

7. Hazard assessment

7.1. Prioritization of the contaminants

Torontonians would be at risk from the presence of carcinogens only if a pathway by which they could become exposed exists. For example, Torontonians who are not using Lake Ontario recreationally (i.e. bathing, fishing) are unlikely to be at risk from exposure to the contaminants present in its sediment. The route of exposure is also important. The availability of contaminants (bioavailability) often differs depending on the route of exposure. More importantly, many effects are route-specific. A contaminant that may be considered carcinogenic by one route of exposure may not induce cancer in humans by another exposure route.

Many organizations including USEPA (EDF, 2001) have concluded that exposure to carcinogens present in the ambient and indoor air is the top ranking concern for the ten contaminants examined in this report. In the case of dioxins and furans, food is the major direct source of exposure. Since there has been a reduction in the release of dioxins and furans from pulp and paper mills as a result of process changes, air emissions remain the major contributor to what is present in the food.

In order to prioritize the carcinogens, the method developed by EDF and described in section 6.1.1.2 was used. The levels of the ten carcinogens in Toronto's air were converted into benzene equivalents (Toxic Equivalency Potentials or TEPS) and the non-cancer properties were converted into toluene TEPs (see table 7.1.1). TEP represents the number of pounds (or kilograms) of benzene (or toluene) that would have to be released to pose approximately the same level of health risk as the reported release of a given contaminant. In simple terms, TEP factor is the ratio of the risk posed by a one-pound (or one-kilogram) release of a given chemical to the risk posed by a one-pound (or one-kilogram) release of benzene or toluene. The cancer risk posed by 1 µg benzene per m³ air is estimated to be 4.1 x 10⁻⁶ or 4.1 in a million (USEPA, 1998). The second column in table 7.1.1 lists the levels of contaminants assumed to be present in Toronto air (data summarized previously in table 6.3.1.1). Columns 3 to 4 list the TEP conversion factors developed by EDF. Columns 5 to 6 provide the benzene and toluene TEPs respectively. The last 2 columns estimate the percentage of benzene or toluene TEPS attributable to a given contaminant based on the total TEPS from all assessed contaminants. TEPS have not been calculated for water releases.

The table shows that benzene accounts for more than half (56 percent) of benzene TEPS and that benzene, chromium (VI) and PAHs together account for the vast majority (94%) of benzene TEPS. It must be recognized that neither asbestos or dioxins were included in this ranking because EDF has not calculated TEP factors.

ToxProbe believes that the contribution of PAHs is significantly underestimated, because of the method EDF used to estimate inhalation potency for PAH. EDF assumed that the potency of PAH is identical for the oral and inhalation route, but there is evidence that PAHs are more potent as carcinogens when exposed by inhalation than by ingestion. Furthermore, EDF's estimate was based on the summation of toxicity attributable to individual PAHs in the mixture. As discussed in section 4.5.2, this approach has been

shown to underestimate the cancer risk from this family of contaminants. It is quite possible that PAHs actually rank higher than benzene.

Asbestos, dioxins and tetrachloroethylene are not included in the ranking of toxicity potential as carcinogens because EDF has not developed benzene TEP factors for these chemicals. EDF developed its TEP factors based on daily intakes estimated from all media including food as a result of air emissions, and the cancer potencies developed by US EPA or Cal EPA. USEPA has withdrawn its dose response assessment for tetrachloroethylene and has yet to finalize the dose response assessment for dioxins and furans. Because of the uncertainty regarding the carcinogenicity of tetrachloroethylene and its levels in the environment, it would be prudent to consider its rank in terms of toluene equivalent (see next paragraph) as well.

The selected carcinogens elicit also non-cancer effects, as discussed briefly in section 4.4. It is therefore appropriate to also establish ranking of these contaminants based on toluene TEPs. In terms of non-cancer effects, cadmium is ranked the highest, followed by tetrachloroethylene. However, It should be pointed out that the rankings based on toluene TEPs and benzene TEPS do not have equal weight, as unacceptable levels of toxicity can be observed with benzene at doses at which toluene is not considered likely to be toxic. Ranking based on benzene TEPs is therefore recommended as the primary ranking scheme for selected carcinogens in Toronto.

EDF has cautioned that TEP is only a tool for screening the potential human health impacts of environmental release. Although TEP-weighted releases are risk assessment based, they do not characterize the estimated increase in health risk associated with a chemical exposure and cannot be combined with information about an exposed population to predict the incidence of adverse effects. Furthermore, the TEP ranking scheme does not take into account qualitative differences, such as the types of cancer that chemicals may cause or the weight of evidence supporting the identification of a chemical as a carcinogen. For example, benzene is a human carcinogen causing acute myeloid leukemia, whereas formaldehyde is a probable human carcinogen causing nasal tumours. Further uncertainty for the ranking in this report results from applying the TEP factors to the ambient air contaminant levels, based on the assumption that the ambient air levels are proportional to the quantities released in air. This assumption may not hold because the contaminants may behave differently in the environment after being released due to different physical and chemical properties.

Table 7.1.2 lists the final ranking of selected carcinogens in terms of environmental exposures and occupational exposures in Toronto. The occupational rank is based on the estimated number of people exposed to each contaminant in the workplace in Toronto as it has been derived in Table 5.1.3.1. The environmental rank is based on toxicity ranking at given ambient levels as shown in table 7.1.1. Benzene and PAHs emerge as important sources of concern in both the workplace and the environment in Toronto.

It should be stressed that while the environmental ranking was weighted taking into account carcinogenic potency of selected contaminants, such weighting was not considered appropriate for occupational exposures because the magnitude of exposure in the workplace was not known.

Table 7.1.1 Ranking of toxicity potential of selected carcinogens in Toronto air

	Ambient levels (mg/m ³)	Cancer TEP air factor	Non-canc TEP air factor	Benzene ¹ TEP	Toluene TEP	% Benzene TEP	% Toluene TEP
1,3-Butadiene	0.32	0.33	1.2	0.11	0.38	2.7	0.012
Asbestos	-	-	-	-	-	-	-
Benzene	2.2	1	17	2.2	37	56	1.1
Cadmium	0.00042	83	5000000	0.035	2100	0.89	64
Chromium (VI)	0.0052	170	6400	0.88	33	23	1.0
Dioxins							
Formaldehyde	3.3	0.003	4.8	0.0099	16	0.25	0.48
PAHs (B[a]P)	0.00036	1600		0.58	0	15	0
Tetrachloroethylene	5	1.8	220		1100		33
Trichloroethylene	1.6	0.059	0.98	0.093	1.5	2.4	0.047
Total				3.9	3300.	100	100

¹ Potency of benzene by inhalation exposure is 4.1×10^{-6} per $\mu\text{g}/\text{m}^3$.

Table 7.1.2 Environmental and occupational ranking of selected contaminants

	Environmental Rank	Occupational Rank
1,3-Butadiene	4	9
Asbestos	-	5
Benzene	1	3
Cadmium	5	7
Chromium (VI)	2	6
Dioxins	-	-
Formaldehyde	7	4
PAHs (B[a]P)	3	2
Tetrachloroethylene	-	1
Trichloroethylene	6	8

7.2. Conclusion

This report summarizes all the readily available information relating to the ten contaminants in Toronto's workplace and environment.

7.2.1 Carcinogenic Potential

Toxicology of the selected contaminants is fairly well described and understood and there is a general consensus regarding their potencies (see section 4). Dioxin-like compounds (dioxins, dibenzofurans and coplanar PCBs), tetrachloroethylene and PAHs are exceptions. For tetrachloroethylene, there is no consensus in the scientific community and regulatory agencies with respect to its ability to induce cancer effects in humans. Tetrachloroethylene is considered unlikely to be a human carcinogen by CEPA and the rationale for that conclusion seems compelling, even though IARC classified this contaminant as a probable human carcinogen. The classification has implications on the estimates of toxicity and IARC's classification may lead to exaggeration of the cancer risk posed by this chemical.

The evidence for dioxin-like compounds being carcinogens is strong and is generally accepted, but USEPA makes a very conservative assumption that these contaminants are toxic even at infinitesimally low doses, while WHO and Canadian CEPA concluded that dioxin-like compounds are not toxic below a certain threshold level. The difference in opinion has great implications for the calculated risk at very low levels of exposure and the USEPA's approach appears to be overly conservative for this family of contaminants.

There are two approaches to assess the potency of a PAH complex mixture. One approach is based on summation of the risk attributed to individual PAHs. This approach underestimates the overall risk from this family of contaminants, probably because the few PAHs for which potency has been estimated account for only a small proportion of PAHs in a typical mixture found in an environmental or occupational setting. It is therefore recommended to calculate cancer risk based on the potency estimate of the whole PAH mixture. WHO and MOE have derived such estimates.

7.2.2 Occupational Exposure

Information on occupational exposure from readily available sources is patchy and out of date. There are about 1,336,000 workers in Toronto and it was estimated that about 118 000 of those are potentially exposed (8.8%) to the ten selected contaminants. It appears that well over 80% of all of these potential exposures come from only four top-ranking sectors (manufacture of wearing apparel, land transport, personal and household services, wholesale and retail trade and restaurants and hotels) and that tetrachloroethylene, PAHs and benzene account for the vast majority (about 80%) of potentially exposed workers (see table 7.2.1). In general, ToxProbe recommends proceeding on a sector-by-sector basis in any

future attempt to study further the occupational exposure to carcinogens in Toronto. ToxProbe also recommends that the current study be used for prioritization for further information gathering and risk reduction planning only, and that any drafting of regulatory policies be conducted only when actual Toronto data have been collected.

Table 7.2.1 Sectors and contaminants with highest above background incidence of occupational exposures in Toronto. The most important exposures are in italics.

Industry sector	Contaminants
Manufacture of wearing apparel, except footwear	<i>Tetrachloroethylene</i> , formaldehyde, PAHs
Manufacture of furniture and fixtures	<i>Formaldehyde</i>
Wholesale and retail trade and restaurants and hotels	<i>Benzene</i> , Asbestos, PAHs
Land transport	<i>PAHs</i>
Personal and household services	<i>Benzene</i> , Tetrachloroethylene, PAHs, Asbestos, Chromium (VI)

7.2.3 Environmental Exposure

Environmental levels are far better established for most media than occupational exposure levels. In terms of exposure from ambient air sources, benzene, chromium VI and PAHs contribute most to the cancer risk from inhalation to the selected substances. Exposure from food may be larger than from air on a gram for gram basis, but for a number of contaminants, the cancer potency is larger by inhalation. The exception is dioxins and related compounds. Their potency estimate is considered the same for all routes of exposure and ingestion of food is the major pathway by which people are exposed.

Levels of the selected contaminants tend to be very low in Toronto drinking water. Information regarding indoor air is less reliable and the indoor air levels can be very much affected by indoor emission sources. Indoor exposures are probably the biggest sources of cancer risk for most of the selected carcinogens. Some of the most important potential indoor sources (e.g. smoking, use of wood-burning fireplace) reflect lifestyle decisions of the residents. Exposures and risks from contaminated soils, surface waters and sediments are also lifestyle dependent, but it is expected that the risk is low for most Toronto residents. Risk could theoretically be significant for residents regularly swimming and bathing in Toronto waters, where exposure to sediment can take place. Furthermore, regular gardening and high volume consumption of home-grown produce could lead to significant exposures for residents who live on contaminated land.

7.2.4 Health Impact

The current report does not estimate the actual risk to Toronto residents due to occupational and environmental exposure to selected carcinogens. Currently available occupational data are insufficient to conduct such assessment. It would be possible to estimate cancer and non-cancer risk for *typical* Toronto residents from environmental exposures to the selected chemicals. It would be harder to estimate with any reliability the number of people at risk from exposures to contaminated soils, surface water and sediments, because exposure would depend on the likelihood and frequency of the residents swimming and bathing in lake Ontario, eating fish caught in that lake and the number of people in Toronto consuming home-grown produce. Although estimates are available for the general US and Canadian populations, city-specific data may be sufficiently different from the national and US averages to have an impact on the outcome of the assessment.

A number of studies have shown that exposure from ambient and, especially, indoor air tends to have the greatest impact on human health. In this context, it needs to be reiterated that although the greatest exposures and therefore risks tend to come from indoor exposure because of the duration Toronto residents tend to spend indoors, outdoor contamination does reach indoor air and often the exposure to outdoor sources is greater while indoors.

Supermarket food comes from many sources and generally the food purchased in Toronto is not likely to differ much from the food purchased in supermarkets elsewhere in the region. Due to the low levels of contaminants, drinking water is unlikely a major source of human exposure for the selected contaminants.

In terms of air, the levels of exposure in Toronto are not expected to be very high in comparison with national averages. Toronto does not have within its boundaries large point sources of the selected contaminants. The most important sources are likely to be mobile sources such as cars, area sources such as residential heating, and small point sources such as dry-cleaning facilities and some restaurants. Because of the high population and high density of population in Toronto, these sources may contribute more to overall exposures in Toronto than they would in smaller communities. Furthermore, the area sources and small point sources tend to be located in the midst of the living community. Toronto should therefore focus its efforts on mapping out and estimating area sources and small sources within its boundaries and on obtaining recent Toronto-specific indoor air data. The studies should cover a wider range of contaminants and include both cancer-causing chemicals and chemicals with other toxic endpoints.