Pharmaceuticals & Personal Care Products and On-Site Systems

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What are PPCPs?

Pharmaceuticals and personal care products, or PPCPs, is a broad term often used in the wastewater industry. This term is used to refer to a group of compounds found in common household products such as medications, cosmetics and cleaning agents. These can include steroids, pharmaceutical compounds, and disinfectants, as well as many other substances. Many of these compounds are also known as organic wastewater contaminants, or OWCs.

Ultimately, many PPCP compounds will end up being discharged in domestic wastewater. Studies have been conducted to examine both the numbers and concentrations of these contaminants that eventually end up in effluent of on-site systems. Godfrey and Woessner (2004) found that detectable quantities of 18 prescription and non-prescription drugs were present in septic tank effluent and other research has shown that compounds such as flame retardants, fragrances and detergent metabolites are also present (Szabo et al. 2004 cited by Godfrey et al. 2007). An increasing level of concern is being raised regarding these compounds and their impacts on the environment.

Problems with PPCPs

On-site systems usually discharge effluent into the native soil without any advanced treatment for PPCPs. As a result, a number of pharmaceutical and other trace compounds reach groundwater systems via the process of on-site system wastewater infiltration (Carrara et al. 2008). This infiltration is becoming a serious issue. In New Mexico, a greater volume of groundwater, private and public wells have been contaminated from on-site systems than from all other sources combined (McQuillan 2004).

When PPCPs are allowed to reach groundwater before they are fully treated, the impacts can be widespread and long-lasting. PPCPs can persist in groundwater for periods of over thirty years as a result of the inability of chemical and biological processes in an aquifer to attenuate many organic compounds (Barber et al. 1988). Also, once many pharmaceutical compounds and estrogen conjugates reach groundwater, they are easily transported and highly mobile (Swartz et al. 2006, Carrara et al. 2008). This can result in these compounds having the potential to contaminate large volumes of groundwater for extended periods of time (Barber et al. 1988).

While the full environmental impacts of many PPCPs are still unknown, preliminary studies have shown that even at very small concentrations, many of these compounds can have serious effects. Ferrari et al. (2003) found that water containing carbamazepine concentrations as low as 25 ug/L resulted in chronic toxicity for some aquatic invertebrates. Estrogen compounds in wastewater may result in the feminization of male fish. Jobling et al. (1998) found that 12 to 44% of fish at sites upstream of sewage treatment plants were intersex, while 16 to 100% of fish downstream were intersex. Although low levels of "intersexuality" are considered normal in some fish species, the levels found were significantly higher than expected.

Treatment of PPCPs

Studies have been conducted to examine methods of preventing PPCPs from reaching groundwater resources. Godfrey et al. (2007) found that percolation of effluent with PPCPs through a 2m thick sand vadose zone was effective in lowering concentrations to below detectable limits for more than 75% of pharmaceutical compounds tested. Sulfamethoxazole (a common antibiotic) and carbamazepine (an anticonvulsant and mood stabilizer) were two of the three most common prescriptions in the study area in terms of mass. Percolation through a 2m sand layer resulted in these compounds (sulfamethoxazole and carbamazepine) being reduced by 17 to 80% and 93 to 99.9%, respectively. In Ontario, the minimum distance from the stone layer of a leaching bed to the high ground water table is only 900mm (Ontario 2007). Further studies may need to be conducted to see if this distance is sufficient for decreasing the concentration of many of these substances to acceptable levels.

Although the exact mechanism by which many PPCPs are removed is not known, evidence suggests that oxic conditions are essential for their removal. Swartz et al. (2006) found that high levels of oxygen in the discharge plume corresponded with low concentrations of PPCPs. Once sub-oxic (low oxygen) conditions were reached, little net loss of PPCPs occurred. It has also been suggested that sorption to the vadose zone media could contribute to the removal of these compounds (Godfrey et al. 2007) although more work is needed on this subject. Some PPCPs are also known to break down through photolysis reactions, a process that is limited in subsurface environments (Halling-Sorensen et al. 1998 cited in Carrara et al. 2008).

Soil type may also play an important factor in influencing how quickly aerobic reactions occur in the discharge plume. Evidence from some studies has suggested that clay compounds and oxide surfaces may act as catalysts in the breakdown of some estrogen compounds (Lee et al. 2003 cited by Swartz et al. 2006).

In areas where the distance to the groundwater is insufficient for the removal of PPCPs or the soil type does not promote oxic conditions, other alternative treatment options exist. The presence of aerobic sand filters and wetlands for pretreatment has been show to improve effluent quality for some PPCPs. Aerobic pretreatment options were effective in treating for all analytes tested for by Standford and Weinberg (2010), including a decrease in concentration of steroid estrogens and nonylphenols, and a reduction of total estrogenic activity. The Stanford and Weinberg study demonstrates that aerobic conditions, such as those found in advanced pretreatment systems, are important for biodegradation and transmutation processes involved in the treatment of PPCPs to occur.

Future Actions

Swatz et al. (2006) have found that caffeine levels in septic tanks are higher than would be expected from human consumption alone, suggesting that direct disposal of waste products down the drain is a contributing source of PPCPs. Actions should be taken to ensure that excess medications, cleaning products and other household items are disposed of properly as opposed to simply being poured down the drain. Most household on-site systems are not designed to treat for compounds such as these.

Guidelines for on-site systems should be reviewed to ensure that minimum soil depths are sufficient for preventing or minimizing groundwater infiltration of PPCPs. Minimum clearance distances between on-site systems and wells, lakes and other water sources should also be reviewed to reflect not only pathogens, but also trace contaminants, including PPCPs.

Where treatment of PPCPs due to soil attenuation is deemed insufficient, advanced pretreatment units involving aerobic respiration should be considered. These options have been proven an effective method of promoting biodegradation and transformation of trace compounds before they are able to reach drinking water sources (Standford and Weinberg 2010). In addition to treatment of PPCPs, advanced treatment options can also help to reduce pathogens. Design of on-site systems that help prevent anoxic subsurface conditions could also help to lower the PPCP concentration of effluent reaching groundwater sources.

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