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17β-Estradiol: Occurrences, Physiological Facts and Biological Effects

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Hormones which we usually deal with in Nature can be sub-categorized: natural steroid hormones (17ß-estradiol; E2, estrone; E1, estriol; E3) and several synthetic hormones (17α-ethynylestradiol; EE2, diethylstilbestrol; DES, bisphenol A). Steroidal hormones are cholesterol derivatives and control sex and growth. Among steroidal hormones, 17ß-estradiol is the most active which commonly occurs in Nature. Several methods such as high performance liquid chromatography (HPLC), gas chromatography-mass spectrometry (GC-MS), liquid chromatography-mass spectrometry-mass spectrometry (LC-MS-MS) and gas chromatography-mass spectrometry-mass spectrometry (GC-MS-MS) have been developed to detect 17ß-estradiol in the environment. 17ß-estradiol is widely detected in sewage treatment plants (STPs), rivers, sediments and digester sludge. Considering persistence (P), bioaccumulation (B), and toxicity (T) of 17ß-estradiol, 17ß-estradiol is sub-persistent, highly bioaccumulative and toxic for wildlife. Many investigators showed that 17ß-estradiol occurred in the aquatic environment and in the sediments at low concentrations. A significant amount (approximately 40% of total detections) of reproductive hormones including 17ß-estradiol was distributed in the U.S. nationwide samples (139 streams across 30 states). The concentration of 17ß-estradiol in the aquatic environment was commonly few nanograms. In addition, the concentration of 17ß-estradiol derivatives in a stream was reported tens of nanograms. The oral uptake of 17ß-estradiol is inactive due to the gastrointestinal or hepatic inactivation. Most of it was transferred as glucuronide conjugates (60-90%), while others were sulfated compounds and diconjugates. Conjugation occurs as 17ß-estradiol in the gastrointestinal tract. The oral uptake of 17ß-estradiol is limited by the absorption of conjugates because of the hydrolysis of 17ß-estradiol and the dose-limiting rate of absorption. Estrogens orally taken up are conjugated by intestinal cell wall and then pass to the liver in which send their metabolites to the bile pool or to the bloodstream. The circulated 17ß-estradiol in our body is bound to sex hormone-binding globulin (SHBG) (about 40%) and serum albumin (about 60%). Unbounded 17ß-estradiol is only 1-2%. SHBG is proportion to estrogen, while it is inversely proportion to testosterone. Thus, the concentration of SHBG in woman is much greater than that in man. Estrogens are excreted as urine, and metabolites of urine are polyhydroxylated conjugated (biologically less active forms). Metabolites of 17ß-estradiol are also found in ovaries in women and in placenta of pregnant women. 17ß-estradiol and estrone are essential sex hormones for women to maintain growth of the uterus and characteristics of femininity. However, many investigators showed that conjugated metabolites could be back into free 17ß-estradiol in STPs and receiving water body. This transformation was caused by *E. coli*. This is supported that *E. coli* is able to synthesize a significant amount of ß-glucuronidase enzyme. 17ß-estradiol was listed as one of human carcinogens by International Agency for Research on Cancer. Some investigators reported that there are strong positive relationships between estrogen therapy and endometrial cancer. As 17ß-estradiol is one of potent endocrine disrupting chemicals, aquatic animals in the surface water body receiving STPs effluent are severely affected. 17ß-estradiol induces intersex of fish, decreasing amount of male fish and sperm, and vitellogenesis/feminization in male fish at very low concentration (few nanograms per liter). In addition, effects of steroidal hormones on wildlife could be worse at the area receiving STP effluent in a stream or in arid/tropical season. Greater than 3 ng E2/L was sufficient to induce biological harmful effects.

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