PROBLEMY EKOROZWOJU – PROBLEMS OF SUSTAINABLE DEVELOPMENT
2018, vol. 13, no 2, 191-198

Monitoring of Organic Micropollutants in Effluents as Crucial Tool in Sustainable Development

Monitoring mikrozanieczyszczeń organicznych jako ważne narzędzie realizacji zrównoważonego rozwoju

***Maria Włodarczyk-Makuła, **Ewa Wiśniowska, ***Agnieszka Popenda**

Katedra Chemii, Technologii Wody i Ścieków, Wydział Infrastruktury i Środowiska, Politechnika Częstochowska, ul. Dąbrowskiego 69, 42-200 Częstochowa, Poland
*E-mail: *mwm@is.pcz.czest.pl; **ewisniowska@is.pcz.czest.pl; ***apopenda@is.pcz.czest.pl*

Abstract
Water resources are crucial issues in sustainable development. From an economic perspective lack of clean water leads to long-lasting effects on human capital and growth. The key problem is to what extent can we give up on the economic growth to preserve the natural resources for future generations. Progress in monitoring will be critical in ensure to achieving sustainable development goals. However monitoring of the status quo is not the only strategy. The better one is monitoring of pollutants discharging in order to prevent or at least to limit their amounts. At present, the afore mentioned monitoring is not carried out with respect to municipal effluents despite the fact that these contaminants are found in the treated wastewater and should be monitored to avoid pollution of surface waters. The types of micropollutants that should be monitored have to be chosen individually for each wastewater treatment plant (WWTP) depending to local conditions that allows to fullfill the tasks in sustainable development. Recent changes in Polish legislations relying on which organic micropollutants are considered when classification of surface and underground water is made, are the proper directions.

Key words: organic micropollutants, environmental safety, sustainable development, surface water, effluents, monitoring

Streszczenie
Zasoby wodne są kluczowym elementem zrównoważonego rozwoju. Z punktu widzenia ekonomii brak czystej wody prowadzi do długofalowych skutków dla rozwoju i wzrostu ludzkości. Kluczowym pytaniem jest co można zrobić, aby rozwój ekonomiczny odbywał się w sposób pozwalający na zachowanie zasobów naturalnych dla przyszłych pokoleń? Postęp w sposobie monitorowania będzie krytyczny dla sprawdzenia i oceny stopnia realizacji celów zrównoważonego rozwoju. Monitorowanie stanu istniejącego nie jest odpowiednio skuteczną metodą. Lepszą strategią jest monitorowanie zrzutów zanieczyszczeń, tak aby można było im zapobiegać lub je ograniczać. Obecnie tego rodzaju monitoring nie jest stosowany w odniesieniu do odpływów z oczyszczalni ścieków komunalnych pomimo tego, że wyniki badań wskazują, że organiczne mikrozanieczyszczenia występują powszechnie w oczyszczonych ściekach. Z tego względu należałoby wprowadzić obowiązek monitorowania stężeń wybranych mikrozanieczyszczeń w ściekach oczyszczonych. Zakres monitoringu powinien być dobrany indywidualnie dla każdej oczyszczalni ścieków w zależności od lokalnych czynników, co pozwoli na realizację zasady zrównoważonego rozwoju. Dobrym kierunkiem jest natomiast wprowadzony w Polsce obowiązek monitorowania wybranych organicznych mikrozanieczyszczeń w wodach powierzchniowych i podziemnych.

Słowa kluczowe: mikrozanieczyszczenia organiczne, bezpieczeństwo środowiskowe, zrównoważony rozwój, wody powierzchniowe, ścieki oczyszczone, monitoring

Introduction

Water resources play an import ant role in sustainable development. *The Future we Want* – outcome document of Rio +20 (United Nations Conference on Sustainable Development, 2012) recognizes water as a core of this kind of development (Water for a Sustainable World, 2015). From an economic perspective lack of clean water leads to long-negative lasting effects on human capital and growth because environmental, social and economic conditions are mutually dependent. About how important clean water is, shows e.g. the casus of ancient Romans. The researchers suggest that because of using lead pipes and lead plates by them damage in nervous systems occurred resulting in the fall of an empire.

The key problem is to what extent can we give up on the economic growth to preserve the natural resources for future generations. Economy of sustainable development offers three strategies in solving this problem:

1. strategy of the effectiveness – it aims to more efficient use of the existing resources, including decrease of harmful pollutants discharge,
2. strategy of coherence – by development of new ecological products,
3. strategy of sufficiency – by changing in attitude of people through limiting consumption of natural resources (Rogall, 2010).

2. Legislations of sustainable development in the aspect of micropollutants monitoring

According to H. Rogall, sustainable development requires consequent implementation of these three above mentioned strategies simultaneously (Rogall, 2010). The implementation of them should be supported by legislation both at international and national level. In that spirit in New York in September 2015 the world leaders adopted *2030 Agenda for Sustainable Development*. It officially came into force on January 1st 2016. It comprises 17 Sustainable Development Goals, including the Goal 6 *Clean water and sanitation* (SDG 6). According to SDG 6: *Clean, accessible water for all is an essential part of the world we want to live in*. This goal should be achieved by 2030, among others, by *improving water quality by reducing pollution, elimination dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater* (Sustainable Development Goals, 2015). The goals included in Agenda results, among others, from the report of United Nations mentioned above (it was published in 2015) (Sustainable Development Goals, 2015). The report emphasizes the role of reliable data to monitor progress of the goal fulfilling. As it is advisable mentioned in report prepared by team managed by William Reidhead (Monitoring Water and Sanitation in the 2030) *it is difficult to manage what is not measured, and what gets measured is far more likely to get measured.* The authors envisage that progress in monitoring will be critical in ensuring the achieving Sustainable Development Goals of *2030 Agenda*. In 2014 GEMI (Integrated Monitoring Initiative) was established. This is an inter-agency initiative focused on integrating and expanding existing monitoring efforts on, among others, water quality and integrated water management resources (www.sdg6monitoring.org/news/presenting-gemi) in United Nations member states. It should ensured harmonized monitoring of entire water cycle. Agencies involved in GEMI have also been reporting on innovative practices for water accounting and management. GEMI allows the Member States to achieve individual countries monitoring interests with flexibility (Monitoring Water and Sanitation in the 2030). Until 2018 GEMI implementation will focus on the development of monitoring methodologies. Protection of the environment against the pollutants should, however, concern not only monitoring, but protection as well. These two operations should be included in the practices of member countries as tools of the accomplishment of sustainable development idea. Protection of the environment is related with not only monitoring but also reducing discharges of pollutants into the environment.

3. Organic micropollutants in wastewater

In case of macropollutants such as: organic compounds (chemical oxygen demand -COD, Biochemical oxygen demand- BOD), nitrogen-N and phosphorus-P compounds even the legislation of not very well developed countries is involved in protection of water environment against them. For example, in Uganda standards for treated effluents were established by the Bureau of Standards and implemented by the National Environment Management Authority. The permissible values for BOD_5 were set at level 50 mgO_2/L, COD 100 mgO_2/L, TSS 100 mgO_2/L, TN 10 mg/L and TP 10 mg/L, respectively. In Kenya the permissible values for treated wastewater discharged into rivers are as follow BOD_5 50 mg/L, COD 250 mg/L, TSS 50 mg/L, TN 50 mg/L and TP 6 mg/L (Muresan, 2013). The standards are less strict than in Europe and in the USA, however by their introducing also developing countries protect the environment and achieve goals in this area.

Micropollutants, especially the organic ones, are limited in wastewater very rarely. It is probably due to the fact that effects of micropollutants presence in the environment are not such spectacularly visible compare to those caused by nitrogen, phosphorus and high loads of organic compounds. The last ones cause euthrophisation and oxygen depletion, extinction of fish and other water organisms. In case of micropollutants the effects are most often to chronic exposure at low concentrations. The effects caused by micropollutants are less spectacular than damage in the environment caused by biogen or organic compounds, but the threats are of high importance. For a long time it looked as if we decrease the loads of COD/BOD and biogenic compounds into surface waters we solve the problem of water resources intended for drinking purposes. We have thought that if we can treat wastewater and water for drinking and industrial purposes we are able to solve problem with expending natural water resources. That is not a true. At present, due to the lack of clean water half the population in the developing countries has been suffering from various diseases. According to the UNEP prognoses ¾ of the humanity will live in areas of water shortage (Rogall, 2010). Even in well developed, European countries the situation is serious. Based on the results of monitoring we can say that organic micropollutants are common contaminants of our living environment (Popenda, 2016). They are found in personal care products and pharmaceutics, we use them in agriculture and various branches of industry. Human's activity is one of the main sources of pollution of the environment by organic micropollutants (Grotenhuis, 2003). Because of this also the humans are able to manage and decrease discharges of these compounds into the environment, including surface waters. Wastewater treatment plants, both industrial and municipal, should be considered as important sources of organic micropollutants of anthropogenic origin (Włodarczyk-Makuła, 2015). However, at present hardly any country has established standards for micropollutants in municipal effluents. Untill now only Switzerland has already decided to reduce micropollutants concentrations and toxicity connected with their presence in wastewater. The Swiss government decided to upgrade approximately 50% of wastewater treatment plants in the coming 20 years (microcropollutants.com).

An example, in Polish legislation some micropollutants are limited in industrial wastewater (Rozporządzenie, Dz,U. 1800, 2014). Mainly those considered as harmful the environment (hexachlorocyclohxane: HCH, tetrachloromethane: CCl_4, pentachlorophenol: PCP, aldrine, dieldrine, endrine, izodrine, DDT, polychlorinated biphenyls: PCB, polychlorinated triphenyls: PCT, hexachlorobenzene: HCB, hexachlorobutadiene: HCBD, trichloromethane: $CHCl_3$, 1,2-dichloroethane: EDC, trichloroethylene: TRI, tetrachloroethylene: PER and trichlorobenzene: TCB. Also insecticides (both chlorinated hydrocarbons, phosphoroorganic and carbaminates), petroleum hydrocarbons, benzene, toluene and xylene BTX andAdsorbable Organic Halides AOX are limited in the industrial wastewater. Germany has also established limits of organic micropollutants in industrial effluents. In Germany AOX and VHHC (volatile halogenated hydrocarbons) are limited in wastewater from manufacturing of coating materials and varnish resins (www. bmub.bund.de). This politics is connected with the fact that at present in ecological risk assessment attention is focused mainly on evaluation, identification and characterization of micropollutants and not on management. This is despite the rule of Environmental Law which says that the primary way that we should act is to avoid contamination, not clean surface water. The law systems seems to be still under furtherance of the idea of evaluation not protection. As a result micropollutant concentrations are measured in surface waters in most European countries, but their concentration is not monitored in municipal effluents.

However, there is data available on concentrations of the organic micropollutants in municipal effluents indicating that the afore mentioned contaminants make significant but still not noticeable problem (Table 1). In the table comparison of the concentrations of selected micropollutants in surface water and effluents is also included. The data indicate that many compounds such as: nonylphenols, DEHP, polycyclic aromatic hydrocarbons-PAHs, polychlorinated biphenyls-PCBs, pharmaceuticals (diclophenac, carbamazpine, ibuprofene, naproxen, E2, EE2) occur in effluents originating from WWTPs at concentrations significantly higher than those in surface water. This is however, not a rule in case of the pollutants that are not used in households, such as MCPA or 2,4-D. What is important micropollutants are commonly found in effluents and the loads discharged into surface waters can pose a serious risk to the environment. This is the first argument supporting the idea of the necessity of organic micropollutants monitoring in municipal effluents, but the type of micropollutants should be matched individually as many conditions affects the pollution of wastewater. All the conditions should be taken into consideration in matching process. The second argument is that organic micropollutants are not efficiently removed from wastewater during treatment. The existing wastewater treatment plants are not designed for removing micropollutants.

This also means that the key question is not if, but which organic microcompounds should be analysed in the effluents. Concentrations of organic pollutants in rivers can be a clue when we choose the pollutants which are the most significant problem. For example, in Poland concentration of the following organic micropollutants in rivers and lakes was measured within national monitoring system in 2010-2015: alachlor, anthracene, atrazine, benzene, brominated diphenyloether, C_{10}-$_{13}$ chloroalkanes, chlorfenwinfos, chloropyriphos, EDC, dichloromethane, DEHP, diurone, endosulphane, fluoranthene, hexachlorobenzene, hexachlorobutadiene (HCBD), heksachlorocyclohexane (HCH), izoproturone, naphthalene, p-nonylophenol, 4-(1,1',3,3'-tetramethylobutylo)-phenol, pentachlorobenzene, pentachlorophenol (PCP), benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, indeno(1,2,3-cd) pyrene, simazine, tributilocine compounds, tetrachlorobenzenes, trichloromethane, trifluraniline,

Table 1. Selected micropollutant concentrations in wastewater and surface water compared to the levels regared as having long-term and acute effects on living microorganisms, source: publications.jrc.ec.europa.eu; Bukhardt-Holm, 2011; Włodarczyk-Makuła, 2015; Min, 2014; Urbaniak, 2017; Nathália , 2011; Iglesias, 2014; Inventory on the presence of pharmaceuticals in Dutch water; Kummerer, 2013; Valdes, 2015; De Oude, 1992; Abd El-Gawas, 2014; Voulvoulis, 2004; Leonard, 2001; www.helcom.fi/Documents/HELCOM%20at%20work/ Projects/BASE/Indicators_TBT.pdf; Nagy, 2013; Wang, 2017

Compound	Concentrations in effluents (ng/L)	Concentrations in surface water (ng/L)	Compound	Concentrations in effluents (ng/L)	Concentrations in surface water (ng/L)
Dioxins PCDDs	0.003 ÷ 0.177	0.728 ÷ 6	Diclophenac	50 ÷ 2,500	2.8 ÷ 470
Furans PCDFs	0.006 ÷ 0.05	0.599	Carbamazepine	482 ÷ 950	n.d ÷ 230
Polychlorinated biphenyls (PCBs)	10 ÷ 908 (7 congeners)	0.3 ÷ 150	Ibuprofen	81 ÷ 2,100	10 ÷ 40
Nonylphenol (NP)	880 ÷ 22,690	0.8^8 ÷ 18,000	Naproxen	21 ÷ 12,500	< LOD ÷ 300
Diethyl phthalate (DEHP)	$6.01{\cdot}10^6$ ÷ $17.04\ 10^6$	110 ÷ 36,000	17β-Estradiol (E2)	< 5 ÷ 631	369
Polycyclic aromatic hydrocarbons (PAHs)	1,025 ÷ 3,056,000	41 ÷ 437 (Nagy, 2013) 4 ÷ 29 (Wang, 2017)	17α-Ethynylestradiol (EE2)	< 5 ÷ 187	43
MCPA	25 ÷ 150	n.d. ÷ 370	2,4-D	13 ÷ 27	< 1000
Diuron	62 ÷ 1,379	2.4 ÷ $2.849{\cdot}10^6$	Dieldrin	< 10	2.5
Aldrin	Production is banned	15.3	Atrazine	no data	100 ÷ $4.9\cdot10^5$
DDT	Production is banned	0.12 ÷ 218	Linear alkylbenzene sulfonate (LAS)	$6{\cdot}10^3$ ÷ $16{\cdot}10^3$	$70{\cdot}10^3$ ÷ $2.45{\cdot}10^6$
Tributylocine (TBT)	$2.5\cdot10^6$	$1.39\cdot10^3$– $1.44\cdot10^3$	Endosulphane	≤ 220	≤ $4\cdot10^3$

n.d.-not detected; LOD – limit of detection

trechloromethane, sum of atrazine, dieldrine, endrine and izodrine, DDT, trichloroethylene and tetrachloroethylene (gios.gov.pl/). Taking into consideration the analyzed micropollutants concentration most examined samples of river water were classified as of very good quality. The exceptions are listed in Table 2.

Table 2. High concentration of micropollutants in Polish river waters (2010-2015), source: www.gios.gov.pl/

Micropollutant	Place of sampling (river name)
Benzo(g,hi)perylene, indene(1,2,3-cd)pyrene	Ina, Chełszcząca, Gowienica, Wołczenica, Rega, Dębosznica, Błotnica, Dzierżęcinka, Głównica, Parsęta, Wieprza, Pisa, Elbląg, Wąska, Sajna, Bóbr, Czernica, Czerna Mała, Obra, Kwisa, Nysa Łużycka, Obrzyca, Odra, Ruzyca, Tywa
Benzo(a)pyrene	Głównica
Benzo(b)fluoranthene	Głównica
Benzo(k)fluoranthene	Głównica
DEHP	Biała, Horodnianka
Endosulphane	Warta
Tributylocine compounds	Odra, Martwa Wisła, Nogat Kanał Żerański

The detailed analysis of the data typical for Poland indicates that the compounds that should be monitored, are polycyclic aromatic hydrocarbons, phthalates (DEHP) and selected biocides: tributilocine and endosulphane.

4. Toxicity of organic micropollutants

The considered organic compounds are also very dangerous to water organisms. The danger that comes from the presence of micropollutants discharges with effluents is spectacular if we compare the concentrations of the pollutants with LOEC (low observed effect concentrations) or NOEC (no observed effect concentration) values. Toxicity and effects on living organisms of the compounds mentioned above are listed in Table 3.

These compounds should be recommended to be monitored in effluents. The second group of micropollutants which should be controlled in effluents in Poland are the ones which LOEC values are significantly lower than LC50, but their concentrations are also at high level in the treated wastewater. It is because OECD classification (Table 4) of toxicity is not always representative for evaluation of environmental effects of micropollutants.

They are mainly pharmaceuticals, e.g. 17α-ethynylestradiol (EE2) concentration in effluent can be even 187 ng/L and NOEC for fish is only 5 ng/L, and LOEC for *Danio rerio* (survival) is only 100 ng/L.

Table 3. Acute and chronic toxicity of selected micropollutants, source: Holdway, 2008; www.sciencedirect.com/topics/agricultural-and-biological-sciences/endosulfan; Eiler, 2000; Beyer, 1996; White Paper, 2008

Compound	Levels of long-term toxic effects for water organisms	Levels of acute toxicity for water organisms
Diethyl phthalate (DEHP)	LOEC *Daphnia magna* 1,3000 µg/L NOEC *Daphnia magna* 640 µg/L	*Daphnia magna* LC50 (48h) 133 ÷ 2,000 µg/L Rainbow trout LC50 (96h) 100,000 µg/L *Gammarus pseudolimnaeus* LC50 (96h) > 10,000 µg/L
Polycyclic aromatic hydrocarbons (PAHs) (total of 16 or 17 compounds)	acenaphtene: fathed minnow embryos: LOEC for growth 495 µg/L and 682 µg/L for survival NOEC 4 ÷ 420 µg/L *Daphnia magna* NOEC 600 µg/L Benzo(a)pyrene: LOEC (27 d): rainbow troat 0.21 µg/L Phenenthrene LOEC: 8 µg/L NOEC 5 µg/L (rainbow trout)	Freshwater fish: Acenaphtene: LC50 (96h) = 580-1730 µg/L *Daphnia magna* LC50 (48h) = 41000 µg/L LC50 (96 h) for snail *Aplexa hypnorum* > 2040 µg/L Anthracene: Sunfish (*Lepomis macrochirus*) LC50 (96h) = 46 µg/L EC50 (3h) *Chlorella vulgaris* = 535 µg/L Benzo(a)anthracene: LC50 (*Daphnia pulex*) (48h) = 10 µg/L Benzo(a)pyrene: *Daphnia magna* (4h LC50) 1.5 µg/L (toxicity increases when UV irradiation is involved) Fluoranthene: *Anabena flosaque* 38% growth inhibition after 14d exposure for 147 µg/L Fluorene: 96H LC50 raibow troat 820 µg/L Naphthalene: *P. promelas* 96h LC50 = 1990 ÷7900 µg/L *Daphnia magna*: 1000 µg/L (LC50 96h)
Endosulphane	LOEC freshwater fish 1 µg/L NOEC freshwater fish < 1 µg/L	LC50 (96h) *Leiostomus xanthurus* = 0.14 µg/L
Tributylocine	No data	7.9 µg/L *Danio rerio* (96 h) 7.9 µg/L *Daphnia magna* (48 h)

LC50 – lethal concentration for 50% of tested organisms

Table 4. Classification criteria of chemicals toxicity according to their harmfulness to aquatic organisms according to EU, source: Commission of the European Communities, 1996

EC(LC)50 value, mg/L	Classification
< 0.1	extremely toxic
0.1 - 1	very toxic
1-10	toxic
10 - 100	harmful
> 100	not toxic

EC50 – effective concentration (50% of tested organisms exhibit the response)

LC50 and EC50 concentrations of the micropollutants are usually at a higher level. For E2 EC50 is in the range 120 ÷ 252 ng/L (fathead minnow) and for EE2 EC50 (*Daphnia magna*) is over 5,000,000 ng/L. For the group of pesticides the dieldrine for which NOEC (*Brachionus calyciforus*) population growth rate is 0.005 µg/L and LOEC (*Brachionus calyciforus*) population growth rate is 0.05 µg/L, while *Daphnia magna* LC50 (96h) 330 µg/L; Rainbow trout LC50 (96h) 1.1 ÷ 9.9 µg/L (Karl, 2006). Despite these considerations it also should be emphasized that in most cases concentrations of organic micropollutants in effluents are lower than LOEC values. It indicates that the problem for the environment can be also caused by the ones which can accumulate and biomagnificate in water, sediments and water organisms. Humans are exposed to the micropollutans not only by water, but also by food, air etc. It makes difficult to distinguish between the dangerous for human from these sources, and distracts attention from the effect of quality of water intake from the environment and health effects (Bukhardt-Holm, 2011). In European Union regulations some of organic micropollutants are taken into consideration, but in surface and underground water, not in wastewater. In *Water Framework Directive* (WFD) (2000/60/EC) in article 16 *Strategy against pollution of water* has been established. Based on this article the list of priority substances which have been selected from the ones representing a significant risk for the environment has been prepared. They were listed in *Annex X* of the directive and established by decision No. 2477/2001/EC. Generally 33 priority substances are listed, among them 11 have been identified as priority hazardous substances, 15 as priority hazardous substances under review. Priority substances included both inorganic and organic compounds. Among 33 substances 29 were the organic ones. *Water Framework Directive* has set the quality standards and emission control measures for hazardous substances. It was also established that 11 priority hazardous substances emissions and discharges should be ceased not later than in 20 years. Priority substances under review should be examined until 2002 to decide if they should be classified as priority hazardous. For the remaining 8 substances in the Annex

X, that are not classified as priority hazardous or under review (including) progressive reduction of the discharges was planned. The list of the priority pollutants was replaced in 2008 by *Annex II* of the *Directive on Environmental Quality Standards* (EQSD). This directive has set environmental quality standards for the substances representing a significant risk in surface waters (including rivers, lakes, transitional and coastal). It established the environmental quality standards for 33 priority substances and 8 priority hazardous substances. Both in WFD and EQSD two standards have been established: long-term standard (annual average concentration AA-EQS) and short-term standard (maximum acceptable concentration (MAC-EQS). The list of priority substances should be revised until 2011. According to this fact in 2012 the proposal of *Directive Amending the Water Frame Directive* and *EQSD* was published. It has included 15 additional priority substances, among them 6 were pointed out as priority hazardous ones. Two existing priority pollutants have been classified as priority hazardous ones. It also has established stricter quality standards for 4 of the priority substances from the previous lists, and revised slightly standard for next three. The fourth criterion which should be taken into consideration is the real possibility of removal of the compounds. To sum up, it can be stated that in the area of the protection of the water environment against to micropollutants no precise requirements are involved with respect to reduction of micropollutants discharges. However, in Poland micropollutants have been included in the system of both surface and underground water classification since 2016. It confirms the danger coming from the presence of the organic pollutants in water environment and it is an appropriate direction in legislation. It also should be emphasized that Polish legislation is similar to other European Union countries because they all follow the Directives mentioned above, however is removal of micropollutants economically reasonable?

5. Costs of treatment of organic micropollutants

According to the data given by Wahlberg et al. (2018) conventional treatment of wastewater costs less than 0,2 EUR/m^3. The balance has been done for pharmaceuticals. This treatment remains about 47% of these micropollutants in wastewater. They are discharged into the surface water. Removal of remaining amount of organic micropollutants increases treatment costs only by 0.06 EUR/m^3 – Table 5.

The development of physico-chemical methods takes place mainly due to the fact that chlorinated organic compounds are persistent to biodegradation and they are not sufficiently removed in the biological treatment plants (Bagal, 2013; Naresh, 2010; Niu, 2004; Pouran 2014, Bernal-Martinez, 2009; Barbusiński, 2013; Czaplicka, 2015; Wiśniowska 2008). Not only advanced oxidation can be used in micropollutants removal, but desorption, extraction- and adsorption as well. Moreover, ion exchange, distillation as well as electrochemical methods can also be applied. There are also known thermal methods of destruction chlorinated organic derivatives. The combination of various degradation methods are usually used in micropollutants removal. However, it should be of aware that the costs of the processes and reagents consumption are relatively quite high. Due to these new, economically effective, methods of micropollutants removal in water environment are still of great interest.

Table 5. Costs of various treatment technologies for removal of pharmaceutical micropollutants from wastewater, source: micropollutants.com/Portals/0/Downloads/Cost-of-treatment-water-micropollutants.pdf)

Treatment method	Costs, EUR/m^3	Residues left after treatment, %
Conventional treatment (without micropollutants removal)	0,17	47
Ozone oxidation	0,23	2
UV radiation	0,3	13
Activated carbon	0,48	3%
Reverse osmosis	0,65	4

6. Conclusions and future recommendations

It is confirmed in the literature data both the presence of dioxins, furans, pesticides, hexachlorobenzene, polychlorinated biphenyls, organic chlorine derivatives, polycyclic aromatic hydrocarbons in effluents from municipal wastewater treatment plants as well as their toxic effect on organisms. At the present state of knowledge, it is not possible to eliminate micropollutants from the wastewater environment completely using both biological and other methods. However, recent changes in legislation based on which organic micropollutants are considered when classification of surface and underground water is made, are the proper directions. The conducted studies are mainly concentrate on the limitation of emission into the individual environmental elements and as a consequence to the food. In order to limit emission of furans, dioxins, and other chlorine derivatives compounds the most important is replace them with others, non-chlorine cellulose and paper bleaching and developing technologies limiting formation of toxic compound long lasting effects s of incineration. Legislation is not precise when we consider the limitation of micropollutants discharges into the water environment. Future studies and acts on the organic micropollutants should focus on:

- legislation of micropollutants discharges control to water environment with respect to organic micropollutants, it must be emphasized that micropollutants which should be analyzed should be individually matched according to the needs for individual WWTPs,

- the limitations with the use of preparation in the agriculture,
- development of technological parameters of unit and integrated processes for removal and degradation of micropollutants in wastewater.

At present and in the future we have to put in place a law regulations which will support innovation and sustainability at the same time.

The research was carried out as a part of BS-PB-402-301/11.

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