Bathing and Showering Guidance Support Document

June 2014

Chemical contamination of household tap water can involve exposure via the oral, inhalation and dermal pathways. When contamination of a private well occurs above a drinking water standard (e.g., federal MCL or CT Action Level – AL), the residents are advised to stop drinking the water while the contamination is investigated and solutions sought. This eliminates the oral pathway but still can involve extensive inhalation and dermal exposure depending upon the nature of the contaminant. This continued exposure leads to the question "What tap water concentration should be the upper limit for B/S exposure?" In this sense we broaden the definition of B/S exposure to include all non-ingestion pathways including contact with water or water-related volatiles via dishwashing, doing the laundry, tooth brushing and other personal hygiene and other household cleaning activities. CT DPH has developed B/S guidance for several contaminants (TCE, 1,4-dioxane, arsenic) and now has created this broader guidance for classes of chemicals for rapid decision-making. However, we always recommend that B/S questions for a specific chemical be brought before our department so that we can make a more specific determination if needed.

As part of this process, CT DPH queried the USEPA/States FSTRAC email list to see if other states had already developed generalized B/S guidance. The results of that survey are summarized in Table 1. As can be seen, no state has developed such generalized guidance and where this is addressed formally it is via a chemical-by-chemical approach typically for volatile organic chemicals. Wisconsin is the only state with a published list of the B/S determinations already made, called "Flush Only" guidance, which they created for 10 chemicals (Irving 2013). Table 2 lists these 10 determinations in comparison to the B/S determinations made presently in CT. Many of the B/S recommendations in CT are lower than the Wisconsin recommendations with this appearing to stem from different target cancer risk levels (10^{-6} in CT, 10^{-4} in WI).

The generalized screening guidance developed by CTDPH makes distinctions between classes of chemicals and across different time frames. To simplify the advice we have divided the classes of chemicals according to 2 criteria:

1) Organic vs. inorganic: organic (carbon-based compounds) tend to have greater volatility and be more easily transported across the skin than inorganic compounds (e.g., metals);

2) Volatile vs. non-volatile: within the organic category there is a large range of volatility with USEPA regional risk screening level (RSL) tables indicating which chemicals USEPA considers to be volatile. This determination is based upon the chemical's Henry's Law constant (>10^{-5} atm-m3/mole) with additional consideration of molecular weight (<200 g/mole being more likely to be volatile). Volatile chemicals can volatilize from tap water and enter the inhalation pathway while non- or low volatility chemicals are not considered to have a substantial inhalation exposure but could still enter the body across the skin (dermal exposure).

Chemical's with the potential for both dermal and inhalation exposure (organic volatiles) can be assumed to have non-ingestion exposure equal to or greater than ingestion exposure. This assumption comes from a variety of studies and exposure models. For example, California OEHHA's CalTox Model projects inhalation slightly more and dermal slightly less than ingestion for a typical VOC such as styrene (http://www.oehha.org/water/phg/pdf/053008appAstyrene.pdf). Other relevant references and models which support this conclusion are Maxwell et al. 1989; Jo et al. 1990a; Krishnan and Carrier 2008. Therefore, the approach in this B/S guidance is that avoidance of ingestion exposure may decrease the overall cancer and non-cancer risk but by a limited amount of up to 2 fold. This small change does not substantially affect the target water concentration. Therefore, for volatile organic chemicals, CT DPH applies the MCL or AL to B/S and other household uses of the water.

If the chemical is organic but non-volatile, dermal uptake is still possible. Jo et al. (1990b) demonstrated that chloroform uptake by the dermal route is roughly equivalent to the inhalation route during a test shower and the CalTox model derives dermal uptake factors that are sizeable compared to inhalation and oral exposures, depending upon the chemical modeled. Therefore, for non-volatile organic chemicals, the screening level assumption is that without oral and inhalation exposure, two important routes are no longer active and that dermal can contribute up to 1/3rd of the exposure limit that the MCL or AL was originally intended to establish. Therefore, the B/S guidance value for non-volatile organics is 3x higher than the MCL or AL.

Inorganic compounds generally have low volatility and low dermal penetration. Therefore, one can assume that non-ingestion pathways will contribute very little to the total exposure of inorganic contaminants. New Jersey DEP developed a white paper on the non-ingestion exposure of an inorganic contaminant, arsenic (Post 2003). That analysis concluded that the non-ingestion exposure of arsenic is <1% of the ingestion exposure. This is a reasonable basis for a ceiling value for inorganic contaminants in drinking water: assuming 1% dermal uptake and also assuming that 100% dermal uptake is on the same order of magnitude as ingestion (Jo et al. 1990b; CalTox), then the dermal route for inorganics might contribute as much as 1% of the drinking water route. This also covers the possibility of small amounts of incidental water ingestion from brushing of teeth or splashing in the shower and bath. This allows the MCL or AL to be exceeded 100 fold as a generalized ceiling for inorganic constituents.

The guidelines need to also address the time frame over which the B/S advice becomes active. Immediate cessation of non-ingestion uses of the water may be difficult or impractical (e.g., finding alternative places to shower) and should only be advised when necessary. CTDPH lists 3 months as a short-term window for obtaining a whole house filter or alternative water supply in those cases where B/S should be discontinued but it is not a substantial short term risk. This applies to detections between 1 and 10 fold greater than the MCL or AL for volatile organics. In that range the long-term cancer or non-cancer risk would still fall below de minimis levels if exposure were up to 3 months, even in sensitive receptors such as young children who may be at greater risk for certain types of carcinogens or developmental toxicants. Detections of volatile organics that are more than 10 fold greater than the MCL or AL lead to the concern of accumulation of risk from even relatively short-term exposures (e.g., 1

month) in the most vulnerable individuals. Also, depending upon how high the exceedance is, there may be concerns over acute effects and detection of odor from using the water. Therefore, the CT DPH advice in >10 fold exceedances is immediate cessation of B/S exposures for volatile organic chemicals. The one exception is where the volatile organic MCL or AL is a high number to start with, > 1000 ug/L. In that case, exceedances represent a large amount of volatile organic in the water which may lead to odor or other tainting and the potential for acute effects. Therefore, DPH recommends immediate discontinuation of B/S if detections of a volatile organic occur over its MCL/AL if the MCL/AL is >1000 ug/L.

The combination of exceedance amount and time frame is different for non-volatile organics and for inorganics given that their non-ingestion exposures are less so that it would take greater amounts of contamination to become a substantial risk. In this case, the non-volatile organics have a >30 fold threshold for immediate cessation of B/S while for inorganics there is no immediate cessation recommendation.

Inhalation of aerosols – another potential exposure route for non-volatile chemicals is the inhalation of aerosols while in the shower. However, experiments and modeling conducted by Zhou et al. (2007) suggest a very low dose of inhaled aerosol relative to ingestion. This is further supported by an analysis of shower aerosols containing non-volatile water disinfection byproducts (Xu and Weisel 2003). Inhalation of these aerosols was estimated to be <1% of the ingestion daily dose. Therefore, quantitative estimation of the aerosol contribution to non-ingestion exposure is not necessary.

Summary

CT DPH has reviewed the underlying exposure pathways as well as B/S guidance developed in other states in developing a framework for organics and inorganics with separation of volatiles from non-volatiles. While the guidance doesn't take the place of chemical-specific criteria, it offers a screening approach for estimating the B/S water concentration as a multiplier of an existing drinking water standard (MCL or CT DPH AL). This guidance distinguishes between cases in which immediate cessation of B/S is recommended vs. those in which up to 3 months can be taken to install a whole house filter or find an alternative supply. The guidance can be used by CT DPH, CT DEEP and local health departments in many rapid decisions regarding detections above the MCL/AL in a residential setting, until CT DPH has an opportunity to make a more specific determination. The guidance is flexible so that case-by-case factors such as the age and number of residents affected and the chemical(s) involved can affect the recommendations given.

References

Irving R. (2013) Chemical Flush Only Advisory Levels. For Screening Purposes Only. Wisconsin Dept. Health.

Jo WK, Weisel CP, Lioy PJ. 1990. Routes of chloroform exposure and body burden from showering with chlorinated tap water. Risk Anal 10: 575-580.

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Xu X1, Weisel CP (2003) Inhalation exposure to haloacetic acids and haloketones during showering. Environ Sci Technol. 37(3):569-76.

Zhou Y, Benson JM, Irvin C, Irshad H, Cheng YS. (2007) Particle size distribution and inhalation dose of shower water under selected operating conditions. Inhal Toxicol. 19(4): 333-342.

Table 1. Bathing and Showering Input from Other States

(based upon responses from query of FSTRAC list, Late March, 2014)

State	General Guidance	Volatiles Guidance	Inorganic Guidance	Time Frame
Michigan, June 1999	No	Whole house water use inhalation model yields exposure to be = to oral; dermal uptake based upon non-steady state penetration model from USEPA	Not specifically addressed	Assumes 3 years until filters put on so exposure only 3 yrs.
Rhode Island	Yes	1-10x MCL, limit contact to extent possible 10x > MCL, no bathing/showering	Same as volatiles	Not addressed
Massachusetts	No	Short-form calculations for shower yield inhaled dose 3-10 fold greater than oral; dermal exposure 10x < oral	Not specifically addressed	Not addressed
Minnesota	No	None	None	Not addressed
Nebraska	No	None – "follows USEPA guidance"	Not addressed	Not addressed
New Jersey	No	None presently but had an approach in the past, need to speak with Paul Saunders		
California (CalTox)	No	Whole house + shower inhalation model yields exposure = to oral; dermal approx. 50% of oral[1]	Not addressed	Not addressed
USEPA, Moya memo[2]	No	Models to calculate volatilization exposure in shower and from other household uses	Not addressed	Not addressed
Wisconsin	No	Have specific "non-flush" advisory levels for 10 chems – see table below; targets 1 in 10^4 cancer risk	E Coli and Arsenic considered	Not addressed
Illinois	No	None	None	Not addressed

[1]See CalTox-8 report for styrene at http://www.oehha.org/water/phg/pdf/053008appAstyrene.pdf

[2]Email from J. Moya, April 7 2014.

Table 2

Wisconsin DNR "Only Flush" Limits (2013) for Chemicals in Potable Water Supply[1]

Chemical	MCL or AL (ug/L)	CT Classification	CT B/S Level (ug/L)	WI DNR Flush Only (ug/L)
Arsenic	10	Inorganic	>500 avoid immediately; >100 avoid in 3 months	100-500
Atrazine	3	Organic	>30 avoid immediately; >3 avoid in 3 months	100
Benzene	5 (MCL) 1 (AL)	Organic	>10 avoid immediately; >1 avoid in 3 months	100
1,2-Dichloropropane	5 (MCL) 1 (AL)	Organic	>10 avoid immediately; >1 avoid in 3 months	60
Methylene chloride	5 (MCL)	Organic	>50 avoid immediately; >5 avoid in 3 months	500
MTBE	70 (AL)	Organic	>700 avoid immediately; >70 avoid in 3 months	1200
Naphthalene	none	---	---	1000
Tetrachloroethylene	5 (MCL)	Organic	>50 avoid immediately; >5 avoid in 3 months	70
Trichloroethylene	5 (MCL) 1 (AL)	Organic	>5 avoid immediately; >1 avoid in 3 months	300
Vinyl Chloride	2 (MCL)	Organic	>20 avoid immediately; >2 avoid in 3 months	2

[1]Irving R. (2013) Chemical Flush Only Advisory Levels. For Screening Purposes Only. Wisconsin Dept. Health.