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Organic Micro Pollutants in Wastewater Sludge

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Domestic and industrial effluents received at wastewater treatment facilities have been shown to contain a wide variety of organic micropollutants which are toxic and persistent enough to threaten human health and the environment. In recent years, much research has been devoted to determining the behavior of these chemicals (polycyclic aromatic hydrocarbons, polychlorinated biphenyls, surfactants, pharmaceuticals, personal care products, endocrine disrupting compounds) during wastewater treatment processes. Among these pollutants, pharmaceutical compounds have been of great concern to scientific communities as no legal standards have been set for discharge into surface waters. Recent investigations document that pharmaceutical compounds in raw wastewaters are generally in the range of 10^{-3}-10^{-6} mg L^{-1} and their chemical and physical properties (solubility, volatility, biodegradability…etc) vary greatly resulting in inconsistency in their behavior during the treatment steps and their removal efficiencies [1-3]. Interest in endocrine disrupting compounds causing reproductive toxicity has also risen in recent years, as sensitive analytical methods have been developed to be capable of detecting these substances at extremely low levels.

All these micropollutants in conventional wastewater treatment processes can be removed through different mechanisms such as biodegradation, volatilization, air stripping and/or adsorption on activated sludge flocs [4,5]. Almost 65% of the micro pollutants removed during activated sludge treatment were transferred from the liquid phase to the solid particles of the mixed liquor [6]. It was observed in a study that quinolone type antibiotics were present in all of the sludge samples from 45 different wastewater treatment facilities and their total concentration could exceed 8905 µg/kg dry weight levels depending on the operation conditions of the treatment facility and applied treatment methods [7]. In a similar study, it was determined that the total estrogen concentration in sludge samples was between 3.16 and 444 µg/kg (dry weight) levels [8]. It is worth noting that almost all of the active pharmaceutical ingredients determined in the wastewater, were also identified in the sludge samples. The most abundantly observed active pharmaceutical ingredients in sludge were ibuprofen, salicylic acid, gemfibroliz and caffeine [9]. All those experimental studies showed that micropollutants are mainly removed from the wastewater with the sludge, unless they are biodegraded significantly during treatment.

While a large fraction of micro pollutants is absorbed into the sludge, they have to be considered during sludge processing. The management of wastewater sludge in an economically and environmentally acceptable way has become increasingly important as a result of this growing concern about micropollutants. Among the available technologies, anaerobic sludge digestion is one of the most frequently used method that stabilizes raw sludge in wastewater treatment plants by converting volatile solids to biogas, while treated sludge is very often reused for agricultural amendments. Micropollutant elimination through anaerobic digestion of the wastewater sludge has been one of the work areas that were focused on in the recent years. Unfortunately, these studies show that anaerobic sludge digestion is not sufficiently efficient in eliminating certain micropollutants. Especially hydrophobic micropollutants degrade very slowly and accumulate under anaerobic conditions [10-12]. For example it was determined in a study that among the active pharmaceutical ingredients, ibuprofen and naproxen elimination through anaerobic digestion of sludge was identified to be above 80%, while it was much lower (55% for nonylphenol monoethoxylate) for endocrine disrupting chemicals [13]. It was stated in another recent study, triclosan, triclocarban and ofloxacin substances were able to be degraded between the rates of 30% and 50%, while carbamazepine was not degraded at all through anaerobic sludge digestion [14].

Releasing a significant portion of the digested sludge into the soil and using them in agricultural purposes states that these micropollutants pose a great threat to the soil and plant environment. It is estimated that more than 200 metric tons of micropollutants are annually discharged with the residual solids from wastewater treatment [15]. Therefore it is an urgent necessity that the significance of biosolids recycling as a mechanism for the release of micropollutants into the environment should be addressed by both regulatory authorities and scientific community. Based on the available information, the following items should be considered in future studies:

-While acute toxic effects of micropollutants on non-target living organisms have been investigated for some compounds, chronic toxicity and environmental effects are only scarcely known.

-The possible uptake of micropollutants into food crops grown on agricultural fields that were fertilized with biosolids should be investigated in detail.

-The monitoring of micropollutants in sludge normally requires the use of time and labor consuming methodologies. Further research is essential for the reliability of the analytical determinations and optimization of the whole procedure.

-And finally, to increase the elimination of micropollutants that are present in significant concentrations in wastewater sludge via anaerobic sludge digestion and to obtain a safer final product with respect to micropollutants should be among the prioritized research in this topic. It is known that disintegration processes (thermal, biological, mechanical or chemical) applied prior to the anaerobic sludge digestion process significantly increase the digester performance. Determining the effects of the new technology sludge disintegration processes on the fate of micropollutants during anaerobic sludge digestion will no doubt contribute greatly to the scientific literature.

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