Occurrence of Endocrine Disruptors in Chemical Industry Wastewaters and Their Fate in Treatment Systems

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INTRODUCTION

Chemical industry is one of the most important sectors in manufacturing industry and has a high pollution potential therefore appropriate treatment for chemical industry effluents is required for the protection of water resources. Chemical industry wastewaters mostly contain organic and inorganic compounds related to the manufacturing operations. Most of these compounds, especially the micropollutants, including endocrine disrupting chemicals (EDCs) and their by-products/metabolites that are present and/or likely to be present in chemical industry wastewater are toxic, mutagenic, carcinogenic or non-biodegradable [1]. Chemical industry effluents are generally treated by physicochemical methods followed by biological treatment, mostly conventional activated sludge. Although this general treatment scheme has been proven to be effective for the removal of conventional pollutants, mostly addressed as lumped parameters such as TOC, COD and BOD [2], their effectiveness on the removal of EDCs is not clearly investigated.

This study aims to

i) identify the main EDCs in the effluents of two different chemical industry facilities,
ii) evaluate the treatment efficiencies of EDCs in conventional wastewater treatment systems, in order to investigate the performance of treatment and to assess post-treatment requirement to prevent pollution of natural resources.

MATERIAL AND METHODS

In the scope of this study, two chemical plants were selected as representatives of two important chemical industry categories (“organic basic chemicals, water and solvent based paint, paint binder material” and “auxiliary products of cosmetic and detergent, plant protection products, antifoam products, auxiliary products of paint industry”). Influent samples were obtained from Plant 1 and Plant 2 equalization tanks that contain mixture of wastewaters from concerned subsectors, with different NACE codes. Effluent samples were taken from wastewater treatment plant (WWTP) discharge points. Monitoring studies were carried out for 4 seasons.

In P-1, wastewaters originated by each manufacturing operation are taken into collection basins before they are collected in the equalization tank and mixed by over flows. Chemical treatment units are composed of coagulation, flocculation and two final sedimentation basins operated in series. The plant is obliged to fulfil the sewage discharge standards to be discharged and treated in organized industrial zone (OIZ) WWTP.

In P-2, industrial wastewater and domestic wastewater originated by personnel are collected in the equalization tank, and thereafter sent to the wastewater pumping station for pH adjustment. After pH adjustment, the wastewater is fed to biological treatment. The effluent is discharged into a channel and is transferred into the sewage.

Samples taken from the monitoring points have been preserved according to the parameters to be measured as described in the standards. Laboratory analysis were carried out with liquid chromatography (LC)-mass spectroscopy (MS)/MS, gas chromatography (GC)-MS/MS, GC/MS and inductively coupled plasma (ICP)-MS techniques according to Standard Methods (2017) and developed in-house methods.

RESULTS AND DISCUSSION

Plant-1:

- A total of 9 EDCs have been commonly detected in the influent of the WWTP.

5 phthalates (dicyclohexyl phthalate (DCHP), dimethyl phthalate, di-n-octyl-phthalate (DnOp), mono-ethylhexyl phthalate (MEHP), mono-n-butyl phthalate), 3 polycyclic aromatic hydrocarbons-PAHs (naphthalene, phenanthrene, pyrene) and a plastic monomer (styrene).

- 7 of the EDCs detected in the influent in all monitoring periods have been treated with efficiencies in the range of 15% and 86%.

- Effluent concentrations of 3 compounds detected in all periods were higher than their inlet concentrations.

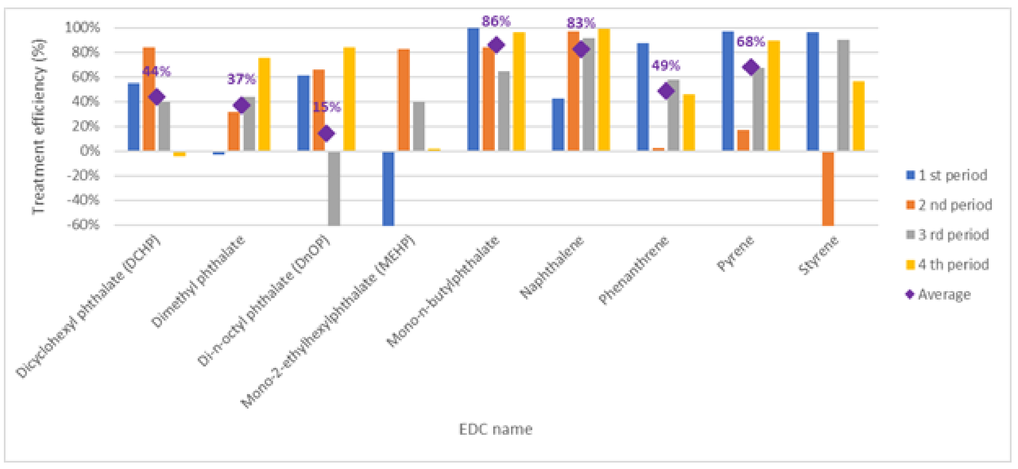

Figure 1 Plant-1 WWTP treatment efficiencies

RESULT AND DISCUSSION

Plant-2:

- A total of 10 EDCs have been always detected in the influent of the WWTP.

5 phthalates (dicyclohexyl phthalate (DCHP), diethyl phthalate (DEP), di-n-butylphthalate (DBP), di-sec-octylphthalate (DEHP) (DOP), mono-2-ethylhexylphthalate (MEHP)), 3 polycyclic aromatic hydrocarbons-PAHs (fluorene, naphthalene, phenanthrene), chloroalkanes C10-13 (short chain chlorinated paraffins) and, octamethylcyclotetrasiloxane (D4).

- 10 EDCs detected in the influent were treated with efficiencies in the range of 77% and 95%.

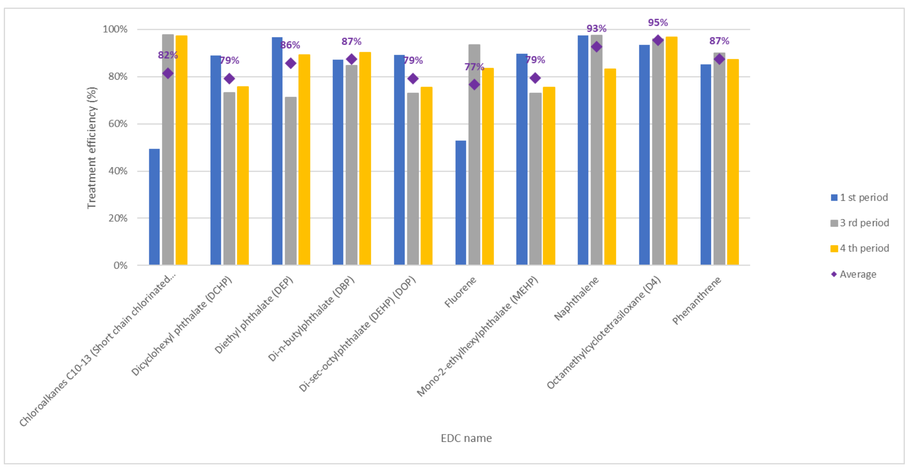

Figure 2 Plant-2 WWTP treatment efficiencies

These results show that;

- EDCs generated by chemical industries can be treated to some extent in conventional chemical or biological wastewater treatment facillities.

- The efficiency of treatment in conventional WWTP operations may show a wide range depending on the type of the EDC compounds.

- Phthalates like dicyclohexyl phthalate (DCHP), and polycyclic aromatic hydrocarbons-PAHs like naphthalene and phenanthrene are commonly found EDCs in chemical industry wastewaters and they would need further advance treatment after conventional treatment operations and would be deposited in the treatment plant sludges.

CONCLUSIONS

Chemical industries manufacture a wide range of products, which periodically can change their production in terms of quality and quantity. Changing the production will affect the wastewater characterization. Besides organic load, chemical industry wastewater includes heavy metals, solvents, priority substances and persistent organic pollutants (POPs [3]. Therefore, chemical industry needs to review the treatment process efficiency regularly [4]. This study includes identifying the main EDCs in the effluents of two different chemical industry facilities, evaluating the treatment efficiencies of EDCs in conventional wastewater treatment systems and investigating the performance of treatment and to assess the post-treatment requirement to prevent pollution of natural resources.

It is concluded that traditional treatment of wastewater can partially remove chemicals (with efficiencies in the range of 15% and 86%), but some traces are still detectable in effluents. In alternative wastewater treatment processes such as advanced oxidation with ozone, hydrogen peroxide and membrane technology such as reverse osmosis might be necessary for further removal of trace level micropollutants, such as EDCs.

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