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The use of hazardous chemical substances in Lithuanian industry: how sound is it?

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ABSTRACT

Various chemical substances are one of the resources used for production processes and incorporated into the composition of goods for consumption. They perform numerous useful functions, but at the same time may be hazardous. The article analyses the relevance of the selected hazardous substances/groups of substances (organotin compounds, phenols and their ethoxylates, phthalates, brominated diphenylethers, chlorinated paraffins, and perfluortensides) to Lithuania, investigate their probable sources based on emission analysis, and look into the substitution possibilities when seeking a more sustainable production and sustainable products.

All the investigated hazardous substances were found in emissions from various industry branches, indicating that they are still in use. The most relevant substances are nonylphenols and their ethoxylates, organotin compounds, phthalates (mainly Bis(2-ethylhexyl) phthalate (DEHP). Industry awareness about hazardous substances is not very high, therefore further measures to encourage substitution are required. This shall be done in double way – by approaching both producers and customers.

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1. Introduction

Various chemical substances are one of the resources used for production processes and incorporated into the composition of goods for consumption (Taylor, 2010). Chemicals may provide strength or plasticity, give colour, treat illnesses or undesired organisms, and perform numerous other useful functions. People employed chemicals already in ancient times. The use became especially widespread since 20th century, when scientists have synthesized new chemical substances, and have identified previously unknown possibilities of their application (Stapleton et al., 2011). New industrial and agricultural chemicals, new pharmaceuticals have been introduced. Society was enjoying the "chemicals revolution", and there was a lot of enthusiasm about it. For example, P. Müller was awarded the Nobel prize for the discovery of pesticidal properties of DDT (Lönngren, 1992).

At the same time many chemical substances have hazardous properties. Sometimes a property is useful for certain application, while it causes risk to human health or environment in other circumstances. Humans knew about some hazards of chemicals already hundreds of years ago, but the clear evidence for the need of control and management evolved together with the widespread use, and became especially pronounced since the middle of the 20th century (Geiser, 2009; Higgins et al., 2011; Lönngren, 1992; Mehtonen, 2009; Morose et al., 2011). Various initiatives in the field of chemicals control are taking part currently: Globally Harmonized System of Classification and Labeling of Chemicals or GHS at the global level, CLP (Regulation on classification, labelling and packaging of substances and mixtures), REACH (Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals) regulations, and WFD (EU Water framework directive) at EU level, etc (REACH, 2006; UN, 2011). Countries around the Baltic Sea have signed a regional HELCOM (Baltic Marine Environment Protection Commission) convention which striving for the Baltic Sea undisturbed by hazardous substances is one of its agreed goals. The Baltic Sea Action Plan (BSAP) was signed in 2007, and it has a task among its other tasks to reduce or to cease pollution with certain hazardous substances to the Baltic Sea. Various frameworks, such as WFD, HELCOM or BSAP provide the lists of hazardous substances of special concern. These lists include substances that are dangerous to the environment and are of major concern for waters at EU or regional level. Information about the environmental concentrations and use of these dangerous to the environment substances in the Baltic Sea region is mainly available from Sweden,

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Denmark, Finland, while information from the other countries is still rather scarce. Lithuania does not have a strong chemicals industry, except of fertilizer production and one oil refinery. Environmental monitoring of "traditional" substances, such as heavy metals, didn't show the problem of pollution (Kruopienė, 2007; Lithuanian MoE, 1999–2008). Thus, the general opinion about hazardous substances was they are not a problem in Lithuania. However, the study carried out by Lithuanian Environmental Protection Agency together with Finish partners revealed quite a different situation (Lithuanian EPA et al., 2007). 9 groups of substances (such as phenols and their ethoxylates, organotin compounds, phthalates, brominated biphenylethers, etc.) have been investigated in 44 sites and found to be present in waters and sediments of water bodies, effluents and sludge from waste water treatment plants (WWTPs). The question arose: where do these substances come from? What are their sources – industry, products, historical pollution?

The aim of the current study was to determine, which hazardous substances are relevant to Lithuania, to investigate their probable sources, and to look into the possible triggers for more sound and sustainable use of chemicals by industry.

2. Methods

Thousands of substances have hazardous properties, while various frameworks cover tenths of them being of bigger concern. Based on lists of hazardous substances by HELCOM and BSAP, and on the experience from the previous studies (BEF, 2007; HELCOM overview, 2007; Hillenbrand et al., 2007), the current study concentrated on the following hazardous substances/groups of substances:

- Organotin compounds (tributyltin – TBT, dibutyltin – DBT, monobutyltin – MBT, monooctyltin – MOT, dioctyltin – DOT);
- Phenols and their ethoxylates: nonylphenols – NP (4-nonylphenol (4-NP), 4-n-nonylphenol (4-n-NP)) and their ethoxylates – NPE (4-nonylphenolmonoethoxylate (NP1EO), 4-nonylphenoldiethoxylate (NP2EO), 4-nonylphenoltri ethoxylate (NP3EO)), and octylphenols – OP (4-tert-octylphenol (4-tert-OP)) and their ethoxylates – OPE (4-octylphenolmonoethoxylate (OP1EO), 4-octylphenoldi ethoxylate (OP2EO), 4-octylphenoltriethoxylate (OP3EO));
- Phthalates and their ethoxylates (bis(2-ethylhexyl) phthalate – DEHP, diethylphthalate – DEP, diisobutylphthalate – DIBP, dibutylphthalate – DBP);
- Polybrominated diphenylethers (PBDE; this group contains a big variety of substances, e.g. PBDE47, PBDE99, PBDE100, PBDE209);
- Chlorinated paraffins (short chain chlorinated paraffins – SCCP, and medium chain chlorinated paraffins – MCCP);
- Perfluortensides (mainly perfluoroctane sulfonate – PFOS, and perfluorooctanoic acid – PFOA).

Judgement about the relevance of hazardous substances to Lithuania was based on the analysis of the following criteria:

- Overview of presence of selected hazardous substances in the environment and of their environmental concentrations;
- Use of hazardous substances by industry;
- Emissions of hazardous substances.

Emission analysis included all the investigated hazardous substances/substance groups (Dudutytė et al., 2011). 103 sampling sites from the entire country covered different types of sites, which potentially emit hazardous substances: discharges from 27 industry branches, sewage from household and supermarkets, run-off from specific areas (e.g. industrial areas, car shredding facilities), filtrate from landfills (not treated at site), discharge from WWTPs. Sampling was performed in March and April of 2011 following ISO/EN standards. Analyses were carried out according to the following standard methods: DIN EN ISO 17353 (F13) for organotin compounds, DIN EN ISO 18857 (GC-MSD) for phenols and their ethoxylates, DIN EN ISO 18856 (GC-MSD) for phthalates, DIN EN ISO 22032 (GS-MSD) for brominated diphenylethers, SOP PI-MA M 3-80 (GC-MSD) for chlorinated paraffins, and DIN 38407-42, draft (LC-MS/MS) for perfluortensides.

3. Environmental concentrations of hazardous substances – are they a problem?

Hazardous organic substances for the first time were investigated in water bodies and sediments during the screening of dangerous substances in the aquatic environment of Lithuania (Lithuanian EPA et al., 2007). In 2009 screening of hazardous substances in the Eastern Baltic marine environment (water and fish samples) covered the sampling sites in coastal area north from Klaipeda and the open sea area north-east from Klaipeda (IVL, 2009). Monitoring of phenols and their ethoxylates (4-NP, 4-n-OP, NP2EO, NP1EO, 4-OP, OP2EO, OP1EO, 4-tert-OP, and technical mixture of NP), tributyltin cation, and phthalates (DEHP, DBP, DEP) is being performed in 18 sites of 12 rivers, 4 times per year since 2011 (Lithuanian EPA, 2012).

Overview of presence of the selected hazardous substances in the environment (water bodies, sediments, and biota) according to the mentioned reports is presented in Table 1.

The existing scarce data on environmental concentrations of hazardous organic substances in the Lithuanian environment show their presence in certain media in certain locations. Screening of hazardous substances (Lithuanian EPA et al., 2007) revealed high

Table 1
Overview of presence of hazardous organic substances in Lithuanian environment.

Hazardous substances/groups of substances	Screening in 2006 (Lithuanian EPA et al., 2007)	Screening in 2009 (IVL, 2009)	Monitoring data (Lithuanian EPA, 2012)
Organotin compounds			
TBT	!	+	+
DBT	!	+	
MBT	!	—	
Phenols and their ethoxylates			
NP	+ (!)	+	+
NPE	—	—	
OP	+	+	
OPE	—	—	
Phthalates and their ethoxylates			
DEHP	!		+
DBP	+		+
DIBP	+		
Polybrominated diphenylethers	+	+	
Chlorinated paraffins			
MCCP		—	
SCCP	—	+	
Perfluortensides			
PFOS		+	
PFOA		—	

! – high environmental concentrations (environmental quality standards are exceeded).
+ – detected during investigations.
— not detected during investigations.
Empty places – no data.

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