BIOLÓGIAILAG NEHEZEN BONTHATÓ SZERVES VEGYÜLETEK (POPS) SZEREPE AZ ELEVENISZAPOS SZENNYVÍZTISZTÍTÁSBAN[1]

[1] Tárgyi cikk magyar nyelven a Vízmű Panoráma 2019. év 5. számában jelent meg. Nemzetközi érdeklődésre való tekintettel közöljük az angol nyelvű összefoglalót is.

ROLE OF PERSISTENT ORGANIC POLLUTANTS (POPS) IN THE BIOLOGICAL WASTEWATER TREATMENT




KIVONAT Az elmúlt évtizedekben számos olyan vegyület került a környezetbe, mely biológiailag nehezen bontható (POP). A nehezen bonthatóság és az inhibíciós hatás együttesen a szennyvíztisztító telep lebontási hatásfokának (η% KOI) csökkenését eredményezi. A POP-vegyületek bontásánál a kometabolizmus elve érvényesül. A xenobiotikus anyagok biológiai lebontásában meghatározó szerepe van a baktériumok plazmidfelvételének és a baktériumkultúra adaptációjának. A kísérleti eredmények azt mutatják, hogy az eleveniszapos rendszerben a gombaölő szerek (Ferbam 85%; Karathane 72%; Dithane 61%) 60 órás tartózkodási idő mellett viszonylag jó hatásfokkal bonthatók. A BTX-vegyületek (benzol 17%; toluol 33%; xilol 22%) hosszú tartózkodási idő (90 óra) esetében is rosszul bonthatók. Egyes esetekben az anaerob rendszer hatékonyabban bont, mint az aerob eleveniszapos rendszer (pl. piridindegradáció). Megállapítható, hogy a jelenlegi ismeretek szintjén az eleveniszapos szennyvíztisztításban a POP-anyagok biológiai lebontásának javítását csak az üzemi paraméterek megfelelő megválasztásával lehet elérni. A biológiai tisztításnak meghatározó szerepe van, de csodamódszerek, mint „szuperbaktérium-adagolás", az eleveniszap baktériumpopulációjának POP-anyagokra történő gyors átállítása nem lehetséges. A POP-anyagok eltávolítására a kétlépcsős biológiai tisztítás (aerob – aerob; aerob – anaerob), az elő- vagy utóoxidáció (UV; ózon) és az adszorpciós (aktív szén; zeolit) eljárások jöhetnek számításba.

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SUMMARY The persistent organic pollutants (POPs) are organic compounds that are resistant and toxic to environmental degradation through chemical and biological processes. Because of their persistence, POPs bioaccumulate with potential adverse impacts on human health and the environment. The parameters inhibit the biological degradability of POPs in the activated sludge system are the followings:

- Biologically persistent materials for example substitutions with chlorine and other halogens.
- Failure of compound to enter the cell due to absence of suitable permeases. The permeases are membrane transport proteins.
- As a result of the low solubility or adsorption of the chemical inaccessibility for the bacteria.
- Unavailability of the proper electron acceptor.
- Unfavorable environmental factors such as temperature, light, pH, dissolved O2 concentration, moisture, or redox potential.
- Absence of other nutrients (e.g., N, P) and growth factors necessary for the microorganisms.
- Toxic compounds effect on the biodegradation potential of the bacteria.
- Low substrate concentration that decreases the biological activity of the microorganisms.
- It is important to mention that as a result of the biological degradation certain derivatives can be more toxic than the parent compound.

There are three conditions of the biological degradability of every organic material:

- presence of the „appropriate" micro-organism,
- formation of the enzyme which activates the decomposition process of the pollutant,
- proper environmental conditions necessary for the enzymatic reaction (e.g. pH, temperature).

Decomposition of the POPs occurs the rules of the co-metabolism. It means that in the course of the decomposition process the POP serves neither energy nor carbon sources for the bacteria. The energy and carbon sources necessary for the bacteria to the decomposition process originate from the non-toxic "so called primary" organic compounds of the wastewater. The process of co-metabolism consists of dehalogenation, substitution of the hydrogen atom(s) with hydroxyl group(s) in the benzene ring, or oxidation of methyl group(s).

The decomposition process of xenobiotics materials is controlled by the plasmid in take of the bacteria. Plasmids or degradative plasmids are extrachromosomal DNA elements that control the transformation of xenobiotic compounds. The catabolic plasmids can be lost if the microorganisms are not maintained on the substrate specific for the enzyme encoded by the plasmid. The degradation plasmids have important role

in the biodegradation of fairly persistent and toxic xenobiotic materials, namely chlorinated compounds. The adaptation is such a kind of change in the bacterial population, e.g. physiological modification that allows the organism to adapt to the variation of the environmental conditions. Adaptation may also be non-genetic if the physiological mechanism generates modified metabolic activity within the existing genetic potential of the microorganism (e.g., enzyme induction). The adaptive process, however can also be generated by a genetic mechanism, that is, by mutation and selection of an organism, if the environmental conditions are suitable for the new microbial cells.

In the course of the decomposition of synthetic organic compounds mainly phenotypic variability is found in bacterial cultures. The processes mentioned above are accompanied by the recreation of the enzyme system, which allows the microbial population to decompose a new synthetic compound, even if this ability is not hereditary.

The inhibitory effects of the POPs on the environmental biodegradation and activity of the activated sludge are measured according to the MSZ EN ISO 8192. The above standard is based on the measurement of oxygen uptake rate by the activated sludge. Based on the measurement, the rate of biodegradation (degraded kgCOD/$_{kgsludge}$·hour) can easily be calculated.

The experimental results show that the fungicides can be decomposed with a relatively high efficiency at 60 hours of residence time (Ferbam 85 %; Karathane 72 %; Dithane 61 %). BTX compounds however are poorly degraded (benzene 17 %; toluene 33 %; xylene 22 %), even if the residence time is fairly long (90 hours).

95 % of the pyridine but only 60 % of the γ-picoline (methylpyridine) can be decomposed in the batch aerobic activated sludge system. Under anaerobic conditions 98 % decomposition rate, while under aerobic conditions only 80 % efficiency decomposition rate were achieved at 40 hours detention time.

Comparing the results, the aerobic and anaerobic degradations of pyridine, it can be concluded that the process of the anaerobic degradation is more effective. The biodegradation of anthracene can be improved by nutrient supplementation. If the value of the nutrient supplementation is 300 mgCOD/L the initial concentration of 2.0 $mg_{anthracene}$/L is reduced to 0.1 $mg_{anthracene}$/L at a 70 hours residence time. The anthracene concentration of the effluent decreased to 1.3 mg/L only without nutrient dosing. The decomposition efficiency of POP materials in the mixed population of activated sludge system can significantly be increased by acclimatization of the activated sludge. The effect of the sludge acclimatization, however significantly depends on the composition and the quality variation of the effluent. It is well known that the POP concentration of the influent in the case of industrial-municipal wastewater mixture, consequently the quality of the influent wastewater changes frequently.

The most important operating parameters for biological treatment of POP materials are the followings: influent load (m^3influent/hour), residence time, suitable nutrient supplementation, appropriate oxygen concentration, temperature, pH and nutrient/bacterial ratio (F/M). The degradation efficiency of POPs compounds can be increased by the usage of two-stage biology (aerobic-aerobic; aerobic-anaerobic), post-oxidation (UV; ozone) and adsorption processes (activated-carbon; zeolite addition). Summarizing, it can be stated that the efficiency of biodegradation of POP materials can only be improved by the proper selection of operating parameters in the activated sludge treatment.

KEYWORDS persistent organic pollutants (POPs); co-metabolism; bacterial plasmids; adaptation; fungicides; BTX compounds; two-stage biological treatment; activated sludge; pre-oxidation; post-oxidation; adsorption processes

Irodalomjegyzék

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