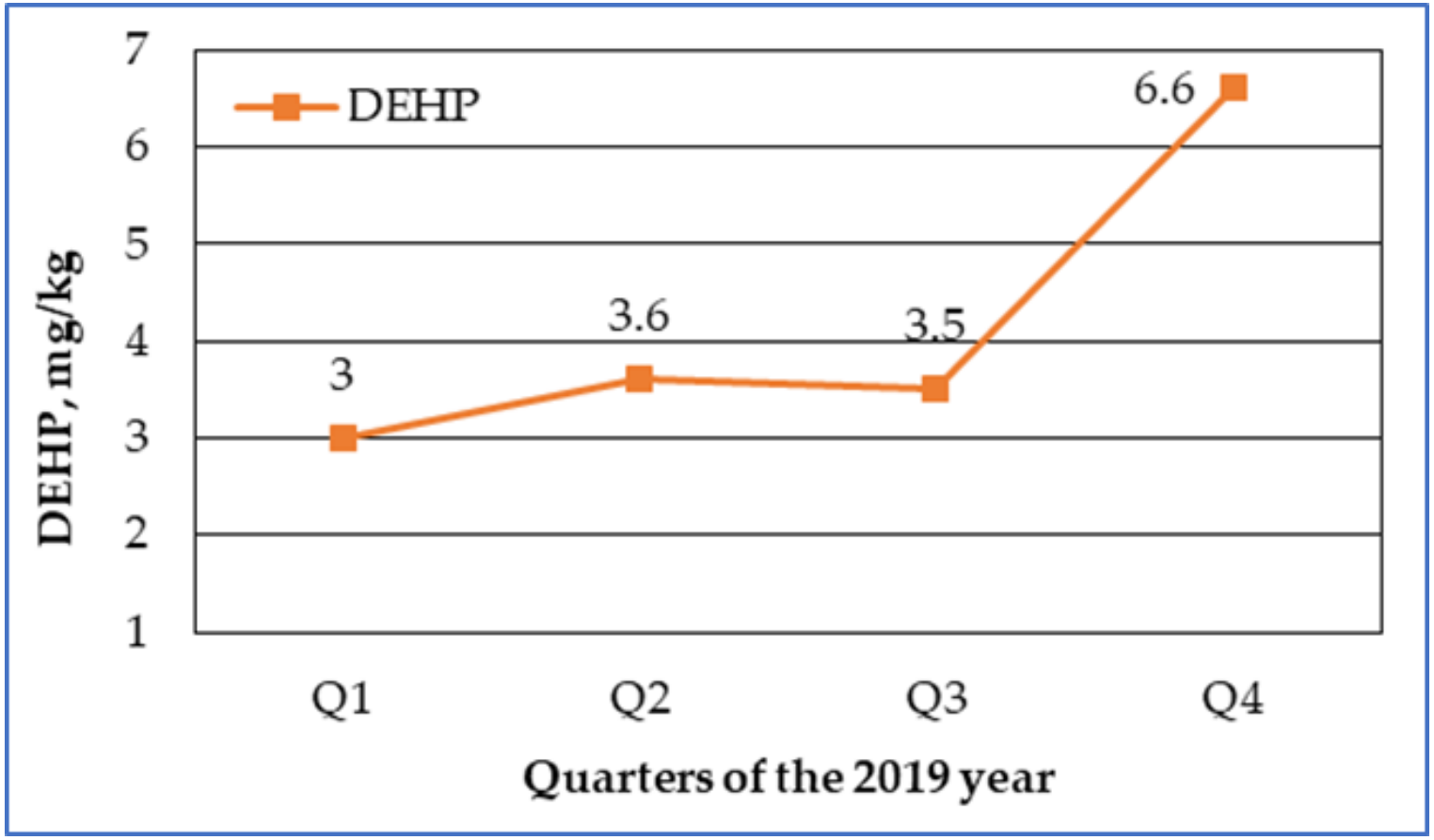
Total/partial prohibition of PAEs, stricter standards, emission controls, environmental labeling, green guidelines and information campaigns, as well as the guideline for manufacturers and taxation, were the main actions, which helped to reduce the PAEs in the environment .



Phthalates' Concentration in Denmark's WWTP

	Cas No	Method detection limit, µg/l	Inlet	Outlet
DMP	131-11-3	0.05	<0.05	<0.05
DEP	84-66-2	0.05	0.20	<0.05
DPP	131-16-8	0.05	<0.05	<0.05
DBP	84-74-2	0.05	0.14	<0.05
DiBP	84-69-5	0.05	0.05	<0.05
DCHP	84-61-7	0.05	<0.05	<0.05
DEHP	117-81-7	0.05	1.2	0.07
$\sum_6$PAEs	-	-	**<1.74**	**<0.37**

Phthalates In The Sludge Of Denmark's WWTP



Conclusions

The current study revealed the **emergence** of the phthalate acid esters in the aquatic environment originating due to **extensive plastics**' commercial and domestic **usage**.

The conducted research disclosed as well, the **influence** of **economic activity** on the pollution of the sewer system by PAEs.

The biggest PAE sources were concentrated in the vicinity of industrial parks, residential areas and roadside drains at some instances with emerging concentrations above MPC.

There is not a lot of research based on PAE analysis in Eastern countries' sewer systems while Western Europe, USA and China sewage systems are well investigated. This comparative analysis of the level of wastewater and sludge pollution by PAEs in sewage systems situated in Eastern countries is a major contribution to knowledge in this field.

DEHP is the predominant PAE in Eastern countries and Denmark's sewage systems as well as in Western Europe countries due to its widespread utilization and low solubility in water.

Conclusions

The Danish and the Lithuanian biological wastewater treatment facilities were more effective for lowering the concentration of DEHP and other analyzed PAEs in the outlet comparing to facilities in Poland.

During the phase of sludge drying, an effective reduction of DEHP concentration is achieved, based on the organic compound volatilization process.

Investigated Danish wastewater and sludge were less polluted by DEHP and other analyzed PAEs in comparison to the Lithuanian or Polish wastewater and sludge.

An active Danish Environmental Protection Agency policy and strategy grounded on numerous legal, educational and managerial actions boosts a new behavior in PAEs use and disposal.

Considering the risk of phthalates' presence in the environment, more studies are needed to determine PAEs contamination dynamics in Eastern countries.