

Chronic Dioxin Exposure

March, 2004

The principle effect from chronic dioxin exposure is an increase in mortality from certain types of cancers. The correlation of dioxin exposure with cancer mortality is easier to detect since there is a well-defined endpoint ... the death of the exposed subject.

However, noncancer effects, are difficult to recognize and studies offer conflicting results. The majority of these types of studies are based on assessing the health risks of dioxin exposure to breast feeding infants and young children. Almost no information is available on the non-cancer risks to adults.

Daily Dioxin Intakes - Noncancer Effects

Several governmental bodies have estimated or recommended acceptable daily intakes or similar parameters for TCDD and the other dioxin-like compounds.

The Agency for Toxic Substances and Disease Registry (ATSDR) defines a minimal risk level (MRL) for a hazardous substance (such as dioxins and furans) as an estimate of daily human exposure that is likely to be without appreciable risk of adverse noncancer health risks over a specified period of time and exposure route. In 1998, ATSDR provided the estimates of Tolerable Intakes for Dioxins and Dioxin-like Compounds that are shown in Table 1 below.

1. Oral MRL's - Noncancer Effects

	<u>Exposure Duration</u>	<u>TCDD Exposure</u>
Acute	< 14 days	200 pg/kg/day
Intermediate	15-265 days	20 pg/kg/day
Chronic	> 1 year	1 pg/kg/day

picogram = pg = 10^{-12} gram = one trillionth of a gram

It is difficult to obtain reliable noncancer information on the effects of actual human exposure. For this reason, the ATSDR relied on laboratory animal studies to develop the estimates of non-harmful exposure levels shown in the above table.

The Acute MRL is based on immunological effects in female mice; the Intermediate MRL on immunological effects in guinea pigs; and the Chronic MRL on developmental effects in rhesus monkey.

One of the difficulties in extrapolating animal studies to human effects is that the biological half-lives of dioxins in laboratory animals and humans are vastly different. TCDD has a half-life of approximately 6 to 8 years in humans and 10 to 30 days in rodents. As a result, TCDD accumulates in human tissue much more so than in most laboratory animals as the result of low-dose exposure. The differences in biological half-lives suggests that human responses to prolonged TCDD exposure would be expected to occur at much lower levels than in laboratory animals.

The lack of reliable human exposure data is not very comforting to those residents that have been exposed to dioxins for a number of years.

Daily Dioxin Intakes – Exposed Children

There has been more than a normal amount of “DioxinSpin” concerning the impact of dioxin levels in Midland Area soils on **Daily Dioxin Intakes**. EPA has indicated that the soil-related contribution to total Daily Dioxin Intake (DDI) is less than 5% for the average US citizen and that approximately 95% of the total DDI is based on diet. For the average US citizen, exposed to TEQ levels of **9.4 ppt**, the 5% - 95% breakdown is true. For the Midland Area residents that are exposed to much higher dioxin levels: (1) the amount of Daily Dioxin Intake is much higher and (2) soil related dioxins become the main contributor to DDI.

In the case of children, when dioxins levels are 200 ppt-TEQ, approximately 55% of the total dioxin intake is soil-related; at 400 ppt-TEQ, approximately 70%; at 900 ppt-TEQ, approximately 85%; and at

2600 ppt-TEQ (a level found in the floodplain), almost 95% of a child’s daily intake of dioxin is related to dioxin exposure from contamination soil.

However, the most important factor is not the percentage of soil related dioxin or diet-related dioxin in the daily intake of dioxin, but the amount of dioxins ingested each day. The only way to control the amount of daily dioxin intake, in children or adults, is to reduce the level of dioxin contamination in Midland Area soils and the floodplain of the river.

Young children are particularly vulnerable to soil-related dioxin exposure due to their playing habits. Table 2 below summarizes the calculation of Daily Dioxin Intakes for a five year old child exposed to typical US dioxin levels (9.4 ppt-TEQ), to average dioxin levels found in Midland (~600 ppt-TEQ), and to dioxin levels found in the Tittabawassee River floodplain.

2. Daily Dioxin Intake – Five Year Old Children

(pg/kg/day)

	<u>US Average</u>	<u>Midland, MI</u>	<u>Floodplain</u>
Dioxin/Furan – TEQ, ppt	9.4	600	2626
Soil Ingestion	0.063	4.02	17.60
Soil Dermal Contact	0.0014	0.09	0.39
Inhalation	0.060	3.83	16.76
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Total Soil-Related Intake	0.124	7.94	34.75
Total Dietary Dioxin Intake	2.27	2.27	2.27
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Total Daily Dioxin Intake	2.394	10.21	37.02

picogram = pg = 10⁻¹² gram = one trillionth of a gram

Even though the Daily Dioxin Intake for a five year old child living in Midland, MI is approximately four times more than the average US exposure level, still 10.2 trillionths of a gram/kg/day is an awfully small amount; so, perhaps, is the 37.02 trillionths of a gram/kg/day if the child is exposed to 2600 ppt-TEQ.

In January, 2001, the Public Health Service (PHS) of the US Department of Health and Human Services issued its position on TCDD. The PHS concluded that there is scientific consensus for a common mode of action of TCDD and other chlorinated dibenzodioxins and dibenzofurans. This involves events that stem from an initial binding of TCDD to the aryl (benzene or aromatic) hydrocarbon (Ah) receptor. TCDD has the highest affinity of any chlorinated dioxins and furans for human forms of the Ah receptor. The receptor is an intracellular protein found in every cell of the vertebrates, including rodents and humans. Through activation of the receptor, TCDD induces a wide spectrum of biological responses considered important to the carcinogenic process. Similar TCDD induced Ah receptor responses have been observed in both humans and rodents at similar concentrations of TCDD in the blood or body tissues. There is scientific consensus that TCDD binding to the Ah receptor is a necessary step – but not the only step – in the inducement of biological responses, including cancer.

Are trillionth grams per day of dioxin intake so small that this level of exposure can be ignored?

Consider this: If a five year old Midland child weighs 18 kilograms (~40 pounds), the Daily Dioxin Intake of 10.21 pg/kg/day is equal to 183.8 pg/day (183.8 trillionths of a gram) still a pretty small amount. If we assume that all of the TEQ is TCDD, then that five year old child playing somewhere in Midland, with a daily exposure to 600 ppt TEQ, will ingest 343,465,900,000 (343 Billion) molecules of TCDD each day. The same five year old child, if exposed to 2626 ppt of TEQ while playing in the floodplain of the river, will ingest more than one trillion molecules of TCDD each day. Actually, the exact number is 1,242,875,100,000 (1.242875×10^{12}) molecules of TCDD. These calculations are based on TCDD's molecular weight of 321.96 and Avogadro's number, 6.023×10^{23} molecules per gm-mole.

Children have wonderfully efficient biological defense mechanisms that protect them from a wide range of bacteria, viruses and toxic chemicals. But there are times when their defense mechanisms are overwhelmed and children get sick and some children, unfortunately, do die.

How many molecules of TCDD or other dioxin can be absorbed or reacted with the Ah receptor sites on a group of cells before the cells become cancerous and overwhelm the body's defense mechanisms? Until this answer is known, it is prudent to reduce dioxin exposure to as low a level as possible.

Dioxin Exposure to Nursing Infants

Dioxins and furans bio-accumulate in human bodies and are stored in the fatty tissues. Human breast milk is very high in lipids but dioxin levels in breast milk drop very rapidly with nursing. After six months of nursing, the dioxin concentration in breast milk has been reduced by 60% and after 12 months of nursing, the dioxin level in a mother's breast milk is only 33% of what it was when nursing was initiated. Dioxin levels in mothers drop because the inventory of dioxins and furans that had been in their bodies is passed on to their infants.

The calculated daily intakes of dioxins by nursing infants over twelve months is shown in Table 3 below:

<u>3. Daily Dioxin Intake – Nursing Infants</u>				
(pg/kg/day)				
Location	<u>US Avg.</u>	<u>Midland</u>	<u>River Floodplain 1</u>	<u>River Floodplain 2</u>
Dioxin Level, ppt-TEQ	9.4	600	940	2600
Breast Milk Dioxin Level, pg/gm BM lipid	4.2	17.9	26.0	65.5
Daily Dioxin Intake, pg/kg/day				
At Birth	242.4	1034	1501	3781
At 3 months	113.2	483	701	1766
At 6 months	54.8	234	339	855
At 9 months	36.3	155	225	566
At 12 months	21.7	93	134	338
Avg. Over 12 months	92.0	392	570	1435
Relative to 5 Year Old Child	38.4X	38.4X	38.9X	38.8X
Relative to Adult	156X	154X	156X	156X

As can be seen from the table, a nursing infant could potentially ingest almost 40 times more dioxin per day than would a five year child in the same location. Because of the high levels of dioxin that could be present in breast milk, a nursing infant could ingest more that 150 times more dioxin per day than would an adult.

A German study of 80 breast-fed infants determined that the average dioxin concentration in the blood serums of the infants was 25.3 pg-TEQ/gm-blood serum lipid after 4 months of nursing. Unfortunately, no information was provided on the environmental levels of dioxins that the mothers had experienced.

The EPA has measured and modeled dioxin body burden levels for both nursing infants, children and adults when exposed to Urban dioxin levels of 9.4 ppt-TEQ. Extrapolation of these body burden levels resulting from higher levels of dioxins are shown in Table 4 below.

4. Dioxin Body Burden Levels
(pg-TEQ/gm blood serum lipids)

Location	<u>US Avg.</u>	<u>Midland</u>	<u>River Floodplain 1</u>	<u>River Floodplain 2</u>
Dioxin Level, ppt-TEQ	9.4	600	940	2600
Dioxin Body Burden levels, pg-TEQ/gm (ppt)				
Infant, 12 Months Nursing	46	196.5	285.4	718.8
Child, 5 Years Old	??	??	??	??
Adult	21.1	99.8	130.8	329.7

Although there is information as to the daily intake of dioxins, both measured and calculated, by young children, no information about the dioxin body burden levels in young children could not be found. The lack of information is very surprising since it is well recognized that young children consume more dioxins on a daily basis than do adults. Perhaps, the sensitivity of the subject matter has prevented an honest appraisal of a problem which may be extremely serious, especially in communities in which dioxin exposure is elevated.

There is always some risk in extrapolating from one dioxin contamination level to higher ones. Without actual data, extrapolation is the only option available. If Dow or a health agency challenges the scientific assumptions that form the basis for these calculations, the remedy is extremely simple.... provide data based on actual sampling and measurement. For the cost of a few dioxin analyzes, a great deal of uncertainty can be eliminated.

“DioxinSpin” has restricted inquiries into the actual amount of dioxin exposure in Midland and in the floodplain for more than twenty years. If adults are not concerned about their own exposure and the levels of dioxins that might be present in their own bodies, it is hard to believe that parents would rather not know the levels of dioxins in their children.

Health Risks to Children Exposed to Dioxins

It is recognized that young children and nursing infants are especially sensitive to dioxins. Unfortunately, there is very little scientific information that defines the impact of daily dioxin intakes at the levels being experienced in Midland.

The Michigan Department of Community Health has stated, “Fetuses, infants, and children may be especially sensitive to dioxin because they are growing and developing rapidly. However, information on the effects of dioxin in children is limited.”

Dr. Theodore Schettler, M.D., MPH, *Human Effects of Dioxin, 2003*, made these remarks, “... in the US, a breast feeding infant consumes approximately [17 – 20 times more dioxin, TCDD equivalent basis, per day] than the average adult. Nursing infant exposures are at levels which cause abnormalities in animal studies. All studies of dioxin toxicity indicate that early development is the lifestage of greatest sensitivity to many of [dioxin’s] health effects. However, since many of the adverse effects of fetal or infant dioxin exposure may be apparent only much later in life, human epidemiological studies of the results of those exposures have yet to be conducted since early exposures are impossible to estimate with accuracy.”

It should be noted that Dr. Schettler’s comments pertain to normal levels (~10 ppt) of dioxins in the US and not to the much higher dioxin levels being found in Midland or in the river floodplain.

Health Risks to Adults Exposed to Dioxins

This topic will be covered in depth in the section entitled “Mortality Studies”. Generally, dioxin/furan exposure is associated with an increase in the incidence of specific cancers and with an increased mortality from those cancers. The higher the dioxin exposure, the higher the increase.

Table 5 below summarizes the calculated daily dioxin intakes for adults and the dioxin body burdens for adults at varying exposure levels.

5. Dioxin Exposure – Adults

Location	<u>US Avg.</u>	<u>Midland</u>	<u>River Floodplain</u>	<u>River Floodplain</u>
Dioxin Level, ppt-TEQ	9.4	600	940	2600
Daily Dioxin Intake, pg/kg/day	0.59	2.54	3.66	9.22
Dioxin Body Burden, pg-TEQ/gm serum lipid	21.1	99.8	130.8	329.7

While Dow has carried out an extensive examination of the mortality of its employees exposed to dioxins that spans almost fifty years, Dow has supposedly never measured the dioxin levels in those employees. Dow studies have “estimated” dioxin exposure levels and have “estimated” that dioxin body burdens in employees might be “very low”, “low”, “medium”, “high” and “very high” – but actual levels have never been determined to verify these estimates. However, based on Dow’s well known position on protecting worker health from the harmful effects of chemical exposure, perhaps Dow has measured dioxin body burdens in its employees... perhaps, the results have just never been published. “Good news” is seldom concealed – just bad. It’s hard to imagine that Dow would knowingly conceal such information.

The EPA has provided some guidance on the lifetime increase for cancer based on daily intake of TCDD. These estimates are shown in Table 6 below:

6. Increased Risk of Cancer – TCDD Exposure

<u>Lifetime Cancer Risk</u>	<u>Daily TCDD Intake</u> (pg-TEQ/kg/day)
1 in 10	300
1 in 100	30.0
1 in 1000	3.0
1 in 1 million	0.001

A small number of epidemiology studies have determined the dioxin body burden levels of exposed workers and have tried to correlate body burden levels with increased mortality. The calculated body burden levels for Midland area adults exposed to dioxin levels of 2000 ppt-TEQ or more are at the same level as those measured in three studies.

7. Body Burden Levels – Adults

(pg-TEQ/gm serum lipid)

<u>Study</u>	<u>Burden Levels</u>	<u>Impact on Mortality</u>
NIOSH, 1991 – 5172 exposed chemical workers	233	1. All Cancers – 15% increase 2. Rare Cancers – 62% increase
NIOSH, 1991 – 1520 exposed chemical workers, > 20 years latency	462	1. All Cancers – 46% increase
German, 1998 – 459 exposed Chlorophenol, phenoxy workers, 20 years latency	296	1. All Cancers – 154% increase
Spanish, 1998 – 549 exposed phenoxy workers, > 20 years latency	244	1. All Cancers – 410% increase over non-exposed workers

Dioxin contamination of Midland Area soils has been known since 1983. Subsequent dioxin measurements taken in 1996 (thirteen years later) confirmed that dioxin levels were even higher than

previously measured. It is now 2004 (twenty-one years later) and that actual levels of dioxins in the blood serum of Midland residents have still not been determined.

The presence of dioxins/furans in fish taken from the Tittabawassee River was detected in the late 1960's or early 1970's. An extensive survey of dioxin/furan levels in the river sediments or floodplain soils was never undertaken until an "accidental" finding of high levels of dioxins/furans was made in late 2001 – more than 30 years after first being detected in the food chain.

Due to the small amount of sampling of Midland Area soils and floodplain soils that has been carried out over the past 20 to 30 years, there is less than a 1% probability that all locations of high dioxin contamination have been found.

The amazing lack of meaningful action to determine actual dioxin exposure levels and to impeditment more than a token amount of corrective action to reduce dioxin exposure is attributed to the effectiveness of "DioxinSpin" by both The Dow Chemical Company and various regulatory agencies.