

Endocrine Disruptors and Pharmaceuticals in the Environment

Shane A. Snyder, Ph.D.

Water Quality R&D Division; Southern Nevada Water Authority;
1001 S. Valley View Blvd.; Las Vegas, Nevada 89153 USA

Full Abstract

The ability for natural and synthetic chemicals to mimic endogenous hormones has been known since at least the 1930's (Walker and Janney 1930; Schueler 1946; Sluczewski and Roth 1948). In 1965, natural estrogens were discovered in wastewater treatment plant outfalls in the United States (Stumm-Zollinger and Fair 1965). In 1970, this work was expanded to include synthetic estrogens used as birth control pharmaceuticals (Tabak and Bunch 1970). In the mid-1970s, scientists in the United States also began to detect other pharmaceuticals near wastewater outfalls (Garrison, Pope et al. 1975; Hignite and Azarnoff 1977). Although these initial reports from the US clearly demonstrated that estrogens and pharmaceuticals were contaminants of wastewater effluents, these data were largely ignored until the 1990s when reports of deformities in fish in the UK were linked to estrogens in wastewater effluents (Desbrow, Routledge et al. 1998; Routledge, Sheahan et al. 1998). The link between estrogenicity of wastewater effluents and the presence of natural and synthetic estrogens has now been well established (Snyder, Keith et al. 1999; Ternes, Stumpf et al. 1999; Snyder, Villeneuve et al. 2001). Furthermore, it is apparent that not only birth control, but also a plethora of pharmaceuticals are readily detectable in the environment (Halling-Sorensen, Nielsen et al. 1998; Daughton and Ternes 1999).

Burgeoning human population growth and subsequent urban density increases are creating greatly elevated demands for fresh water. This growth in population also results in proliferation of agricultural development and in escalated wastewater flows. Without question, the propensity for the contamination of fresh water will rise as human population continues to grow.

Water treatment can reduce the concentrations of most contaminants. Ozone was evaluated at pilot and full scale, and found to readily reduce the estrogenicity of wastewater effluent. Free chlorine was found to be highly effective for the oxidation of phenolic steroids and acidic pharmaceuticals, while it was ineffective for ketone steroids (i.e., progesterone and testosterone). UV at typical disinfection doses was largely ineffective for nearly all compounds evaluated. Reverse osmosis and nanofiltration was able to efficiently remove all target analytes, while ultrafiltration and microfiltration were largely ineffective. Activated carbon was selectively able to removal target compounds, with removal efficacy related to contaminant structure and carbon activation. The use of advanced treatment technologies can undoubtedly remove the majority of emerging contaminants; however, the cost justification for additional treatment must be based on human and environmental health, not simply detection or absence.

In order to determine the level of a contaminant that may begin to impact human health, a risk assessment must be completed. One of the fundamental components of a risk assessment is the reference dose. The reference dose is a concentration at or below which no adverse health effects would be expected over a lifetime of exposure. In the US, the EPA has established reference doses for several chemicals in drinking water. Many of these chemicals are regulated under the Safe Drinking Water Act (SDWA). Using EPA risk assessment paradigm, reference doses for several pharmaceuticals and endocrine disrupting chemicals were calculated.

Another critical component of a risk assessment is exposure data. Data for exposure via drinking water is relatively sparse. As part of the risk assessment process, target pharmaceuticals and EDCs were monitored in twenty US drinking waters from geographically diverse locations (Table 1).

An analysis of occurrence data coupled with calculated references doses shows that human health impacts from trace pharmaceuticals and endocrine disruptors in drinking water is highly unlikely. Reference doses were generally three orders of magnitude (or greater) than the maximum concentrations detected in drinking water. However, environmental concerns remain. It is prudent that utilities consider trace contaminants in new/upgraded drinking water facility designs; however, for most pharmaceuticals and EDCs improved treatment of wastewater would reduce both environmental

and human exposure. Analytical methodology is becoming increasingly more sensitive and accurate. Without question, we will continue to detect trace concentrations certain chemicals irrelevant of treatment processes.

Table 1 Concentrations of EDCs and Pharmaceuticals in US Drinking Waters (n=20)

Compound	Hits	% Freq	Min (ng/L)	Max (ng/L)	Median (ng/L)	Ave (ng/L)
DEET	18	90	2.1	30	5.1	8.2
Atrazine	15	75	1.4	430	29	74
Meprobamate	15	75	1.6	13	3.8	6.1
Dilantin	14	70	1.1	6.7	2.3	2.7
Ibuprofen	13	65	1	32	3.8	7.9
Iopromide	13	65	1.1	31	6.5	8.5
Caffeine	12	60	2.6	83	23	25
Carbamazepine	11	55	1.1	5.7	2.8	2.8
TCEP	7	35	3	19	5.5	10.1
Gemfibrozil	5	25	1.3	6.5	4.2	3.9
Metalochlor	4	20	14	160	86	86
Estrone	2	10	1.1	2.3	1.7	1.7
Progesterone	2	10	1.1	1.1	1.1	1.1
Erythromycin	1	5	1.3	1.3	1.3	1.3
Musk Ketone	1	5	17	17	17	17
Naproxen	1	5	8	8	8	8.0
Sulfamethoxazole	1	5	20	20	20	20
Triclosan	1	5	43	43	43	43
Trimethoprim	1	5	1.3	1.3	1.3	1.3

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