Drinking Water Quality: Di(2-ethylhexyl)phthalate (DEHP) Contaminant Levels

Type of EPHT Indicator	Hazard, Exposure
Measures	Level of Contaminant in Finished Water 1. Yearly distribution of number of Community Water Systems (CWS) by maximum DEHP concentration (cut-points: <2, <4, <6, <10, >10 µg/L DEHP). 2. Yearly distribution of number of CWS by mean DEHP concentration (cut-points: <2, <4, <6, <10, >10 µg/L DEHP). 3. Average Concentration of DEHP, by Year. Potential Population Exposure to Contaminants in Finished Water 4. Yearly distribution of number of people served by CWS by maximum DEHP concentration (cut-points: <2, <4, <6, <10, >10 µg/L DEHP). 5. Yearly distribution of number of people served by CWS by mean DEHP concentration (cut-points: <2, <4, <6, <10, >10 µg/L DEHP).
Derivation of Measures	DEHP measures will be developed from water system attribute and water quality data stored in state Safe Drinking Water Act (SDWA) databases such as the Safe Drinking Water Information System (SDWIS/State). Data will be cleaned and transformed to a standard format. Analytical results of drinking water samples (usually taken at entry points to the distribution system or representative sampling points after treatment) will be used in conjunction with information about each CWS (such as service population and latitude and longitude of representative location of the CWS service area) to generate the measures.
Units	DEHP, µg/L
Geographic Scope	State and Community Water System
Geographic Scale	The finest detail will be approximate point location of the community water distribution system represented by water withdrawal point, water distribution extents, principal county served, or principal city served.
Time Period	2000-Most Recent Year Available
Time Scale	Calendar year
Rationale	**Di (2-ethylhexyl)phthalate and Public Health** DEHP is the most commonly used of a group of related chemicals called phthalates or phthalic acid esters. Some people who drink water containing DEHP well in excess of the maximum contaminant level (MCL) for many years may have problems with their livers or could experience reproductive difficulties and may have an increased risk of getting cancer. (U.S.EPA, 2010) In an analysis of occurrence data from the EPA 6 Year Review of National Primary Drinking Water Regulations, DEHP was detected in 3,098 systems, which collectively serve more than 45 million people (EPA, 2009). Concentrations of DEHP were greater than the MCL in 460 systems serving

11.5 million people. DEHP was the highest occurring regulated synthetic organic chemical found based on the percent of detections found from the 6 Year Review data. This contamination could be due, in part, to sample contamination from older generation laboratory and field sampling equipment made of plastics that contained and released phthalates (EPA, 2009).

Most of what we know about the health effects of DEHP comes from studies of rats and mice given high amounts of DEHP. Brief oral exposure to very high levels of DEHP damaged sperm in mice. Although the effect reversed when exposure ceased, sexual maturity was delayed in the animals. High amounts of DEHP damaged the liver of rats and mice. Whether or not DEHP contributes to human kidney damage is unclear.

The Department of Health and Human Services has determined that DEHP may reasonably be anticipated to be a human carcinogen. The EPA has determined that DEHP is a probable human carcinogen. These determinations were based entirely on liver cancer in rats and mice. The International Agency for Research on Cancer has stated that DEHP cannot be classified as to its carcinogenicity to humans.

People are exposed through ingestion, inhalation, and, to a lesser extent, dermal contact with products that contain phthalates. For the general population, dietary sources have been considered as the major exposure route, followed by inhaling indoor air. Infants may have relatively greater exposures from ingesting indoor dust containing some phthalates (Clark et al., 2003). Human milk can be a source of phthalate exposure for nursing infants (Calafat et al., 2004; Mortensen et al., 2005). The intravenous or parenteral exposure route can be important in patients undergoing medical procedures involving devices or materials containing phthalates. In settings where workers may be exposed to higher air phthalate concentrations than the general population, urinary metabolite and air phthalate concentrations are roughly correlated (Liss et al., 1985; Nielsen et al., 1985; Pan et al., 2006). Phthalates are metabolized and excreted quickly and do not accumulate in the body (Anderson et al., 2001).

Biomonitoring Information

Four metabolites of DEHP were measured for the Fourth National Report on Human Exposure to Environmental Chemicals: mono-(2-ethyl-5-hexyl) phthalate (MEHP), mono- (2-ethyl-5-oxohexyl) phthalate (MEOHP), mono-(2-ethyl- 5-hydroxyhexyl) phthalate (MEHHP) and mono-(2-ethyl- 5-carboxypentyl) phthalate (MECPP). MEHP is primarily formed by the hydrolysis of DEHP in the gastrointestinal tract and then absorbed. By contrast, DEHP present in medical devices and parenteral delivery systems results in the diester parent compound, rather than the monoester metabolite. being directly introduced into the blood. After parenteral administration hydrolysis of DEHP most likely also occurs in the blood, and subsequent metabolism is similar to that following ingestion (Koch et al.,

	2005a, 2005b, 2005c). MEOHP, MEHHP, and MECPP are produced by the oxidative metabolism of MEHP and are present at roughly three- to five-fold higher concentrations than MEHP in urine (Barr et al., 2003; Fromme et al., 2007; Koch et al., 2003). MEHP is the putative toxic metabolite of DEHP. Liver toxicity, decreased testicular weight, and testicular atrophy have been observed in rodents fed high doses over a short term or with chronic dosing (McKee et al., 2004; NTP-CERHR, 2000c, 2006). In contrast, marmoset monkeys fed high dose DEHP for longer than a year did not demonstrate testicular or liver toxicity (NTP-CERHR, 2006). Very high doses of DEHP have suppressed estradiol production in female rats (Lovecamp-Swan and Davis, 2003). The U.S. Food and Drug Administration determined that in adults, the amounts of DEHP or MEHP received from intravenous delivery systems or blood transfusions (DEHP is hydrolyzed to MEHP in stored blood) would result in short-term elevations similar to background levels (FDA, 2001). However, critically ill neonates and infants receiving selected or multiple intensive procedures, such as exchange transfusions, extracorporeal membrane oxygenation, and parenteral nutrition, could receive higher exposures than the general population (Calafat et al., 2004; FDA, 2001; Loff et al., 2000; Weuve et al., 2006). The levels of MEHP reported in NHANES 1999-2000, 2001-2002, and 2003-2004 appear roughly comparable to those reported previously in several small U.S. studies involving adults (Blount et al., 2000), pregnant women in New York City (Adibi et al., 2003), and low income African-American women in Washington, DC (Hoppin et al., 2002). In another sample of men attending an infertility clinic, the median and 95th percentile values of urinary MEHP were similar, but MEHHP and MEOHP were about three to five times higher than comparable values found in males in two NHANES survey periods (1999-2000, 2001-2002) (CDC, 2005; Hauser et al., 2007). In separate analyses of NHANES 1999-2000 and NHANES 2001-2002, the adjusted geometric mean levels of urinary MEHP were significantly higher in children compared with adolescents and adults, and in females compared with males (CDC, 2005; Silva et al., 2004). Studies of hospitalized neonates have reported urinary geometric mean levels of MEHP, MEOHP, and MEHHP that were two to five times higher, or more (depending on the intensity of DEHP-product exposure), than the geometric means of children in the NHANES subsamples for all three survey periods (Calafat et al., 2004; Weuve et al., 2006). Small studies of plasma and platelet donors have reported very high levels of MEHP, MEOHP, MEHHP and MECPP in urine collected shortly after these procedures (Koch et al., 2005b, 2005c). Finding a measurable amount of one or more DEHP metabolites in urine does not mean that the levels of the metabolites or the parent compound cause an adverse health effect. Biomonitoring studies on levels of urinary DEHP metabolites provide physicians and public health officials with reference values so that they can determine whether people have been exposed to higher levels of DEHP than are found in the general population. Biomonitoring data can also help scientists plan and conduct research on exposure and health effects.

	Sources of DEHP Phthalates are industrial chemicals, often called **plasticizers**, that are added to plastics make them more flexible and resilient. Phthalates are also used in other applications as solubilizing and stabilizing agents. Numerous products contain phthalates: adhesives; automotive plastics; detergents; lubricating oils; some medical devices and pharmaceuticals; plastic raincoats; solvents; vinyl tiles and flooring; and personal-care products, such as soap, shampoo, deodorants, lotions, fragrances, hair spray, and nail polish. Phthalates are often used in polyvinyl chloride-type plastics, such as plastic bags, garden hoses, inflatable recreational toys, blood product storage bags, intravenous medical tubing, and toys (ATSDR, 2001, 2002). Because they are not chemically bound to the plastics to which they are added, phthalates can be released into the environment during use or disposal of the product. Various phthalate esters have been measured in specific foods, indoor and ambient air, indoor dust, water sources, and sediments (Clark et al., 2003). DEHP is primarily used to produce flexibility in plastics, mainly polyvinyl chloride, which is used for many consumer products, toys, packaging film, and blood product storage and intravenous delivery systems. Concentrations in plastic materials may reach 40% by weight. DEHP has been removed from or replaced in most toys and food packaging in the United States. Following ingestion, DEHP is metabolized to more than 30 metabolites which are rapidly eliminated in urine, and in humans, as glucuronide conjugates (Albro et al., 1982; Albro and Lavenhar, 1989; ATSDR, 2002; Peck and Albro, 1982). The major source of di(2-ethylhexyl) phthalate in drinking water is discharge from rubber and chemical factories (U.S. EPA, 2010). **DEHP Regulation and Monitoring** The EPA limits the amount of DEHP that may be present in drinking water to 6 parts of DEHP per billion parts of water (6 ppb), or 6 ug/L. The Occupational Safety and Health Administration (OSHA) sets a maximum average of 5 milligrams of DEHP per cubic meter of air (5 mg/m^3) in the workplace during an 8-hour shift. The short-term (15-minute) exposure limit is 10 mg/m^3.
Use of Measure	These measures can assist by addressing the following surveillance functions: • Distribution measures provide information on the number of CWS and the number of people potentially exposed to DEHP at different concentrations. • Maximum concentrations provide information on the peak potential exposure to DEHP at the state level. • Mean concentrations at the CWS level provide information on potential exposure at a smaller geographic scale.
Limitations of The Measure	The current measures are derived for CWS only. Private wells may be another source of population exposure to DEHP. Transient non-community

	water systems, which are regulated by EPA, may also be an important source of DEHP exposure. Measures do not account for the variability in sampling, numbers of sampling repeats, and variability within systems. Concentrations in drinking water cannot be directly converted to exposure, because water consumption varies by climate, level of physical activity, and between people (EPA 2004). Due to errors in estimating populations, the measures may overestimate or underestimate the number of affected people.
Data Sources	Iowa Department of Natural Resources
Limitations of Data Sources	Ground water systems may have many wells with different DEHP concentrations that serve different parts of the population. Compliance samples are taken at each entry point to the distribution system. In systems with separate wells serving some branches or sections of the distribution system, the system mean would tend to underestimate the DEHP concentration of people served by wells with higher DEHP concentrations. Exposure may be higher or lower than estimated if data from multiple entry points for water with different DEHP levels are averaged to estimate levels for the PWS.
Related Indicators	Public Water Use
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