toxic nation

A REPORT ON POLLUTION IN CANADIANS

ENVIRONMENTAL | DEFENCE

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Errata

Page 4, Paragraph 4, Sentence 2
Should read: The most common form of cancer in women, breast cancer, has increased by 74.3 per cent in the last 17 years,...

Page 5, Table 3
Breast cancer statistic should read: 74.3% increase (1987-2005)

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Executive Summary

Toxic Nation: A Report on Pollution in Canadians

A cocktail of harmful toxic chemicals was detected in every person tested in a cross-Canada study of pollution in people conducted by Environmental Defence. *Toxic Nation: A Report on Pollution in Canadians* confirms that, no matter where people live, how old they are or what they do for a living, they are contaminated with measurable levels of chemicals that can cause cancer and respiratory problems, disrupt hormones, and affect reproduction and neurological development.

Studies conducted in the United States and Europe have revealed that people from all walks of life are contaminated by a mixture of toxic chemicals, but information on pollution in Canadians has been limited until now. The study described in our report is the first in Canada to test for a broad range of chemicals in average Canadians throughout the country.

Canadian industries release many of the chemicals for which we tested. In 2003, air pollution emitted by Canadian industries alone totalled over 4.1 billion kilograms (kg) and comprised millions of kg of chemicals, such as carcinogens, hormone disruptors, respiratory toxins and reproductive/developmental toxins. Scientific research surveyed in this report links exposure to toxic chemicals to many ailments that have been increasing in Canadians in recent decades, including several forms of cancer, reproductive disorders, birth defects, asthma and neurodevelopmental disorders.

For the *Toxic Nation* report, Environmental Defence tested 11 people from across the country to examine the range of pollutants that can be found in Canadians' bodies. We tested blood and urine samples for the presence of 88 chemicals that are released through industrial and agricultural processes into our land, air and water; people can also be exposed to these chemicals through contact with, or use of, consumer products. The chemicals tested for include heavy metals, polybrominated diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs), perfluorooctane sulfonate (PFOS), organochlorine pesticides, organophosphate insecticide metabolites, and volatile and semi-volatile organic compounds (VOCs).

The objectives of the study were to: (a) determine whether pollutants are present at measurable levels in Canadians; (b) add to the growing body of knowledge about the type and concentration of chemicals found in the populations of industrialized countries; (c) identify chemicals of concern that may affect the health of Canadians; and, (d) create awareness of strategies people can take to reduce their exposure to such chemicals.

Environmental Defence's *Toxic Nation* report coincides with the mandatory five-year review of Canada's overarching law regulating toxic chemicals, the Canadian Environmental Protection Act (CEPA). The findings of our study on pollution inside Canadians demonstrate that CEPA has been ineffective in protecting people from toxic contamination.

Key Findings

- Laboratory tests detected 60 of the 88 chemicals tested in 11 volunteers, including 18 heavy metals, five PBDEs, 14 PCBs, one perfluorinated chemical, 10 organochlorine pesticides, five organophosphate insecticide metabolites and seven VOCs.

- On average, 44 chemicals were detected in each volunteer, including 41 carcinogens, 27 hormone disruptors, 21 respiratory toxins and 53 reproductive/developmental toxins.

- To our knowledge, this report is the first cross-Canada study to measure PFOS levels in people, and our findings show that PFOS contamination is likely widespread in the Canadian population.

- Results from one volunteer, a First Nations leader from northern Quebec, showed the highest levels of mercury and persistent organic pollutants (POPs), such as PCBs and organochlorine pesticides. These findings are consistent with previous studies indicating that, despite the distance from most point sources of pollution, many chemicals tend to accumulate in the North due to air and water currents and climatic conditions.

- Although PCBs were banned in the 1970s, they were detected in all volunteers, including those born in the early 1980s. However, our results suggest that the ban has been successful in decreasing people's exposure. The study revealed a higher number of PCBs in older volunteers in comparison with younger volunteers; for example, between 12 and 14 PCBs were detected in the samples from volunteers aged 60 and older, whereas five PCBs were detected in the samples from volunteers aged 25 and under.

The findings of this study do not prove that worrisome health trends among Canadians are solely or directly due to exposure to harmful chemicals. However, all potential causes for poor health must be examined and the likely contribution of toxic chemicals cannot be ignored.

Recommendations

Canadians expect their country to be a leader in the protection of human health and the environment. The *Toxic Nation* report calls on the Government of Canada to acknowledge the research and policy initiatives of other jurisdictions, and to act to ensure that Canadians receive at least the same level of protection against toxic chemicals as Europeans and Americans. The proposed new chemicals framework of the European Union (EU)—REACH (Regulation, Evaluation and Authorisation of CHemicals)—if passed in its current form, will provide the most stringent regulation of chemicals and the highest level of protection for human health of any jurisdiction. In the United States, the proposed Child, Worker, and Consumer-Safe Chemicals Act has the potential to follow the European lead. The EU and several U.S. states have also taken action to ban some of the most toxic chemicals, including brominated flame retardants, perfluorinated chemicals and their precursors, and phthalates.

The CEPA Review began in fall 2005 and is an opportunity to bring the regulation of toxic chemicals in Canada up to international standards. Environmental Defence is participating in the Review and recommending significant improvements to the Act, including:

Establish timelines to virtually eliminate the use of toxic chemicals:

- Achieve virtual elimination of all releases of carcinogens to the air and water by 2008.
- Establish timelines to virtually eliminate respiratory toxins, endocrine disruptors, and reproductive and neurological toxins from use, release, generation, disposal or recycling.
- As a matter of priority, ban brominated flame retardants, perfluorinated chemicals and their precursors, and phthalates.

Make industry accountable for its chemicals:

- Shift the burden of proof onto industry to prove the safety of its chemicals before their introduction to, or continued use in, the market.
- Mandate industry to adopt a safe substitution policy to replace toxic substances with safer or non-toxic substances.

Regulate toxic chemicals in consumer products:

- Expand CEPA to regulate toxic chemicals that may be released during the use, or disposal of, consumer products.

Reduce pollution in the Great Lakes basin:

- Given that 45 per cent of Canada's total toxic air pollution is emitted in the Great Lakes basin, a special section of CEPA is needed to focus on this pollution hotspot.

Environmental Defence also urges Canadians to reduce their personal exposure to toxic chemicals wherever possible. Sources of toxic exposure are varied and numerous, and small changes in lifestyle and purchasing habits can make a difference in the level of pollutants each person carries. Environmental Defence encourages people to visit the *Toxic Nation* web site at **www.ToxicNation.ca/pledge** and commit to at least five actions that will reduce their exposure to harmful chemicals.

However individual Canadians choose to act, the Canadian government cannot turn its back on the evidence of human contamination revealed in *Toxic Nation*. Toxic chemicals emitted by industry and released through contact with, or use of, consumer products are measurable in Canadians. To protect people today and safeguard the health of future generations, the Canadian government must set a course to ensure that all citizens, no matter where they live, how old they are or what they do for a living, will not be exposed to toxic substances.

Overview

Chemical Canada

In the last 50 years, the global production and use of manufactured chemicals have increased substantially. More than 80,000 new chemicals have been created, and the quantity of chemicals produced, used and released into the environment is drastically higher now than a generation ago. Scientific studies have found toxic chemicals in every corner of every country—in the land, the air, the water, wildlife, people's blood and women's breast milk.

Information on the health and environmental effects of chemicals has not kept pace with their development and use. As a result, many of the chemicals that people are exposed to every day have never been assessed for their impact on human health. The pace of regulation has also fallen far behind the pace of chemical development, and, as new chemicals enter the market (without undergoing adequate safety testing), governments struggle to "manage" known toxic chemicals already in use.

In Canada, over 23,000 chemicals are registered for production and use in the market, and each year an increasing volume of toxic chemicals is released into the environment. A recent report by Environmental Defence and the Canadian Environmental Law Association, *Shattering the Myth of Pollution Progress in Canada: A National Report* , showed that between 1995 and 2002 the volume of chemicals reported released and transferred in Canada increased by 49 per cent.[1] The findings were based on a PollutionWatch analysis of data from Environment Canada's national pollution reporting program—the National Pollutant Release Inventory (NPRI). PollutionWatch data for 2003 show that Canadian industries reported releasing nearly 18 million kilograms (kg) of carcinogens, over 14 million kg of hormone disrupting chemicals, nearly 4.3 billion kg of respiratory toxins, and over one billion kg of reproductive/developmental toxins (Table 1).[2] A more detailed analysis of the NPRI data also revealed that nearly half (45 per cent) of all toxic air emissions and over one-third (36 per cent) of all reported emissions to water originate in the Great Lakes basin—home to over one third of all Canadians.[3] In addition to being exposed to industrial emissions, Canadians are exposed to chemicals every day through commonly used products in their homes, schools and workplaces.

The myth that Canada's vast landscape is pristine and untainted is also dispelled by the report *The Maple Leaf in the OECD*, which confirms that internationally Canada has one of the worst pollution records among industrialized countries (Table 2).[4] From emissions of air pollutants, like VOCs and sulphur oxides, to the

Table 1. Pollutant releases by industry in Canada in 2003

Substance Type	Amount Released
Carcinogens	Nearly 18 million kg
Hormone disruptors	Over 14 million kg
Respiratory toxins	Over 4.3 billion kg
Reproductive/developmental toxins	Over 1 billion kg

Source: PollutionWatch analysis of data from the National Pollutant Release Inventory, Environment Canada (October 2005)

Table 2. Canada's environmental ranking among OECD nations

Pollution Indicator	Canada's Ranking out of the OECD nations
Volatile organic compounds (non-methane) (kg/capita)	29th of 29
Sulphur oxides (kg/capita)	27th of 28
Nitrogen oxides (kg/capita)	26th of 28
Carbon monoxide (kg/capita)	28th of 28
Ozone-depleting substances (kg/capita)	12th of 14
Greenhouse gases (tonnes of CO_2/capita)	27th of 29
Nuclear waste (kg/1,000 people)	30th of 30
Pesticide use (kg/km^2 arable land)	8th of 30

Source: Gunton, T.I. (2005)

production of nuclear waste, Canada consistently ranks at the bottom of the 30 industrialized countries that report to the Environmental Data Compendium of the Organisation for Economic Co-operation and Development (OECD). Canada has held on to its poor environmental ranking for over a decade now, placing 28th of 30 countries in 1992, 2002 and again in 2005.

Chemical Pollution and Human Health

A large body of scientific research links exposure to toxic chemicals to many ailments that plague Canadians, including several forms of cancer, reproductive problems and birth defects, respiratory illnesses such as asthma, and neurodevelopmental disorders such as Attention Deficit Hyperactivity Disorder (ADHD). Statistics on Canadian health trends show that the occurrence of some of these illnesses has been increasing in recent decades.

The findings of this study do not prove that the increase in chemical production and emissions is solely or directly responsible for declining health trends among Canadians. However, scientific studies surveyed in this report demonstrate a connection between exposure to toxic chemicals and the occurrence of disease and illness in people. Public health officials should take note of the correlation between increased use of toxic chemicals and increases in the occurrence of diseases and illnesses.

Cancer

Cancer is the leading cause of death in Canada. Since the late 1980s, the number of new cases of cancer per year increased by 54.4 per cent, and the number of deaths increased by 43.4 per cent (Figure 1).[5] The most common form of cancer in women, breast cancer, has increased by 74.3 per cent in the last 17 years, while prostate cancer, the most common form of cancer among men, has increased by 121.5 per cent (Table 3).[6] Combined, over 40,000 new cases of breast and prostate cancer will be diagnosed in 2005.[7] Overall, more than 40 per cent of Canadians will develop cancer during their lifetime, and a quarter of Canadians will die from the disease.[8]

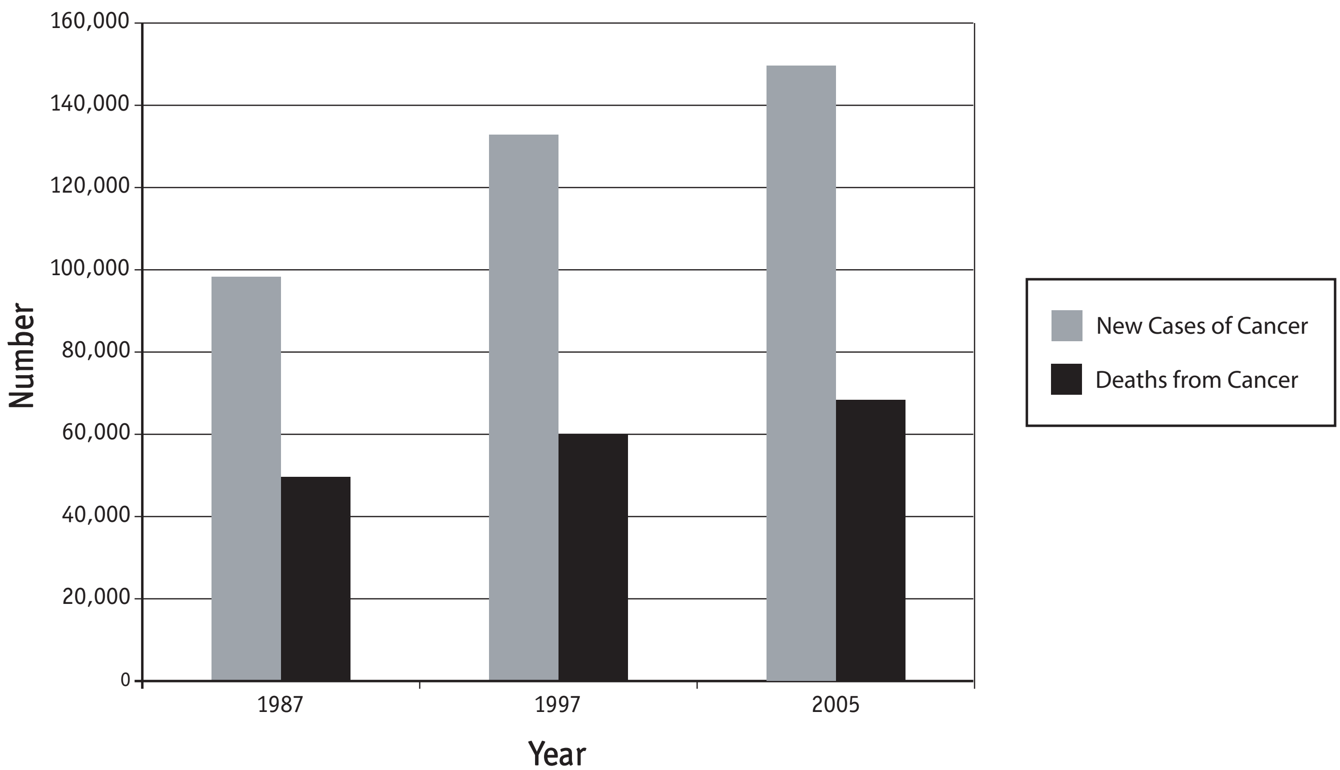


Figure 1. Canadian cancer trends 1987-2005
Source: Adapted from Canadian Cancer Society/National Cancer Institute of Canada (2005) and Canadian Cancer Society (2000)

Although researchers often point to Canada's aging population to explain the increase in the incidence of cancer, data from the Canadian Cancer Society, Health Canada and Statistics Canada show that cancer incidence has increased among Canadians aged 20 to 44. The types of cancer most common among this age group differ from those among older people, which suggests that risk factors other than age may be responsible for certain types of cancer.[9]

A report by the Canadian Cancer Society found that the most significant increases in cancer among 20- to 44-year-olds were for non-Hodgkin's lymphoma and thyroid, lung and testicular cancer.[10] The report showed that between 1987 and 1996:

- non-Hodgkin's lymphoma increased by 31.5 per cent among women and 36 per cent among men;
- thyroid cancer increased by 59.4 per cent among women and 37.8 per cent among men;
- lung cancer increased by 17.1 per cent among women; and
- testicular cancer increased by 15.3 per cent.[11]

These findings are consistent with the results of another study on the incidence of testicular germ cell cancer in Ontario, which found that between 1964 and 1996 testicular cancer increased by 59.4 per cent, the greatest increase being among 15- to 29-year-olds.[12] Unfortunately, these types of long-range data do not exist for other types of cancer at the national level.

Canadian data on trends in childhood cancer are also lacking, although cancer is known to be the most common cause of death by disease in Canadian children.[13] The most common forms of cancer among Canadian children are leukemia and cancers of the brain and spinal cord. According to U.S. studies, childhood cancer rates have increased gradually and with consistency for many forms of the disease, while increasing most rapidly for leukemia and cancers of the central nervous system (i.e., brain tumours).[14]

Many chemicals used and released in Canada are either known to cause cancer or suspected of being carcinogenic. Recognized cancer-causing chemicals include several phthalates, VOCs, heavy metals, polychlorinated biphenyls (PCBs), pesticides, dioxin and furans, and brominated flame retardants.[15] Some chemicals that have only recently been studied for their potential to cause cancer include perfluorinated chemicals and bisphenol A.[16]

Table 3. Canadian health statistics

Ailment	Statistic
Cancer	54.4% increase (1987-2005)
Breast cancer	74.3% increase (1987-2005)
Prostate cancer	121.5% increase (1987-2005)
Asthma	Six-fold increase (from 2% to 12%) in children and youth (1978-1996)
Learning disabilities	10% of Canadians
Behavioural problems	17% to 21% of children (2002)
Infertility	8% of couples
Birth defects	5% of children (1995)

Neurodevelopmental Disorders: Behavioural Problems and Learning Disabilities

Several types of behavioural problems common in children are linked to neurodevelopment, the most well known of which is ADHD. In 2002, the National Longitudinal Survey of Children and Youth (NLSCY) reported that 17 to 21 per cent of Canadian children have a behavioural problem (Table 3).[17] Although Canadian data tracking the prevalence of behaviour problems over the course of previous decades are lacking, certain data sources show that the prevalence of these disorders may be on the rise. Sales of Ritalin, a stimulant most commonly prescribed to treat ADHD, increased by nearly 110 per cent between 1994 and 1998, from 26.8 million pills in 1994 to 56.2 million pills in 1998 (Table 3).[18] A U.S. study found that the diagnosis rates for autism and ADHD nearly quadrupled between 1989 and 2000, with the prevalence of ADHD increasing by 381 per cent and the prevalence of autism increasing by 358 per cent.[19]

Learning disabilities, such as dyslexia, are surprisingly common among Canadians. Learning disabilities are the most common long-term condition children suffer between birth and age 14.[20] Across all age groups, three million Canadians, or one in 10, have a learning disability (Table 3).[21] Learning disabilities are lifelong medical disorders that affect people's ability to interpret what they see and hear or to link information from different parts of the brain. These neurological disorders significantly affect all aspects of human functioning; youth with learning disabilities are more likely to drop out of high school, become young offenders, commit suicide and have trouble keeping a job in their adulthood.[22]

Researchers are now exploring the effects of chemicals on the developing brain and their role in the development of behavioural problems and learning disabilities. Recent scientific research, supported by the Learning Disabilities Association of Canada (LDAC) and the Canadian Institute of Child Health (CICH), shows that chemicals such as metals, pesticides, VOCs, dioxins and PCBS are toxic to the developing brain.[23] These neurotoxins produce permanent alterations in brain development and function, which can lead to learning disabilities and behavioural disorders. Scientific studies have also found that a newer group of chemicals, polybrominated diphenyl ethers (PBDEs), may disrupt the thyroid and cause neurodevelopmental disorders.[24]

Reproductive Disorders

Reproductive disorders affect both fertility and the development of healthy babies. In Canada, 8 per cent of couples of reproductive age are infertile (Table 3).[25] The most common male reproductive problems include testicular cancer, low sperm count and motility, undescended testes and hyposadias (a congenital defect of the penis). Numerous international studies show that the prevalence of all four male reproductive disorders have increased in recent decades, with one recent report suggesting that the four disorders are symptoms of one overarching disorder, testicular dysgenesis syndrome, that may now be more common due to "adverse environmental influences."[26]

Female reproductive problems include endometriosis, failure to ovulate normally, tubal pregnancies and miscarriages. Canadian data on female reproductive problems are lacking; however, a recent U.S. study found that, contrary to popular belief, rising rates of infertility among women cannot be entirely explained by voluntary delayed childbearing and the effect of age on fertility. One report found that, between 1982 and 1995, impaired fertility among women aged 15 to 44 increased by 25 per cent overall, with only a 6 per cent increase in women aged 35 to 44 but a 42 per cent increase among 15 to 24-year-olds—demonstrating that younger women in particular are showing signs of fertility problems.[27]

Current studies on hormone disrupting synthetic chemicals, such as phthalates, bisphenol A, PBDEs and PCBs, show that these substances may be contributing to rising rates of reproductive problems in people. In a comprehensive review of existing research, Ted Schettler, co-author of *Generations at Risk: Reproductive Health and the Environment*, found that "a large number of reports document the unequivocal impacts of environmental contaminants on wildlife reproductive health, including reduced sperm counts, reproductive failure, birth defects of the reproductive tract, and behavioural abnormalities."[28] Earlier this year, the results from a study involving human subjects showed that chemicals in the environment, specifically phthalates, may be affecting the reproductive development of male infants.[29]

The impact of environmental contaminants on male to female birth ratios is another issue that the scientific community has recently raised. At least two studies have recognized a correlation between exposure to pollutants and a decrease in the number of male births.[30] In one First Nations community in Sarnia, Ontario, birth records from 1994 to 2003 revealed that twice as many girls than boys were born. The community is located next to large petrochemical, polymer and chemical plants. Researchers indicated that they cannot be sure that the sudden declining ratio in the birth of males relative to females in the community is due to environmental exposure, but the possibility merits immediate study.[31] It is well known that, in comparison to male foetuses, female foetuses are stronger and more able to survive in harsher conditions, so when exposed to pollutants male foetuses may be more likely to perish in the womb or suffer obstetric complications.[32]

Respiratory Illnesses

Respiratory illnesses, such as bronchitis, emphysema, asthma, and lung cancer, affect three million Canadians.[33] Asthma, an illness that is most common in children and youth, affects 7 to 10 per cent of the pediatric population[34] and nearly 13 per cent of youth aged 12 to 19.[35] The prevalence of asthma among newborns to 19-year-olds has increased in recent decades, from 2 per cent in 1978 to 12 per cent in 1996 (Table 3).[36] Among all Canadians aged 12 and older, the prevalence of asthma increased from 6.5 per cent in 1994/95 to 8.4 per cent in 2000/01.[37] According to the Canadian Lung Association, a general trend exists of increased deaths and hospitalizations due to asthma in Canada and the rest of the industrialized world.[38]

Lung cancer is another prevalent respiratory disease. It is the most common form of cancer diagnosed in Canadians and the leading cause of cancer deaths in both men and women. It is estimated that in 2005, lung cancer will be diagnosed in an estimated 22,200 Canadians, and 19,000 will die of it.[39] Although smoking cigarettes is a major cause of lung cancer and smoking rates are now at the lowest level in Canadian history, the prevalence of lung cancer continues to increase.[40]

Air pollution, and smog specifically, is well known to be a significant cause of respiratory diseases and related deaths. The health effects of smog include asthma, bronchitis, allergies and premature death. The federal government estimates that up to 16,000 premature deaths per year in Canada are associated with ambient air pollution that can include nitrogen oxide, sulphur oxide, particulate matter and VOCs.[41] In the most comprehensive study of the health effects of air pollution, the Ontario Medical Association (OMA) found that in Ontario alone more than 5,800 residents are expected to die prematurely in 2005 due to breathing polluted air. The OMA also expects that almost 60,000 air-pollution-related visits to emergency departments will occur in Ontario in 2005 alone, mainly due to cardiovascular and respiratory illnesses such as asthma.[42]

In addition to outdoor and industrial air pollutants, the Canadian Lung Association highlights residential pesticides and indoor chemical pollutants found in many common household products as causes and triggers of respiratory illnesses.[43]

Linking Chemicals to Effects on Health

Through a comprehensive literature review, the Environmental Working Group (EWG), based in Washington D.C., demonstrated that chemicals are studied intensively only after they harm human health or contaminate the biosphere (Figure 2).[44] EWG's review illustrates that we cannot take comfort in a lack of scientific proof of harm, particularly in the case of chemicals that the scientific community has only recently begun to study. The federal government has a duty to avoid repeating the mistakes made in the past when warning signals about some of the most notorious toxic chemicals were ignored. Toxic chemicals such as dichlorodiphenyltrichloroethane (DDT) and PCBs were banned only after they had wreaked havoc on the environment and human health for decades, and because of their persistent nature, they continue to threaten human health. Chemicals such as perfluorinated chemicals and brominated flame retardants may be the DDTs and PCBs of the future, but only a few governments have placed bans on these chemicals or developed programs for their phase-out.

Toxic Chemicals Policy in Canada

Chemical regulation has one central purpose: to protect the health and safety of people and the environment from the potential harm caused by the thousands of substances used in our society. Canada's approach to the regulation of toxic chemicals has failed to fulfill this key purpose.

Under Canada's current approach to toxic chemicals management, the majority of chemicals on the market have never been, and never will be, assessed for their potential effects on human health. In addition, when there has been uncertainty about the effects of a chemical, the government has delayed taking precautionary action to protect people from potential harm. Even worse, Canada has no vision of a future free of toxic substances; rather, our federal government allows chemicals that are known to harm health to remain on the market indefinitely.

Canada's Approach to Toxic Chemicals

Canada's overarching national toxic chemicals law is the Canadian Environmental Protection Act (CEPA) (1999). It regulates the manufacture, marketing, use, transport and disposal of toxic chemicals. Similarly, the Pest Control Products Act (PCPA) regulates the use of pesticides. The new PCPA received Royal Assent in December 2002, and would represent a major step forward in the protection of human health, particularly children, except that it is not yet in force. Toxic chemicals in consumer products are regulated by the Hazardous Products Act.

The approach to toxic chemical regulation under CEPA has proven to be ineffective in protecting the health of Canadians and the environment for four main reasons:

1. No emphasis is placed on the virtual elimination of toxic substances.

The approach to pollution prevention under CEPA ensures that exposure to toxic chemicals will continue to compromise the health of future generations of Canadians. Under CEPA, the goal has been to minimize the volume of toxic chemical emissions through "end of pipe" solutions, rather than to eliminate the production of toxic chemicals at the source. In fact, contrary to the preamble of CEPA, which states that "the Government of Canada acknowledges the need to virtually eliminate the most persistent and bioaccumulative toxic substances", only one toxic substance has been slated for virtual elimination.[45] Even the government's

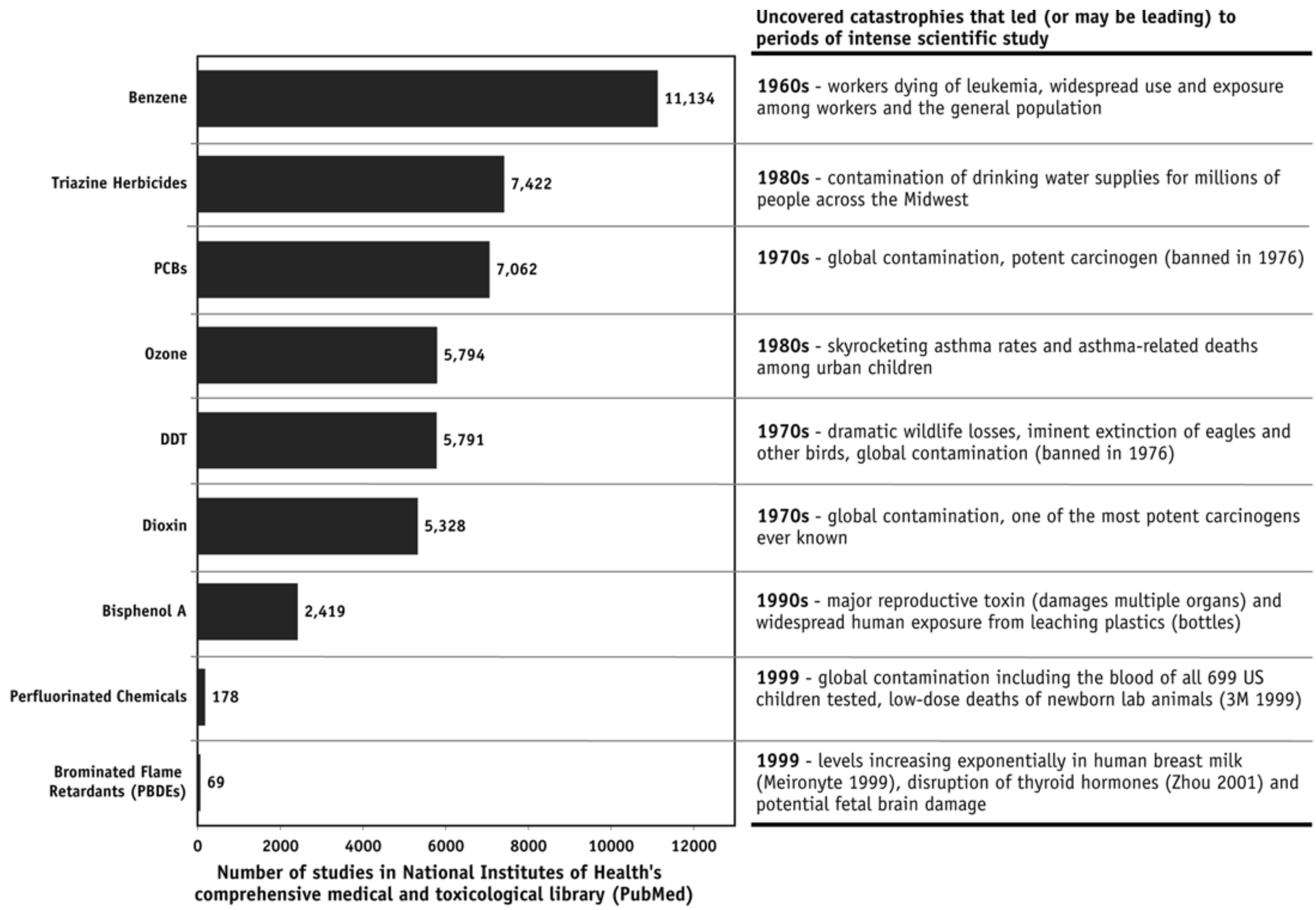


Figure 2. Chemical research trails damage to human health and the environment
Source: EWG Compilation (2003)

less ambitious measures to reduce the amount of toxic chemicals flowing into the environment are ineffective. So far only five Pollution Prevention Plans have been developed, and none of them has been implemented.[46] The plans have no regulatory or mandatory nature and their contents are not publicly available, meaning that to satisfy the pollution prevention requirement, a company that produces toxic chemicals is required only to write a document that can be secretly filed away.

Protecting public health from chemical releases does not merely require reducing the volume of toxic chemicals being released; rather, it requires phasing out the production and use of the most toxic chemicals. To achieve the phase-out of toxic chemicals, the substitution principle must be used as the primary pollution prevention tool. Substitution involves replacing a toxic chemical with a safer or non-toxic substance, or redesigning the product or system to eliminate the need for the toxic chemical. Substitution must be mandatory for all chemicals that are, or are suspected to be, inherently toxic, and should involve strict timelines.

2. Industry is not accountable for its chemicals.

Under CEPA, safety testing is not required for the vast majority of chemicals. When the Act was introduced, blanket approval was given to approximately 23,000 existing chemicals, without any requirements for safety assessment. Health Canada and

Environment Canada are in the midst of a lengthy process to categorize those 23,000 chemicals (which make up the Domestic Substances List) by 2006 and to select chemicals of greatest concern. As of fall 2005, Health Canada and Environment Canada have devised draft lists that include approximately 4,600 substances of greatest concern that may be selected to undergo Screening Level Risk Assessment (SLRA). All chemicals on the Domestic Substances List remain on the market while the categorization and screening process continues. Non-governmental organizations have raised concerns that the approaches used to select those chemicals of greatest concern may be flawed, and that the final list may not capture all substances that are persistent or bioaccumulative and inherently toxic.

In addition to existing substances, every year approximately 300 new chemicals are introduced to the Canadian market; the toxicity data and testing requirements for these chemicals are insufficient to determine the risks they pose to human health, and the data are not peer reviewed or publicly available.[47]

Beyond the details of CEPA, there is one basic, overarching problem with the approach to the safety assessment of chemicals under the Act: companies are not required to conduct adequate safety testing before their chemicals enter the market. Rather, the government is responsible for proving a chemical is hazardous after it is already in use. For existing substances, which make up the majority of chemicals on the market, companies are not required to conduct retroactive safety testing. For new substances, the requirements for safety assessment are inadequate and do not ensure that all new toxic substances will be identified and kept off the market. This substance by substance approach to regulating toxic chemicals is ineffective for several reasons:

- First, the approach is extremely time and labour intensive and places an unfair burden on the public purse.
- Second, because of a lack of government resources, the majority of chemicals on the Canadian market will never be adequately assessed for their safety, and many chemicals that are extremely harmful to human health will continue to be used and released.
- Third, when a chemical is identified as potentially hazardous, the safety assessment process is dangerously slow-it typically takes 10 to 15 years to complete the safety assessment and for any restrictions to take effect.

The burden of proof must be shifted to industry to prove that a chemical is safe *before* it is permitted to enter, or continue to be used, on the market. To prove the safety of all existing and new chemicals industry should be required to submit safety data, including the latest information on health effects.

3. CEPA does not regulate chemicals used in products.

CEPA focuses on toxic chemicals that industry uses, manufactures and releases but does not address the release of toxic chemicals during the use of a product or its disposal. This major gap in the scope of CEPA leaves consumers vulnerable to exposure to toxic chemicals through the use of products.

Toxic chemicals in products are mainly regulated under the Hazardous Products Act, which has been ineffective in protecting people, particularly children, from potential exposure. The Hazardous Products Act includes no requirements for a pre-market assessment of risks associated with a product, and only after Health Canada receives complaints or recognizes a potential risk is a post-market assessment conducted. Even after Health Canada determines that a product poses a risk, it has no authority to mandate product recalls; it can seize only products in storage, meaning that products already on store shelves remain unless companies take voluntary action to impose their own recall.[48] The primary tools Health Canada relies on to protect consumers are public advisories and warnings.

In the 1990s, for example, Greenpeace found dangerously high levels of cadmium and lead in a variety of plastic children's products that are commonly used in Canada. While no regulations exist regarding plastic products intended for use by children three years of age or older, the levels detected in the products far exceeded guidelines proposed by Health Canada.[49] Greenpeace's study also detected high levels of di(2-ethylhexyl) phthalate (DEHP), which was assessed in the early 1990s under CEPA and was found to be "CEPA-toxic." This example illustrates the disconnect between the regulation of toxic chemicals under CEPA and the regulation of consumer products under the Hazardous Products Act, since, at this time, there is no regulatory limit for phthalate levels in children's plastic products in Canada.[50]

Expanding the scope of CEPA to cover toxic chemicals in products would ensure that all toxic chemicals in products are regulated and, in the case of new products, that at least some pre-market assessment will occur. Inclusion of toxic chemicals used in consumer products under CEPA will also give Health Canada the authority to regulate chemicals in products in a precautionary manner and to develop programs to eliminate their use through phase-outs. As the overarching law on toxic substances, CEPA should cover all chemicals in Canada, whether they be released through industrial emissions or from products.

4. No attention is focused on the largest pollution hotspot in Canada: the Great Lakes basin.

Nearly half (45 per cent) of the toxic air emissions released in Canada and over one-third (36 per cent) of all reported releases to water originate from industrial facilities located in the Great Lakes basin.[51] A special subsection of CEPA that focuses on Great Lakes protection is needed to curtail these emissions and provide protection for the Great Lakes ecosystem and its more than 10 million citizens. A similar Great Lakes section already exists in the U.S. Clean Water Act.

Air pollution knows no boundaries, so while the population of the Great Lakes basin will benefit from stronger laws to decrease toxic air emissions, so will the populations of other regions that receive air pollution from Great Lakes industries.

The CEPA Review and International Action on Toxic Chemicals

CEPA's mandatory five-year review is an opportunity to address the shortcomings in Canada's approach to the regulation of toxic chemicals. The CEPA Review comes on the heels of a proposal for a new framework, REACH (Registration, Evaluation and Authorisation of CHemicals), for the regulation of toxic chemicals in the European Union (EU) and the proposal for stronger regulation of toxic chemicals in the United States under the Child, Worker, and Consumer-Safe Chemicals Act of 2005. These pieces of legislation are models that the Canadian government should seek to emulate in its effort to bring the regulation of toxic chemicals in Canada up to international standards.

The EU's proposed REACH framework will be voted on by the end of 2005 and, if passed in its current form, will become the most progressive piece of toxic chemical legislation of any jurisdiction. No chemical will be allowed on the market until safety data are made available, companies will be responsible for proving the safety of the chemicals they use, and chemicals that are known to be toxic will be phased out and replaced with safe substitutes. Within the REACH framework, member states of the EU will be able to place precautionary restrictions or bans on chemicals that are suspected of causing irreparable damage. The EU has already put in place restrictions and bans to protect people from some of the most harmful chemicals, including brominated flame retardants and phthalates.

In July 2005, Democratic senators in the United States introduced the Child, Worker, and Consumer-Safe Chemicals Act as an amendment to the Toxic Substances Control Act (TSCA). The proposed amendment encompasses the most proactive aspects of the European legislation and is seen as a first step towards reforming U.S. regulations in line with REACH. Under the proposed Act, industry would be responsible for proving the safety of their chemicals prior to gaining market access, the Environmental Protection Agency (EPA) would gain access to business information on chemicals, and a Safer Alternatives Program and green chemistry research network would be established to support the substitution and phase-out of toxic chemicals.

While the EU and the United States have taken different approaches in updating their chemical regulations, either by devising a new framework or amending an existing one, both have incorporated three central components of 21st-century chemical regulation: shifting the burden of proof to industry to prove the safety of their new and existing chemicals, requiring safety data prior to market access, and focusing on the substitution of toxic chemicals with safer alternatives. The CEPA Review is an opportunity to update the regulation of chemicals in Canada through amendments that follow the precedents set by REACH and the Child, Worker and Consumer-Safe Chemicals Act.

Methodology

Volunteers

Environmental Defence tested 11 volunteers from across Canada. Volunteers were selected to represent the diversity of the Canadian population, including men and women from a variety of geographic locations, ethnicities, ages and occupations. All the volunteers were 18 years of age or older, were not knowingly pregnant and had no known medical condition that would preclude them from participating in the study.

Four men and seven women volunteered to participate in the study. The age range was 23 to 75, with 47 being the average. The volunteers were a TV producer, First Nations chief, doctor, postal worker, artist, small business owner, lawyer, student, student leader, trade union leader and environmental activist. These volunteers are known to their loved ones as mothers, fathers, sisters, brothers, aunts, uncles and grandparents. They come from the West Coast, the Prairies, central Canada, the North, Quebec and Newfoundland. More information about each volunteer is included in the "Results" section.

Choice of Laboratories

To complete the analysis of the blood and urine samples, two laboratories were contracted-Centre de Toxicologie, Institut National de Santé Publique du Québec (INSPQ) in Sainte-Foy, Quebec, and Accu-Chem Laboratories in Richardson, Texas. The analyses required to determine the presence and concentration of the chemicals in the samples were complex, and no single lab had the capacity to test for all the chemicals that Environmental Defence selected for inclusion in the study.

Both labs are respected in their field. The toxicology centre at INSPQ is a leader in the Canadian public health sector and has over 30 years experience in clinical, industrial and environmental toxicology. INSPQ was selected as the primary lab and conducted the analyses for heavy metals, PBDEs, PCBs, organochlorine pesticides, organophosphate insecticide metabolites and perfluorooctane sulfonate (PFOS). Accu-Chem has over 20 years experience in providing reliable test results for a wide array of occupational and environmental toxins and conducted the analysis for VOCs.

Choice of Chemicals

The chemicals included in the analyses were selected on the basis of several considerations (Appendix 2):

- Environmental Defence looked at which chemicals have been included in studies conducted by other organizations in the United States and Europe to ensure that our study contributed to the international analysis of pollution in people.

- The potential health effects of the chemicals were also considered, and those chemicals that are most harmful to human health, and particularly to children's development, were targeted for study. Such chemicals include carcinogens, hormone disruptors, reproductive/developmental toxins and respiratory toxins.

- A few of the most harmful, persistent and bioaccumulative chemicals were selected for their potential to be phased out and added to the virtual elimination list under CEPA. For these chemicals, consideration was given to actions other jurisdictions have taken to impose regulations or bans.

- Once the above considerations were taken into account, the final set of chemicals was determined by assessing technical feasibility and the cost of testing. Given this, chemicals such as PFOA, phthalates, triclosan, bisphenol A, dioxins and furans were not included in the study.

Chemical Groups Included in the Study

PBDEs (polybrominated diphenyl ethers)

PBDEs are used in brominated flame retardants in a range of products, including furniture, carpets, mattresses, curtains, some clothing and electronics (televisions, computers, etc.). These chemicals are highly persistent and bioaccumulative; they are suspected hormone disruptors and can cause cancer and reproductive and developmental disorders. PBDEs are suspected of having particularly damaging effects on the thyroid (which controls brain development) and, as a result, PBDEs may cause neurodevelopmental disorders such as learning disabilities and behavioural problems.

The level of PBDEs in North Americans is far higher than levels found in people anywhere else in the world, and studies show that levels are increasing. While the Canadian government has no plans to pursue a ban of PBDEs, other jurisdictions are taking precautionary action. By 2006 certain types of PBDEs will be banned in the European Union, Maine and California; in Hawaii they will be banned in 2008.

Perfluorinated Chemicals

Perfluorinated chemicals are widely used for their resistance to environmental breakdown in a range of consumer products. PFOS is used as a stain repellent on clothing and other fabric products, such as carpets. This chemical is also used in food packaging, particularly in microwave popcorn bags and packaging for fast food. Another perfluorinated chemical of concern that we were unable to test for is PFOA (perfluorooctanoic acid), which is used to make GORE-TEX® products and Teflon® products, such as non-stick cookware. Although much more research is needed on these chemicals, existing studies have shown that perfluorinated chemicals are extremely persistent. Studies also suggest that these chemicals can cause cancer and disrupt hormones.

In July 2004, Canada was the first country to take precautionary action on perfluorinated chemicals by banning for a two-year period three fluorinated polymers that contain telomer alcohols; in 2006, depending on new information the ban can either be lifted or made permanent. Fluorotelomer alcohols are precursors that transform into fluorocarboxylates, such as PFOA and PFOS. Sweden has proposed that PFOS be banned globally under the Stockholm Convention on Persistent Organic Pollutants.

VOCs (volatile and semi-volatile organic compounds

People are exposed to VOCs through paints and varnishes, solvents, gasoline ingredients, adhesives and many other products, as well as through polluted air and contaminated tap water. VOCs have various health effects; most VOCs are recognized carcinogens and suspected hormone disruptors, respiratory toxins and reproductive/developmental toxins. All VOCs are toxic to the nervous system.

In Canada, some VOCs are listed as toxic under the Canadian Environmental Protection Act (CEPA), while others have no research or reporting requirements. Canada has the highest emissions of VOCs per capita of all OECD member countries.

PCBs (polychlorinated biphenyls

PCBs have been banned in Canada since 1977, yet they continue to be released into the environment from sources in other countries and from PCB-containing industrial equipment that is still in use here in Canada. PCBs are highly toxic and persistent chemicals that build up in wildlife and people through the process of bioaccumulation. PCBs cause many types of cancer, as well as reproductive and developmental disorders. These chemicals damage the nervous, immune and cardiovascular systems, leading to birth defects, brain damage and decreased immune function. PCBs are also suspected of being hormone disruptors.

Under the Stockholm Convention on Persistent Organic Pollutants, Canada is required to phase out the remaining uses of PCBs (in electrical transformers and other equipment) by 2025 and to dispose of these PCBS in an environmentally sound manner by 2028.

Organochlorine pesticides

Organochlorine pesticides are mainly used on agricultural crops-the fruits and vegetables we all eat. The most notorious organochlorine pesticide is dichlorodiphenyltrichloroethane (DDT), which has been banned in Canada, but continues to be used in other countries. Canada still allows the use of many organochlorine pesticides other than DDT, even though research has shown that these chemicals are persistent and bioaccumulative. Organochlorine pesticides as a group of chemicals are recognized carcinogens and reproductive/developmental toxins; they are also suspected hormone disruptors and respiratory toxins.

Organophosphate insecticide metabolites

Dialkyl phosphate metabolites are breakdown products of organophosphate insecticides such as parathion, diazinon, malathion, and chloropyrifos, which have a variety of applications for lawns, agricultural crops, and mosquito and pest control. These chemicals are suspected of causing cancer and reproductive, developmental and neurological disorders.

In Canada, a variety of restrictions apply to the use of these chemicals, especially in residential settings. Many of these chemicals, however, are used extensively in agriculture in Canada and in other countries from which we import fresh produce.

Heavy metals

Heavy metals in our environment include lead, mercury, arsenic and cadmium; some occur naturally, but most come from human-made sources. Most exposures to arsenic come from wood that is pressure treated with chromated copper arsenate (CCA), which is found in playgrounds, fences, decks and other constructions. Manufacturers of CCA-treated wood voluntarily agreed to stop producing it for consumer use by the end of 2003; however, CCA-treated wood is still available in stores until existing stock is sold. Exposures to lead come from lead paint and emissions from industrial facilities such as metal smelters. Coal-fired power plants are the major source of mercury, which is also found in batteries, fluorescent light tubes, thermometers and related equipment. The major sources of cadmium are pigments and cigarette smoking; emissions also come from industrial sources such as lead and copper smelting and municipal waste incineration. The most common source of exposure to metals is food.

As a group, heavy metals are known to cause cancer and reproductive and developmental disorders. Many heavy metals are also suspected hormone disruptors and respiratory toxins. Canada has a variety of tools in place to regulate the production, use and disposal of these chemicals, but much stronger regulations are needed.

Categorizing Chemicals According to Their Effects on Health

All chemicals included in the study were categorized according to four groups of health effects: carcinogens, hormone disruptors, respiratory toxins and reproductive/developmental toxins. The chemicals were categorized according to information obtained from Scorecard.org Chemical Profiles in August 2005.[52] Scorecard.org differentiates between chemicals that are recognized and suspected of causing adverse health effects; in our study we included both recognized and suspected health effects in our total count of health effects. For example, our count of 41 carcinogens detected includes both recognized and suspected carcinogenic chemicals. Also, in this report the health category "reproductive/developmental toxins" combines three separate health effects categories identified on Scorecard.org: developmental toxins, reproductive toxins and neurotoxins.

Choice of Biological Materials

The biological materials selected for analysis were determined by the laboratories and are consistent with their established analytical protocols. Several of the tests can be conducted using a variety of biological materials, including hair, breast milk, body fat, blood and urine. Blood and urine are the preferred biological materials because, unlike breast milk, they can be taken from every volunteer. Drawing blood and urine samples is less invasive than sampling body fat and, in many cases, these materials also provide more accurate results than hair strand tests. Appendix 1 provides more detail about the analytical methods used in the study.

Personal and Lifestyle Questionnaire

The volunteers were asked to complete a brief lifestyle questionnaire that was used to explore linkages between a person's lifestyle and the chemicals found in his or her body. The questionnaire gathered responses about the following:

- gender
- age
- weight-gain, loss, stability
- place of residence
- occupation
- visit to malaria-infested area
- diet (vegan, dairy-and-egg-eating vegetarian, fish-eating vegetarian, omnivore)
- proportion of diet that is organic
- hours of computer use per day
- recent purchase of consumer products likely to contain brominated flame retardants, such as carpet, mattress, sofa or car
- use of air fresheners
- pesticide use in and around the home and garden
- consumption of cigarettes

Limitations of the Study

The *Toxic Nation* report is a groundbreaking project that begins to explore contamination levels in the Canadian population. In other industrialized countries, considerable research has been conducted on the burden of chemicals found in human residents; in Canada, however, the amount of research conducted on the pollution in Canadians is limited. Our study begins to fill this knowledge gap.

Because our sampling methodology was not randomized and our sample size of 11 is too small to produce statistically significant results, the *Toxic Nation* findings are largely demonstrative. The detection of so many chemicals in every volunteer is, however, cause for concern and further analyses.

It is important to note that scientists have not yet developed reliable or affordable tests for detecting the vast majority of chemicals in human samples. While for some chemicals no tests are available, for others the tests developed may not be sensitive enough to detect a chemical even if it is present in a sample. Testing for chemical concentrations in human samples is expensive; for example, testing for the 88 chemicals included in this study cost $1,545 Cdn per volunteer. These technical limitations, combined with financial restrictions, mean that the group of chemicals included in our study is not a complete representation of all the chemicals people are exposed to daily. While we tested for 88 chemicals, in reality most Canadians are exposed to a much larger number of chemicals each day.

While the results for a volunteer may show a level of a chemical higher or lower than the median level, the results cannot be used to predict how exposure to a chemical will affect the individual's health. Scientific knowledge about the human health effects of many individual chemicals is limited.[53] Even less information is available on the cumulative effects of long-term exposure to multiple chemicals at low levels.[54] In effect, Canadians are test subjects in an uncontrolled experiment on the impact of daily exposure to a multitude of harmful toxic chemicals.

Specific Limitations: VOCs

Detecting VOCs in human biological samples is difficult because VOCs disappear very quickly from blood after exposure. Usually, when determining exposure to VOCs, a breath or urine sample is drawn very shortly after exposure. This type of sampling was not possible for our study due to time and organizational restrictions and, as a result, very few VOCs were detected in our volunteers.

Results and Discussion

Group Results

Our study confirms the presence of toxic chemicals in Canadians no matter where they live, how old they are or what they do for a living. The laboratory tests detected 60 of the 88 chemicals in 11 volunteers: 18 heavy metals, five PBDEs, 14 PCBs, one perfluorinated chemical, 10 organochlorine pesticides, five organophosphate insecticide metabolites, and seven VOCs (Table 4). Excluding VOCs, which are difficult to detect in human samples, nearly every chemical in each chemical group was detected. On average, 44 chemicals were detected in each volunteer, including 41 carcinogens, 27 hormone disruptors, 21 respiratory toxins and 53 reproductive/developmental toxins (Table 5).

Table 4. Number of chemicals detected in the *Toxic Nation* study

Chemical Group	Total Number of Chemicals Tested For	Total Number of Chemicals Detected	Average Number of Chemicals Detected in a Volunteer
Heavy metals	19	18	17
PBDEs	5	5	3
PCBs	16	14	10
PFOS	1	1	1
Organochlorine pesticides	13	10	8
Organophosphate insecticide metabolites	6	5	4
VOCs	28	7	1
Total	**88**	**60**	**44**

Table 5. Number of chemicals detected in the *Toxic Nation* study volunteers that are linked to a listed health effect

Chemicals' Effect on Health	Number of Chemicals Detected in Study Volunteers that are Linked to a Listed Health Effect*		
	Total	Average	Range
Carcinogen	41	28	18-36
Hormone disruptor	27	18	13-24
Respiratory toxin	21	15	12-18
Reproductive/developmental toxin	53	38	28-46

*Includes both recognized and suspected health effects for each chemical as identified in Scorecard.org Chemical Profiles in August 2005. The number of chemicals that affect health is greater than the total number of chemicals because a chemical may have multiple health effects.

Table 6. Chemical concentrations detected in the *Toxic Nation* study volunteers

Chemical Group	Chemical Concentrations in All Study Volunteers*		
	Median	Minimum	Maximum
Heavy metals (µmol/L in whole blood): beryllium, copper, lithium, lead, zinc, selenium	2.7	< 0.05	160
Heavy metals (nmol/L in whole blood) arsenic, bismuth, cadmium, cobalt, manganese, molybdenum, nickel, silver, tellurium, tin, thallium, uranium, mercury	7	< 0.07	220
PBDEs (µg/L in plasma)	0.011	< 0.01	0.43
PCBs (µg/L in plasma)	0.018	< 0.01	19
PFOS (µg/L in plasma)	10	6.9	30
Organochlorinated pesticides (µg/L in plasma)	0.0098	< 0.005	8.2
Organophosphate insecticide metabolites (µg/g cre in urine)	1.9	< 0.67	61
VOCs (ng/mL in whole blood)	< 0.5	< 0.5	1.9

*Values of less than (<) = not detected at the lowest level of detection.

While our test group of 11 volunteers is small, our results are consistent with other studies on the presence of chemicals in people.[55] For example, in our study we found that the number of PCBs detected in the samples from older volunteers was higher than the number detected in younger volunteers. PCBs were banned in the 1970s, and while they continue to persist in the environment, higher concentrations of more types of PCBs occur in older people who would have been exposed to larger amounts of more types of PCBs before the ban was imposed. A decreased presence of PCBs in the younger volunteers in this study suggests that when governments take action to eliminate the use of toxic chemicals, people's toxic load will decrease, even if it does take several decades.

We also found that the volunteer from a First Nations community in northern Quebec had the highest concentrations of mercury and persistent organic pollutants (POPs) such as PCBs and organochlorine pesticides. Numerous scientific studies have documented elevated levels of POPs in the North and particularly among First Nations populations. Research has found that many chemicals tend to accumulate in the North due to air and water currents and climatic conditions.[56] The consumption of marine mammals by northern populations may also contribute to higher levels of POPs and mercury in these people because these chemicals bioaccumulate in fatty tissues. While marine mammals may have both cultural and nutritional significance to people in the North, these animals are high up the food chain and their levels of POPs and mercury tend to be high.

Heavy Metals

18 of 19 heavy metals tested for were detected (Table 4), and 13 of 19 were detected in all volunteers. Three of the four heavy metals of highest concern (cadmium, lead and arsenic) were detected in all volunteers, and mercury was detected in 10 of 11 samples. Beryllium was not detected in any of the volunteers, since exposure to this metal occurs mostly in the workplace.

Similar concentrations of cadmium, lead and arsenic were detected in most volunteers. The median lead concentration was 0.11345 µmol/L, with a range of 0.054 µmol/L to 0.39 µmol/L (Table 7). The median cadmium concentration was 7.77 nmol/L, with a range of 3.5 nmol/L to 28 nmol/L (Table 7). For arsenic, the median concentration was 27.45 nmol/L, with a range of 15 nmol/L to 61 nmol/L (Table 7). The median mercury concentration was 33.52 nmol/L, but most volunteers had mercury concentrations well below this level because the median was skewed by one significantly higher value of 190 nmol/L (Table 7). Excluding this high value, the median mercury concentration was 14.52 nmol/L. The highest concentrations of mercury were found in volunteers from northern parts of Canada. A volunteer from northern Quebec had the highest concentration of mercury, 190 nmol/L, which was nearly six times higher than the median concentration detected. The second highest concentration of mercury, 58 nmol/L, was found in the volunteer from St. John's, Newfoundland.

Table 7. Heavy metals concentrations detected in the *Toxic Nation* study volunteers

Heavy Metal	Chemical Concentrations in All Volunteers*		
	Median	Minimum	Maximum
Lead (µmol/L in whole blood)	0.11345	0.054	0.39
Cadmium (nmol/L in whole blood)	7.77	3.5	28
Arsenic (nmol/L in whole blood)	27.45	15	61
Mercury (nmol/L in whole blood)	33.52	< 0.5	190

*Values of less than (<) = not detected at the lowest level of detection

PBDEs

5 of 5 PBDEs tested for were detected (Table 4). The most common PBDE was PBDE 47, which was detected in 10 of 11 volunteers, at a median concentration of 0.1572 µg/L, with a range of 0.031 µg/L to 0.43 µg/L. The least common PBDE was PBDE 100, which was detected in three of 11 volunteers. All five PBDEs were detected in two volunteers, and the PBDE levels detected were fairly similar for all volunteers.

PBDEs are found in three commercial mixtures: pentabromodiphenyl ether (PeBDE), octabromodiphenyl ether (OBDE), and decabromodiphenyl ether (DBDE). PBDE 47 falls under the chemical subclass of tetrabrominated diphenyl ethers, which are a component of PeBDE. The volume of PeBDE on the North Amercian market in 1999 was 7,100 tonnes, which was 95 per cent of the worldwide market demand for this PBDE.[57] In 2001, the total worldwide market demand for all PBDEs was about 67,390 tonnes.[58] PeBDE is commonly used in polyurethane foams in office and residential furniture, automotive upholstery, sound insulation and imitation wood products.[59]

PCBs

14 of 16 PCBS tested for were detected (Table 4), and five of 16 (PCB Aroclor 1260, 118, 138, 153 and 180) were detected in all volunteers. PCB 28 and 52 were not detected, and PCB 128 was detected in only one volunteer.

As mentioned above, a higher number of PCBs were detected in the samples from older volunteers in comparison with those from younger volunteers; for example, between 12 and 14 PCBs were detected in the samples from volunteers aged 60 and older, whereas only five PCBs were detected in the samples from volunteers aged 25 and under. The lower number of PCBs in the younger volunteers is most likely the result of the 1970s ban on PCBs.

PCB Aroclor was found in the highest concentrations, at a median of 2.86 µg/L; however, most concentrations of this chemical in volunteers were below this level. The median was skewed by an extreme value of 19 µg/L, which was detected in the volunteer from northern Quebec. For most PCBs, the concentrations in this volunteer were higher than those in any other volunteer. PCBs are POPs, which, as mentioned above, tend to accumulate in the North, exposing people there to amounts of pollutants that are greater than those to which people further south are exposed.

PFOS

PFOS was detected in 11 of 11 volunteers at a median concentration of 10 µg/L, with a range of 6.9 µg/L to 30 g/L (Table 6). This study is the first to measure PFOS levels in Canadians from across the country. Since this chemical was detected in all volunteers, the study results suggest that PFOS contamination may be widespread.

PFOS is used as a stain repellent on clothing and other fabric products, such as carpets. It is also used in food packaging, particularly microwave popcorn bags and packaging for fast food.

While this is the first cross-Canada study of PFOS levels in Canadians, other studies have documented PFOS levels in numerous other countries and in Nunavut and the Northwest Territories (Figure 3). Studies of Americans detected PFOS levels of 37.5 parts per billion (ppb) in children,[60] 31 ppb in the elderly[61] and 34.9 ppb in the general adult population.[62] Median PFOS levels have also been documented at more than 30 ng/mL in the U.S.; less than 30 ng/mL in Poland; between 10 ng/mL and 25 ng/mL in Korea, Belgium, Malaysia and Brazil; between 4 ng/mL and 10 ng/mL in Italy and Columbia; and less than 3 ng/mL in India.[63] In Nunavut and the Northwest Territories, the mean concentration of PFOS was 36.9 ng/mL.[64]

Organochlorine Pesticides

10 of 13 organochlorine pesticides tested for were detected (Table 4); four of 13 (oxychlordane, trans-nonachlor, p,p'-DDE and beta-HCH) were detected in all volunteers, and hexachlorobenzene was detected in 10 of 11 volunteers. Three organochlorine pesticides (aldrin, alpha-chlordane, and gamma-chlordane) were not detected in any volunteers.

The presence of oxychlordane and trans-nonachlor in human samples represents an exposure to the pesticide chlordane, which is a persistent and bioaccumulative substance. Oxychlordane is a breakdown product (or metabolite) of chlordane, and trans-nonachlor is a main component of that pesticide. In the 1950s, 1960s and 1970s, chlordane was commonly used in agriculture on crops, in residential settings on lawns and gardens and also to control termites. In the mid-1970s, restrictions were placed on the use of chlordane. By the 1980s most applications of this chemical were prohibited, and as of 1995 all uses of chlordane had been phased out completely in both Canada and the United States.[65]

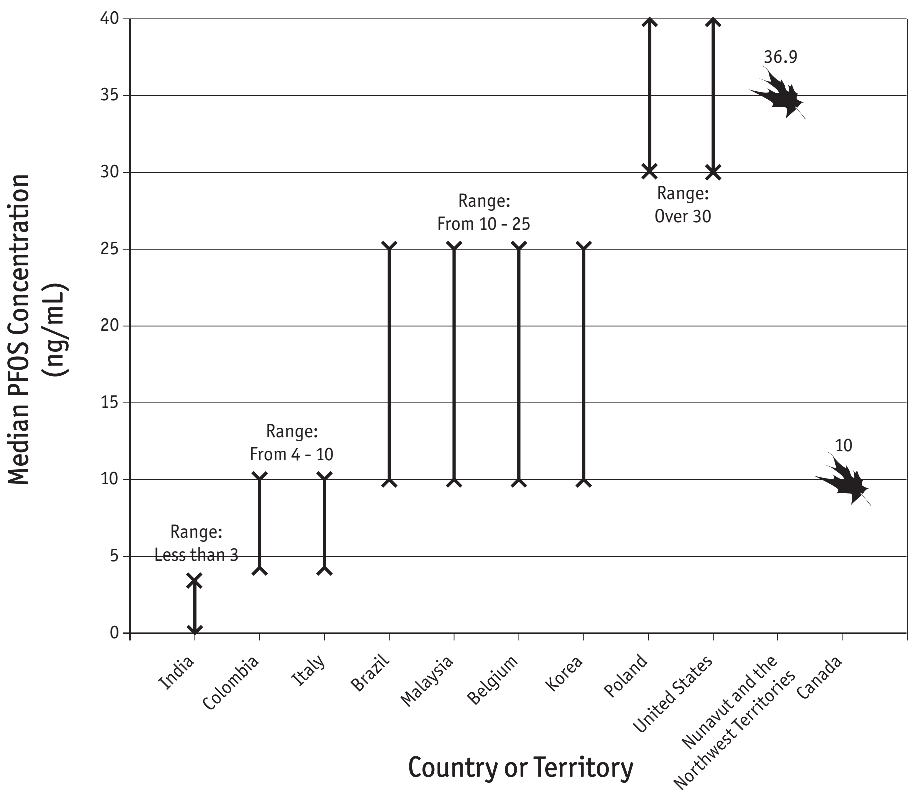


Figure 3. International comparison of median PFOS concentrations
Source: Adapted from Kannan et al. (2004), Allsopp et al. (2005), and Environmental Defence (2005)

Another pesticide product that was found in all volunteers was p,p'-DDE, which is a breakdown product of the pesticide DDT. The p,p'-DDE levels detected in volunteers were the highest of the organochlorine pesticides, at a median of 1.7754 µg/L and a the range of 0.33 µg/L to 8.2 µg/L. DDT is a persistent and bioaccumulative pollutant that has been banned in Canada since 1990. As a POP, it is not surprising that the highest level of p,p'-DDE detected in our study was in the volunteer from northern Quebec, at a level over four times the median.

Organophosphate Insecticide Metabolites

5 of 6 organophosphate insecticide metabolites (also called dialkyl phosphate metabolites) tested for were detected (Table 4). The most common metabolite detected was dimethyl thiophosphate (DMTP), which was found in all 11 volunteers at a median concentration of 15.51 µg/g cre, with a range of 3.2 µg/g cre to 61 µg/g cre. The highest concentration detected (61 µ g/g cre) was almost four times the median.

Most organophosphate insecticides break down into dialkyl phosphate metabolites. These metabolites are not toxic themselves but are markers of exposure to organophosphate insecticides, which are suspected of being carcinogenic and harmful to reproduction and development. DMTP specifically is a metabolite of several organophosphate insectides, including azinphos methyl, chlorpyrifos methyl, dimethoate, fenitrothion, fenthion, isazaphos-methyl, malathion, methidathion, methyl parathion, oxydemeton-methyl, phosmet, pirimiphos-methyl and temephos.[66]

VOCs

7 of 28 VOCs tested for were detected (Table 4) (benzene, 1,2-Dichlorobenzene, 1,4-Dichlorobenzene, styrene, ethylbenzene, M.P-Xylenes and O-Xylene). The most common VOC detected was M.P-Xylenes, which was found in samples from seven of 11 volunteers.

Mixed xylenes (such as M.P-xylenes) have been detected from petroleum refining, motor vehicles, residential wood-burning stoves and fireplaces. Xylenes are used as solvents in aviation fuel and in many household products, including pens or inks and coatings, carpet adhesives, latex caulk, latex paint, aerosol paint and lacquers, and various mouldings. Tobacco smoke is also a common indoor source of xylenes.[67] Xylenes affect the neurological and respiratory systems and may cause reproductive problems.

Personal History and Chemical Exposure

The results of the *Toxic Nation* study show that all the volunteers-regardless of their age, race, gender, place of residence, occupation, diet or the products they used in their home-were polluted with a cocktail of chemicals. While a similar mix of chemicals was detected in the samples from most volunteers, every individual's results were distinct. In the case of the volunteer from northern Quebec, we can speculate that his extreme levels of many POPs are related to his place of residence; for most volunteers, however, drawing any conclusions about how they may have been exposed to their specific chemical load is difficult. On the basis of a sample size of 11 individuals we were unable to extrapolate any trends from the data that would suggest how individuals may be exposed to a chemical, and the information provided through the lifestyle questionnaire was insufficient to conduct a toxicological analysis of how any individual may have been exposed. Also, some of the chemicals that were detected have been banned for many years, which shows that people continue to be exposed to chemicals that persist in the environment and cause long-term contamination of air, water and soil. Wide-spread contamination of the biosphere by numerous chemicals makes it difficult to determine specific routes of exposure for any particular individual. While it is certain that all people are contaminated to some degree and often through sources they cannot control, individuals can minimize their exposure to toxic chemicals through personal lifestyle changes. Because chemicals have the potential to cause wide-spread contamination throughout the biosphere, ultimately the federal government must take action to phase out the use of toxic chemicals.

After finding out their results, many of the *Toxic Nation* volunteers have pledged to make simple changes in their homes to reduce their exposure to toxic chemicals. To find out more, visit the *Toxic Nation* web site at **www.ToxicNation.ca/pledge**, and make your own Chemical Reduction Pledge.

Volunteer Individual Profiles and Results — Robert Bateman

Age: 75
Sex: Male
Occupation: Artist and naturalist
Place of residence: Saltspring Island, BC; spent 55 years in southern Ontario

Exposure to chemicals on the job: Exposure to various chemicals through oil paints, acrylics, and printmaking, as well as exposure to asbestos as a teacher in the 1960s and to arsenic in museum work in the 1950s and 1960s
Height: 5'10" (178 cm)
Weight: 160 lb (73 kg), stable
Diet: Omnivore
Proportion of diet that is organic: 80%
Hours spent in front of computer/day: 0
Purchase of products likely to contain brominated flame retardants: 7 years ago
Visited malarial area: Yes, yearly since 1953
Use of air fresheners: None
Pesticide use: Occasional use of wasp nest spray
Consumption of cigarettes: None

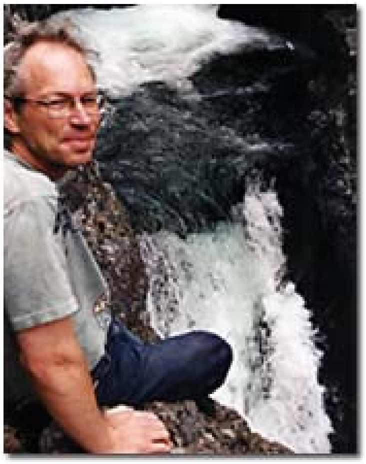
Table 8. Number and concentration of chemicals detected in Robert, and median chemical concentration in study volunteers

Chemical Group	Robert's Results			Median Concentration in Study Volunteers
	Number of Compounds Detected	Median Concentration	Concentration range	
Heavy metals (µmol/L in whole blood): Beryllium, copper, lithium, lead, zinc, selenium	5 of 6	2.5	< 0.05 to 120	2.7
Heavy metals (nmol/L in whole blood): Arsenic, bismuth, cadmium, cobalt, manganese, molybdenum, nickel, silver, tellurium, tin, thallium, uranium, mercury	12 of 13	5.5	< 10 to 190	7
PBDEs (µg/L in plasma)	2 of 5	< 0.02	< 0.01 to 0.031	0.011
PCBs (µg/L in plasma)	12 of 16	0.042	< 0.01 to 2.3	0.018
PFOS (µg/L in plasma)	1 of 1	6.9	n/a	10
Organochlorine pesticides (µg/L in plasma)	10 of 13	0.015	< 0.005 to 2.5	0.0098
Organophosphate insecticide metabolites (µg/g cre in urine)	5 of 6	1.2	< 0.67 to 5.3	1.9
VOCs (ng/mL in whole blood)	1 of 28	< 0.5	< 0.5 to trace	< 0.5
Total number of chemicals found in Robert: 48 of 88				

Table 9. Number of chemicals detected in Robert that are linked to a listed chemical health effect, and the study average

Chemicals Effect on Health	Number of Chemicals Detected that are Linked to a Listed Health Effect	
	In Robert	Average in Study Volunteers
Carcinogen	32	28
Hormone disruptor	19	18
Respiratory toxicant	16	15
Reproductive/developmental toxicant	42	38

Volunteer Individual Profiles and Results — Norm Tandberg



Age: 54
Sex: Male
Occupation: Letter Carrier with Canada Post
Place of residence: Victoria, BC

Exposure to chemicals on the job: Worked in an ice plant 1970-73
Height: 6' (181 cm)
Weight: 175 lb (79 kg), stable
Diet: Omnivorous (limited meat intake)
Proportion of diet that is organic: 50%
Hours spent in front of computer/day: 0
Purchase of products likely to contain brominated flame retardants: 5 years ago
Visited malarial area: No
Use of air fresheners: None
Pesticide use: none in garden, flea spray 6 years ago, neighbour uses pesticides
Consumption of cigarettes: none

Table 10. Number and concentration of chemicals detected in Norm, and median chemical concentration in study volunteers

Chemical Group	Norm's Results			Median Concentration in Study Volunteers
	Number of Compounds Detected	Median Concentration	Concentration range	
Heavy metals (µmol/L in whole blood): Beryllium, copper, lithium, lead, zinc, selenium	5 of 6	1.6	< 0.05 to 94	2.7
Heavy metals (nmol/L in whole blood): Arsenic, bismuth, cadmium, cobalt, manganese, molybdenum, nickel, silver, tellurium, tin, thallium, uranium, mercury	12 of 13	5.9	< 10 to 160	7
PBDEs (µg/L in plasma)	3 of 5	< 0.02	< 0.01 to 0.13	0.011
PCBs (µg/L in plasma)	11 of 16	0.024	< 0.01 to 1.2	0.018
PFOS (µg/L in plasma)	1 of 1	9.5	n/a	10
Organochlorine pesticides (µg/L in plasma)	9 of 13	< 0.01	< 0.005 to 0.96	0.0098
Organophosphate insecticide metabolites (µg/g cre in urine)	5 of 6	1.9	< 0.67 to 10	1.9
VOCs (ng/mL in whole blood)	3 of 28	< 0.5	< 0.5 to 1.6	< 0.5
Total number of chemicals found in Norm: 49 of 88				

Table 11. Number of chemicals detected in Norm that are linked to a listed chemical health effect, and the study average

Chemicals Effect on Health	Number of Chemicals Detected that are Linked to a Listed Health Effect	
	In Norm	Average in Study Volunteers
Carcinogen	31	28
Hormone disruptor	20	18
Respiratory toxicant	15	15
Reproductive/developmental toxicant	41	38

Volunteer Individual Profiles and Results — Cheryl Henkelman

Age: 46
Sex: Female
Occupation: Owner of Guardian Angel Home and Pet Sitting Services
Place of residence: Fort Saskatchewan, AB

Exposure to chemicals on the job: Pesticide and fungicide exposure at provincial tree nursery
Height: 5'5" (165 cm)
Weight: 120 lb (54 kg), stable
Diet: Lacto-ovo vegetarian
Proportion of diet that is organic: 20%
Hours spent in front of computer/day: 1
Purchase of products likely to contain brominated flame retardants: Over 20 years ago
Visited malarial area: No
Use of air fresheners: Occasional
Pesticide use: None
Consumption of cigarettes: None

Table 12. Number and concentration of chemicals detected in Cheryl, and median chemical concentration in study volunteers

Chemical Group	Cheryl's Results			Median Concentration in Study Volunteers
	Number of Compounds Detected	Median Concentration	Concentration range	
Heavy metals (µmol/L in whole blood): Beryllium, copper, lithium, lead, zinc, selenium	5 of 6	3.1	< 0.05 to 100	2.7
Heavy metals (nmol/L in whole blood): Arsenic, bismuth, cadmium, cobalt, manganese, molybdenum, nickel, silver, tellurium, tin, thallium, uranium, mercury	12 of 13	5.2	< 10 to 106	7
PBDEs (µg/L in plasma)	2 of 5	< 0.02	< 0.02 to 0.014	0.011
PCBs (µg/L in plasma)	12 of 16	0.036	< 0.01 to 1.8	0.018
PFOS (µg/L in plasma)	1 of 1	9.3	n/a	10
Organochlorine pesticides (µg/L in plasma)	8 of 13	< 0.005	< 0.005 to 1.5	0.0098
Organophosphate insecticide metabolites (µg/g cre in urine)	1 of 6	< 0.67	< 0.67 to 5.4	1.9
VOCs (ng/mL in whole blood)	0 of 28	< 0.5	< 0.5 to < 1.0	< 0.5
Total number of chemicals found in Cheryl: 41 of 88				

Table 13. Number of chemicals detected in Cheryl that are linked to a listed chemical health effect, and the study average

Chemicals Effect on Health	Number of Chemicals Detected that are Linked to a Listed Health Effect	
	In Cheryl	Average in Study Volunteers
Carcinogen	26	28
Hormone disruptor	18	18
Respiratory toxicant	13	15
Reproductive/developmental toxicant	35	38

Volunteer Individual Profiles and Results — Merrell-Ann Phare

Age: 40
Sex: Female
Occupation: Legal Counsel and Executive Director of the Centre for Indigenous Environmental Resources (CIER)
Place of residence: Winnipeg, MB

Exposure to chemicals on the job: None
Height: 5'10" (178 cm)
Weight: 140 lb (64 kg), stable
Diet: Lacto-ovo vegetarian
Proportion of diet that is organic: 35%
Hours spent in front of computer/day: 6
Purchase of products likely to contain brominated flame retardants: Within the last 5 years
Visited malarial area: South Africa, 1995
Use of air fresheners: Incense
Pesticide use: None
Consumption of cigarettes: None

Table 14. Number and concentration of chemicals detected in Merrell-Ann, and median chemical concentration in study volunteers

Chemical Group	Merrell-Ann's Results			Median Concentration in Study Volunteers
	Number of Compounds Detected	Median Concentration	Concentration range	
Heavy metals (µmol/L in whole blood): Beryllium, copper, lithium, lead, zinc, selenium	5 of 6	2.1	< 0.05 to 89	2.7
Heavy metals (nmol/L in whole blood): Arsenic, bismuth, cadmium, cobalt, manganese, molybdenum, nickel, silver, tellurium, tin, thallium, uranium, mercury	10 of 13	0.16	< 0.07 to 190	7
PBDEs (µg/L in plasma)	3 of 5	< 0.02	< 0.01 to 0.12	0.011
PCBs (µg/L in plasma)	9 of 16	0.011	< 0.01 to 0.72	0.018
PFOS (µg/L in plasma)	1 of 1	12	n/a	10
Organochlorine pesticides (µg/L in plasma)	6 of 13	< 0.01	< 0.005 to 0.95	0.0098
Organophosphate insecticide metabolites (µg/g cre in urine)	4 of 6	2.5	< 0.67 to 61	1.9
VOCs (ng/mL in whole blood)	1 of 28	< 0.5	< 0.5 to 0.5	< 0.5
Total number of chemicals found in Merrell-Ann: 39 of 88				

Table 15. Number of chemicals detected in Merrell-Ann that are linked to a listed chemical health effect, and the study average

Chemicals Effect on Health	Number of Chemicals Detected that are Linked to a Listed Health Effect	
	In Merrell-Ann	Average in Study Volunteers
Carcinogen	26	28
Hormone disruptor	15	18
Respiratory toxicant	13	15
Reproductive/developmental toxicant	35	38

Volunteer Individual Profiles and Results — Kapil Khatter

Age: 39
Sex: Male
Occupation: Family physician
Place of residence: Toronto, ON

Exposure to chemicals on the job: Formaldehyde in medical school
Height: 5'7" (170 cm)
Weight: 165 lb (75 kg), stable
Diet: Omnivore
Proportion of diet that is organic: 10%
Hours spent in front of computer/day: 8
Purchase of products likely to contain brominated flame retardants: Within the last 6 months
Visited malarial area: Yes
Use of air fresheners: None
Pesticide use: None
Consumption of cigarettes: None

Table 16. Number and concentration of chemicals detected in Kapil, and median chemical concentration in study volunteers

Chemical Group	Kapil's Results			Median Concentration in Study Volunteers
	Number of Compounds Detected	Median Concentration	Concentration range	
Heavy metals (µmol/L in whole blood): Beryllium, copper, lithium, lead, zinc, selenium	4 of 6	0.14	< 0.05 to 120	2.7
Heavy metals (nmol/L in whole blood): Arsenic, bismuth, cadmium, cobalt, manganese, molybdenum, nickel, silver, tellurium, tin, thallium, uranium, mercury	13 of 13	6.9	0.035 to 130	7
PBDEs (µg/L in plasma)	2 of 5	< 0.02	< 0.01 to 0.071	0.011
PCBs (µg/L in plasma)	11 of 16	0.015	< 0.01 to 0.69	0.018
PFOS (µg/L in plasma)	1 of 1	13	n/a	10
Organochlorine pesticides (µg/L in plasma)	8 of 13	0.0058	< 0.005 to 0.79	0.0098
Organophosphate insecticide metabolites (µg/g cre in urine)	5 of 6	3.4	< 0.67 to 28	1.9
VOCs (ng/mL in whole blood)	1 of 28	< 0.5	< 0.5 to trace	< 0.5
Total number of chemicals found in Kapil: 45 of 88				

Table 17. Number of chemicals detected in Kapil that are linked to a listed chemical health effect, and the study average

Chemicals Effect on Health	Number of Chemicals Detected that are Linked to a Listed Health Effect	
	In Kapil	Average in Study Volunteers
Carcinogen	28	28
Hormone disruptor	17	18
Respiratory toxicant	14	15
Reproductive/developmental toxicant	39	38

Volunteer Individual Profiles and Results — Sarah Winterton

Age: 45
Sex: Female
Occupation: Program Director, Environmental Defence
Place of residence: Toronto, ON

Exposure to chemicals on the job: no
Height: 5'4" (163 cm)
Weight: 150 lb (68 kg), stable
Diet: Omnivore (limited meat intake)
Proportion of diet that is organic: 50%
Hours spent in front of computer/day: 6
Purchase of products likely to contain brominated flame retardants: Within the last 2 years
Visited malarial area: No
Use of air fresheners: None
Pesticide use: None
Consumption of cigarettes: None

Table 18. Number and concentration of chemicals detected in Sarah, and median chemical concentration in study volunteers

Chemical Group	Sarah's Results			Median Concentration in Study Volunteers
	Number of Compounds Detected	Median Concentration	Concentration range	
Heavy metals (µmol/L in whole blood): Beryllium, copper, lithium, lead, zinc, selenium	5 of 6	2.7	< 0.05 to 120	2.7
Heavy metals (nmol/L in whole blood): Arsenic, bismuth, cadmium, cobalt, manganese, molybdenum, nickel, silver, tellurium, tin, thallium, uranium, mercury	12 of 13	5.8	< 10 to 190	7
PBDEs (µg/L in plasma)	2 of 5	< 0.01	< 0.01 to 0.14	0.011
PCBs (µg/L in plasma)	12 of 16	0.017	< 0.01 to 0.85	0.018
PFOS (µg/L in plasma)	1 of 1	13	n/a	10
Organochlorine pesticides (µg/L in plasma)	9 of 13	0.0054	< 0.005 to 0.53	0.0098
Organophosphate insecticide metabolites (µg/g cre in urine)	1 of 6	< 0.67	< 0.67 to 17	1.9
VOCs (ng/mL in whole blood)	1 of 28	< 0.5	< 0.5 to trace	< 0.5
Total number of chemicals found in Sarah: 43 of 88				

Table 19. Number of chemicals detected in Sarah that are linked to a listed chemical health effect, and the study average

Chemicals Effect on Health	Number of Chemicals Detected that are Linked to a Listed Health Effect	
	In Sarah	Average in Study Volunteers
Carcinogen	27	28
Hormone disruptor	19	18
Respiratory toxicant	16	15
Reproductive/developmental toxicant	38	38

Volunteer Individual Profiles and Results — Christine Chui

Age: 25
Sex: Female
Occupation: student in graphic animation
Place of residence: Toronto, ON; born in Hong Kong, China, and spent 16 years in Edmonton, AB.

Exposure to chemicals on the job: None
Height: 5'7" (170 cm)
Weight: 135 lb (61 kg), stable
Diet: Omnivore
Proportion of diet that is organic: 10%
Hours spent in front of computer/day: 5
Purchase of products likely to contain brominated flame retardants: Within the last 6 months
Visited malarial area: No
Use of air fresheners: Yes
Pesticide use: None
Consumption of cigarettes: None

Table 20. Number and concentration of chemicals detected in Christine, and median chemical concentration in study volunteers

Chemical Group	Christine's Results			Median Concentration in Study Volunteers
	Number of Compounds Detected	Median Concentration	Concentration range	
Heavy metals (µmol/L in whole blood): Beryllium, copper, lithium, lead, zinc, selenium	5 of 6	1.9	< 0.05 to 160	2.7
Heavy metals (nmol/L in whole blood): Arsenic, bismuth, cadmium, cobalt, manganese, molybdenum, nickel, silver, tellurium, tin, thallium, uranium, mercury	12 of 13	5.8	< 10 to 220	7
PBDEs (µg/L in plasma)	2 of 5	< 0.01	< 0.01 to 0.15	0.011
PCBs (µg/L in plasma)	5 of 16	< 0.01	< 0.01 to 0.33	0.018
PFOS (µg/L in plasma)	1 of 1	9.6	n/a	10
Organochlorine pesticides (µg/L in plasma)	5 of 13	< 0.01	< 0.005 to 1.1	0.0098
Organophosphate insecticide metabolites (µg/g cre in urine)	2 of 6	< 0.67	< 0.67 to 3.9	1.9
VOCs (ng/mL in whole blood)	0 of 28	< 0.5	< 0.5 to <1.0	< 0.5
Total number of chemicals found in Christine: 32 of 88				

Table 21. Number of chemicals detected in Christine that are linked to a listed chemical health effect, and the study average

Chemicals Effect on Health	Number of Chemicals Detected that are Linked to a Listed Health Effect	
	In Christine	Average in Study Volunteers
Carcinogen	18	28
Hormone disruptor	14	18
Respiratory toxicant	12	15
Reproductive/developmental toxicant	28	38

Volunteer Individual Profiles and Results — Nycole Turmel

Age: 63
Sex: Female
Occupation: President, Public Service Alliance of Canada
Place of residence: Gatineau, QC

Exposure to chemicals on the job: No
Height: 5'8" (173 cm)
Weight: 140 lb (63 kg), stable
Diet: Omnivore
Proportion of diet that is organic: 20%
Hours spent in front of computer/day: 0.5
Purchase of products likely to contain brominated flame retardants: Within the last 2 years
Visited malarial area: Yes, 1995
Use of air fresheners: None
Pesticide use: None
Consumption of cigarettes: None

Table 22. Number and concentration of chemicals detected in Nycole, and median chemical concentration in study volunteers

Chemical Group	Nycole's Results			Median Concentration in Study Volunteers
	Number of Compounds Detected	Median Concentration	Concentration range	
Heavy metals (µmol/L in whole blood): Beryllium, copper, lithium, lead, zinc, selenium	5 of 6	2	< 0.05 to 120	2.7
Heavy metals (nmol/L in whole blood): Arsenic, bismuth, cadmium, cobalt, manganese, molybdenum, nickel, silver, tellurium, tin, thallium, uranium, mercury	12 of 13	6.7	< 10 to 140	7
PBDEs (µg/L in plasma)	5 of 5	0.029	0.025 to 0.26	0.011
PCBs (µg/L in plasma)	12 of 16	0.049	< 0.01 to 3.5	0.018
PFOS (µg/L in plasma)	1 of 1	11	n/a	10
Organochlorine pesticides (µg/L in plasma)	10 of 13	0.012	< 0.005 to 2.2	0.0098
Organophosphate insecticide metabolites (µg/g cre in urine)	4 of 6	1.4	< 0.67 to 12	1.9
VOCs (ng/mL in whole blood)	2 of 28	< 0.5	< 0.5 to 1.9	< 0.5
Total number of chemicals found in Nycole: 51 of 88				

Table 23. Number of chemicals detected in Nycole that are linked to a listed chemical health effect, and the study average

Chemicals Effect on Health	Number of Chemicals Detected that are Linked to a Listed Health Effect	
	In Nycole	Average in Study Volunteers
Carcinogen	34	28
Hormone disruptor	23	18
Respiratory toxicant	17	15
Reproductive/developmental toxicant	45	38

Volunteer Individual Profiles and Results — Véronique Martel

Age: 23
Sex: Female
Occupation: Communications Officer, Fédération étudiante universitaire du Québec (FEUQ)
Place of residence: Montreal, QC

Exposure to chemicals on the job: None
Height: 5'4" (163 cm)
Weight: 115 lb (52 kg), stable
Diet: Omnivore
Proportion of diet that is organic: 10%
Hours spent in front of computer/day: 6
Purchase of products likely to contain brominated flame retardants: N/A
Visited malarial area: No
Use of air fresheners: None
Pesticide use: None
Consumption of cigarettes: 15 per day

Table 24. Number and concentration of chemicals detected in Véronique, and median chemical concentration in study volunteers

Chemical Group	Véronique's Results			Median Concentration in Study Volunteers
	Number of Compounds Detected	Median Concentration	Concentration range	
Heavy metals (µmol/L in whole blood): Beryllium, copper, lithium, lead, zinc, selenium	4 of 6	0.059	< 0.05 to 100	2.7
Heavy metals (nmol/L in whole blood): Arsenic, bismuth, cadmium, cobalt, manganese, molybdenum, nickel, silver, tellurium, tin, thallium, uranium, mercury	12 of 13	1.2	<10 to 130	7
PBDEs (µg/L in plasma)	1 of 5	< 0.01	< 0.01 to 0.11	0.011
PCBs (µg/L in plasma)	5 of 16	< 0.01	< 0.01 to 0.32	0.018
PFOS (µg/L in plasma)	1 of 1	10	n/a	10
Organochlorine pesticides (µg/L in plasma)	5 of 13	< 0.01	< 0.005 to 0.33	0.0098
Organophosphate insecticide metabolites (µg/g cre in urine)	5 of 6	2.4	< 0.67 to 17	1.9
VOCs (ng/mL in whole blood)	1 of 28	< 0.5	< 0.5 to trace	< 0.5
Total number of chemicals found in Véronique: 34 of 88				

Table 25. Number of chemicals detected in Véronique that are linked to a listed chemical health effect, and the study average

Chemicals Effect on Health	Number of Chemicals Detected that are Linked to a Listed Health Effect	
	In Véronique	Average in Study Volunteers
Carcinogen	20	28
Hormone disruptor	13	18
Respiratory toxicant	12	15
Reproductive/developmental toxicant	30	38

Volunteer Individual Profiles and Results — David Masty

Age: 60
Sex: Male
Occupation: Chief of Whapmagoostui First Nation
Place of residence: Whapmagoostui (Great Whale), QC

Exposure to chemicals on the job: No
Height: 6'2" (188 cm)
Weight: 150 lb (68 kg), stable
Diet: Omnivore, only occasional fish and egg consumption
Proportion of diet that is organic: 20%
Hours spent in front of computer/day: 2
Purchase of products likely to contain brominated flame retardants: Within the last year
Visited malarial area: No
Use air fresheners: Yes
Pesticide use: None
Consumption of cigarettes: None

Table 26. Number and concentration of chemicals detected in David, and median chemical concentration in study volunteers

Chemical Group	David's Results			Median Concentration in Study Volunteers
	Number of Compounds Detected	Median Concentration	Concentration range	
Heavy metals (µmol/L in whole blood): Beryllium, copper, lithium, lead, zinc, selenium	5 of 6	1.3	< 0.05 to 100	2.7
Heavy metals (nmol/L in whole blood): Arsenic, bismuth, cadmium, cobalt, manganese, molybdenum, nickel, silver, tellurium, tin, thallium, uranium, mercury	10 of 13	0.18	< 0.07 to 190	7
PBDEs (µg/L in plasma)	5 of 5	0.077	0.034 to 0.43	0.011
PCBs (µg/L in plasma)	14 of 16	0.29	< 0.03 to 19	0.018
PFOS (µg/L in plasma)	1 of 1	30	n/a	10
Organochlorine pesticides (µg/L in plasma)	10 of 13	0.12	< 0.005 to 8.2	0.0098
Organophosphate insecticide metabolites (µg/g cre in urine)	3 of 6	< 0.67	< 0.67 to 4.7	1.9
VOCs (ng/mL in whole blood)	3 of 28	< 0.5	< 0.5 to 1.1	< 0.5
Total number of chemicals found in David: 51 of 88				

Table 27. Number of chemicals detected in David that are linked to a listed chemical health effect, and the study average

Chemicals Effect on Health	Number of Chemicals Detected that are Linked to a Listed Health Effect	
	In David	Average in Study Volunteers
Carcinogen	36	28
Hormone disruptor	24	18
Respiratory toxicant	18	15
Reproductive/developmental toxicant	46	38

Volunteer Individual Profiles and Results — Mary Sexton

Age: 43
Sex: Female
Occupation: Filmmaker/Producer
Place of residence: St. John's, NL

Exposure to chemicals on the job: None
Height: 5'6" (168 cm)
Weight: 170 lb (77 kg), stable
Diet: Pesco-vegetarian
Proportion of diet that is organic: 35%
Hours spent in front of computer/day: 10 to 12
Purchase of products likely to contain brominated flame retardants: Within the last 2 years
Visited malarial area: No
Use of air fresheners: Yes
Pesticide use: None
Consumption of cigarettes: 1/day

Table 28. Number and concentration of chemicals detected in Mary, and median chemical concentration in study volunteers

Chemical Group	Mary's Results			Median Concentration in Study Volunteers
	Number of Compounds Detected	Median Concentration	Concentration range	
Heavy metals (µmol/L in whole blood): Beryllium, copper, lithium, lead, zinc, selenium	5 of 6	10	0.04 to 200	2.7
Heavy metals (nmol/L in whole blood): Arsenic, bismuth, cadmium, cobalt, manganese, molybdenum, nickel, silver, tellurium, tin, thallium, uranium, mercury	13 of 13	2.5	< 0.05 to 89	7
PBDEs (µg/L in plasma)	2 of 5	< 0.02	< 0.01 to 0.1	0.011
PCBs (µg/L in plasma)	11 of 16	0.016	< 0.01 to 0.76	0.018
PFOS (µg/L in plasma)	1 of 1	14	n/a	10
Organochlorine pesticides (µg/L in plasma)	9 of 13	0.006	< 0.005 to 0.47	0.0098
Organophosphate insecticide metabolites (µg/g cre in urine)	5 of 6	2	< 0.67 to 7.9	1.9
VOCs (ng/mL in whole blood)	3 of 28	< 0.5	< 0.5 to 0.8	< 0.5
Total number of chemicals found in Mary: 49 of 88				

Table 29. Number of chemicals detected in Mary that are linked to a listed chemical health effect, and the study average

Chemicals Effect on Health	Number of Chemicals Detected that are Linked to a Listed Health Effect	
	In Mary	Average in Study Volunteers
Carcinogen	31	28
Hormone disruptor	20	18
Respiratory toxicant	17	15
Reproductive/developmental toxicant	42	38

Conclusion and Recommendations

A cocktail of harmful toxic chemicals is measurable in Canadians. The laboratory analyses detected 60 of the 88 chemicals tested for in 11 volunteers, including 18 heavy metals, five PBDEs, 14 PCBs, one perfluorinated chemical, 10 organochlorine pesticides, five organophosphate insecticide metabolites and seven VOCs. Excluding VOCs, which are difficult to detect in human samples, nearly every chemical in each chemical group was detected.

On average, 44 chemicals were detected in each volunteer, including 41 carcinogens, 27 hormone disruptors, 21 respiratory toxins and 53 reproductive/developmental toxins. Of particular note were the results for the First Nations leader from northern Quebec, whose mercury level far exceeded the alert threshold and whose levels of POPs, such as PCBs and organochlorine pesticides, ranked the highest. Other key findings include a decreased presence of PCBs in younger volunteers, and the first cross-Canada measure of PFOS levels, which suggests that PFOS contamination is likely widespread in the Canadian population.

Canadians expect their country to be a leader in the protection of human health and the environment. Environmental Defence urges the Government of Canada to acknowledge the research and policy initiatives of other jurisdictions, and to act to ensure that Canadians receive at least the same level of protection from toxic chemicals as Europeans and Americans. If passed in its current form, the European Union's proposed chemicals framework, REACH, will provide the most stringent regulation of chemicals and the highest level of protection for human health of any jurisdiction. In the United States, the proposed Child, Worker, and Consumer-Safe Chemicals Act has the potential to follow the European lead. To bring the regulation of toxic chemicals in Canada up to international standards Environmental Defence recommends that CEPA:

Establish timelines for the virtual elimination of toxic chemicals:

- Achieve virtual elimination of all releases of carcinogens to the air and water by 2008.
- Establish timelines to virtually eliminate respiratory toxins, endocrine disruptors, and reproductive and neurological toxins from use, release, generation, disposal or recycling.
- As a matter of priority, ban brominated flame retardants, perfluorinated chemicals and their precursors, and phthalates.

Make industry accountable for its chemicals:

- Shift the burden of proof to industry to prove the safety of its chemicals before their introduction to, or continued use in, the market.
- Mandate industry to adopt a safe substitution policy to replace toxic substances with safer or non-toxic substances.

Regulate toxic chemicals in consumer products:

- Expand CEPA to regulate toxic chemicals that may be released during the use or disposal of consumer products.

Reduce pollution in the Great Lakes basin:

- Given that 45 per cent of the nation's total toxic air pollution is emitted in the Great Lakes basin, a special section of CEPA is needed to focus on this pollution hotspot.

Canadians can also reduce their personal exposure to toxic chemicals wherever possible. Sources of toxic exposure are varied and numerous, and small changes in lifestyle and purchasing habits can make a difference in the level of pollutants each person carries. We urge people to visit the *Toxic Nation* web site at **www.ToxicNation.ca/pledge** and commit to at least five actions that will reduce their exposure to harmful chemicals.

However individuals choose to act, the Canadian government cannot turn its back on the evidence of human contamination revealed in *Toxic Nation*. Toxic chemicals emitted by industry and released through contact with, or use of, consumer products are measurable in Canadians. To protect people today and safeguard the health of future generations, the Canadian government must set a course to ensure that all citizens, no matter where they live, how old they are or what they do for a living, will not be exposed to toxic substances.

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Glossary

Arsenic
Most exposures to the heavy metal arsenic come from wood that is pressure-treated with Chromated Copper Arsenate (CCA), which is found in playgrounds, fences, decks and other constructions. (Manufacturers of CCA wood stopped producing in at the end of 2003, although stores can still sell the wood until the stockpiles are gone). Arsenic is a carcinogen and has been shown to cause lung, skin, bladder, liver, kidney and prostate cancer. Arsenic can also cause blood disorders, cardiovascular diseases, and is a known hormone disruptor that affects metabolism and immune function.

Bioaccumulation
Bioaccumulation is the increase in concentration of a substance in the tissues of a living organism throughout its lifetime. Every day we are exposed to a mixture of substances through contaminated air, water, food and products. As exposure occurs, certain chemicals that are very slowly metabolized or excreted build up in the tissues of living organisms.

Bisphenol A
Bisphenol A is primarily used to make polycarbonate plastic (recycling # 7) food and beverage containers and epoxy resins that are used to line metal cans for foods, such as cans of soup. Bisphenol A can leach from these products as they age, to be subsequently ingested by people. Recent research has shown that this chemical is an estrogenic hormone disruptor that can cause reproductive damage and birth defects that may lead to prostate and breast cancer in adulthood.

Body burden
Body burden refers to the amount of a chemical, or a number of chemicals, stored in the body at a given time, especially a potential toxin in the body as the result of exposure.

Brominated Flame Retardants (BFRs)
Brominated flame retardants (BFRs) are used to slow the spread of fire in upholstered furniture, mattresses, curtains, carpets and electronics. BFRs contain PBDEs (polybrominated diphenyl ethers), a group of chemicals that are highly persistent and bioaccumulative; they are suspected hormone disruptors and can cause cancer, reproductive and developmental disorders. PBDEs are suspected of having particularly damaging effects on the thyroid (which controls brain development), and as a result, PBDEs may cause neurodevelopmental disorders such as learning disabilities and behaviour problems. PBDEs leach from products, and have been detected in house dust, human blood and breast milk.

Cadmium
Cadmium is a heavy metal that comes from both natural and man-made sources. Most exposures to cadmium come from pigments and bakeware, as well as electronic equipment, car parts, batteries, phosphate fertilizer, sludge applications in agriculture and contaminated food. This heavy metal is known to cause lung and prostate cancer, and is toxic to the gastrointestinal tract, the kidneys, and the respiratory, cardiovascular and hormonal systems.

Carcinogen
Any substance that can cause or aggravate cancer.

Domestic Substances List
The Domestic Substances List has been compiled under the *Canadian Environmental Protection Act* (CEPA).The list includes more than 23,000 substances that were manufactured in, imported into or used in Canada on a commercial scale from 1984 to 1986. Health Canada and Environment Canada are aiming to classify and assess all substances on the Domestic Substances List by September 2006. All substances not on the list are considered new and must be reported prior to importation or manufacture so that they can be assessed to determine if they are toxic.

Hormone disruptors (a.k.a. Endocrine disruptors)
Hormone or endocrine disruptors are substances that can interfere with the normal functioning of the hormone system of both people and wildlife in a number of ways to produce a wide range of adverse effects including reproductive, developmental and behavioural problems.

Hyposadias
Hyposadias is a condition that affects approximately one in 500 newborn males. This congenital defect results in the urethral opening being somewhere other than the tip of the penis. In severe cases, the penis is also deformed. In these instances, the condition is usually corrected through surgery. Less serious occurrences are often left alone but this can add to fertility problems when the man is older.

Lead
Lead is a heavy metal that occurs naturally in the environment and is produced from man-made sources. Most exposures to lead come from lead paint and emissions from industrial facilities like metal smelters. Other sources of exposure include crystal tableware, porcelain enamel and contaminated food. Lead is a suspected carcinogen, a known hormone disruptor, and can damage

almost every organ and system in the human body, particularly the nervous system. Lead has been indicated as a cause of decreased mental ability, developmental delays, behavioural disorders and reproductive defects.

National Pollutant Release Inventory (NPRI)
The National Pollutant Release Inventory is a program managed by Environment Canada. It is a database of information on annual releases to air, water, land and disposal or recycling from all sectors - industrial, government, commercial and others. The National Pollutant Release Inventory is the only legislated, nation-wide, publicly-accessible inventory of its type in Canada.

Neurodevelopmental Disorders
Neurodevelopmental disorders are disabilities in the functioning of the brain that affect a child's behaviour, memory, or ability to learn. These effects may result from exposure of the fetus or young child to certain environmental contaminants, though current data do not indicate the extent to which environmental contaminants contribute to overall rates of neurodevelopmental disorders in children. A child's brain and nervous system are vulnerable to adverse impacts from pollutants because they go through a long developmental process beginning shortly after conception and continuing through adolescence.

Neurotoxicants
Exposure to chemical substances can cause adverse effects on the nervous system (neurotoxicity). Chemicals toxic to the central nervous system can induce confusion, fatigue, irritability, and other behavioural changes. Exposure to methyl mercury and lead cause central nervous system toxicity, and can also cause degenerative diseases of the brain (encephalopathy). Chemicals toxic to the peripheral nervous system affect how nerves carry sensory information and motor impulses from the brain to the rest of the body.

Organochlorine Pesticides
Organochlorine pesticides (OPs), such as DDT, were introduced in the 1940s. Many of their uses have been restricted because they persist in the environment. These chemicals are highly toxic and as a group of chemicals are recognized carcinogens and reproductive/developmental toxins, they are also suspected hormone disruptors and respiratory toxins. Organochlorine pesticides can enter the environment from direct application and runoff, emissions from waste incinerators, releases from manufacturing plants and disposal of contaminated waste in landfill.

Organophosphate Insesticides
A broad group of pesticides still in use that represent the most commonly used insecticides in agriculture and home uses. Organophosphate insecticides are suspected of causing cancer, reproductive, developmental and neurological disorders.

Organophosphate Insecticide Metabolites (Dialkyl phosphate metabolites)
Most organophosphate pesticides are metabolized in the body to measurable breakdown products known as dialkyl phosphate metabolites. Dialkyl phosphates themselves are not considered toxic, but they are markers of exposure to organophosphate insecticides.

Persistent
Compounds that are not easily broken down in the environment and therefore stay in the environment for a very long time are known as "persistent".

Perfluorooctane Sulfonate (PFOS)
A key ingredient in stain-repellants, PFOS is widely used in a variety of consumer products - from wrapping for microwave popcorn to fire extinguishing foam. PFOS is a perfluorinated chemical, and although much more research is needed on these chemicals, existing studies have shown that perfluorinated chemicals are extremely persistent. Studies also suggest that these chemicals can cause cancer and disrupt hormones.

Perfluorooctanoic Acid (PFOA)
PFOA belongs to a group of perfluorinated chemicals (PFCs) that are widely used in consumer products for their resistance to environmental breakdown. PFOA and its precursors (substances that under the right conditions form into PFOA) are most commonly used to make non-stick cookware, and stain and water repellents on clothes, upholstery and carpeting. As these types of products are used, harmful chemicals actually break away from the product and enter our household air and food-and our bodies. Although much more research is needed on the health impacts of perfluorinated chemicals, existing studies have shown that PFCs are extremely persistent and can cause numerous types of cancer, as well as neurological and reproductive defects.

Phthalates
Phthalates are a group of manufactured chemicals that are widely used as plasticizing additives in a broad range of consumer products, including cosmetic and personal care products, PVC con-

sumer products and construction materials. These chemicals are also used in synthetic fragrances to extend the scents' staying power. Phthalates are relatively persistent in the environment and have been found in drinking water, soil, household dust, wildlife, fatty foods (meat and dairy products) and in the blood and breast milk of people. Scientific research has shown that phthalates disrupt hormones, and can cause birth defects of male reproductive organs.

Pollution Prevention Plans
The Canadian Environmental Protection Act, 1999 (CEPA 1999) gives the Minister of the Environment the authority to require the preparation and implementation of pollution prevention plans for CEPA 1999 toxic substances (substances that have been added to Schedule 1 of CEPA 1999).

Pollution prevention is defined in the Canadian Environmental Protection Act as "the use of processes, practices, materials, products, substances or energy that avoid or minimize the creation of pollutants and waste and reduce the overall risk to the environment or human health."

Polybrominated diphenyl ethers (PBDEs)
See brominated flame retardants.

PCBs (polychlorinated biphenyls)
PCBs have been banned in Canada since 1977, yet they continue to be released into the environment from sources in other countries, and from PCB-containing industrial equipment that is still in use here at home. PCBs are highly toxic and persistent chemicals that have been building up in wildlife and people through the process of bioaccumulation. PCBs cause many types of cancer and damage the nervous, immune and cardiovascular systems, leading to birth defects, brain damage and decreased immune function.

Reproductive/Developmental Toxicants
Reproductive toxicants can affect sexual behaviour, onset of puberty, sperm count, fertility, gestation time, pregnancy outcome, lactation and premature menopause. Developmental toxicants, a sub-group of reproductive toxicants, can cause adverse effects for the developing child, such as birth defects.

Respiratory Toxicants
Respiratory toxicants cause adverse effects to the structure or functioning of the respiratory system (nasal passages, pharynx, trachea, bronchi, and lungs), and produce a variety of acute and chronic pulmonary conditions, including local irritation, bronchitis, pulmonary edema, emphysema, and cancer.

Respiratory toxicants include categories of substances like toxic gases, vapors from solvents, aerosols, and particulate matter. Ozone and fine particles are known to pose a significant threat to respiratory health. Ground-level ozone, the main component in smog, causes breathing problems, aggravates asthma, and increases the severity and incidence of respiratory infections

Testicular Dysgenesis Syndrome
Testicular dysgenesis syndrome (TDS) is a term that includes a number of male reproductive health disorders, including poor sperm quality, undescended testes, hypospadias and testicular cancer. Scientific research suggests these symptoms of testicular dysgenesis syndrome all originate during the development of the fetal testes.

Toxaphene
Toxaphene was one of the most widely used insecticides, but is now banned in many countries. People are most often exposed to toxaphene through their diet, especially if it includes fish from contaminated sources. Toxaphene has been measured in oils and fats, root vegetables, meats and grains.

Toxic
Materials that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and exposures necessary to cause these effects can vary widely.

Triclosan
The chemical triclosan is a synthetic antimicrobial/antibacterial agent whose use has become widespread in toothpastes and mouthwashes, deodorants, cosmetics, fabrics, plastics and other products. No data have demonstrated that antibacterials provide any additional benefits over using ordinary soap and water when it comes to protecting against viral infectious diseases. Research has instead shown that triclosan may have several negative health effects; it can cause allergies and asthma by weakening the immune system; it disrupts the hormonal system; it can bioaccumulate; and, it belongs to a class of chemicals that are suspected of causing cancer in humans. Studies have also shown that when triclosan is exposed to sunlight in water it may convert into the potent toxic chemical dioxin.

Virtual Elimination
Under the Canadian Environmental Protection Act, virtual elimination is the reduction of releases to the environment of the most dangerous toxic substances to a level below which these releases cannot be accurately measured.

VOCs (Volatile and Semi-volatile organic compounds)

VOCs, such as the chemicals xylene, benzene, and toluene, are found in many household products, including paints, varnishes, paint stripping products, and adhesives. VOCs are airborne particles that contribute to poor air quality indoors and out. VOCs are one of the building blocks of smog, and are toxic to the nervous system. Some VOCs are cancer-causing. The health effects of different VOCs range from damage to the reproductive, neurological and respiratory systems, birth defects, and impaired kidney and liver function.

Measurements

µg/L (microgram per litre), equivalent to parts per billion (ppb)
ng/mL (nanogram per millilitre), equivalent to parts per billion (ppb)
µg/g (microgram per gram), equivalent to parts per million (ppm)
cre= creatinin, in urine measurement
µmol/L (micromoles per litre)
nmol/L (nanomoles per litre)

Appendix 1. Sampling and Analytical Methodology

Laboratories:

- Centre de Toxicologie, Institut National de Santé Publique du Québec (INSPQ) in Ste-Foy, Quebec, conducted the analysis for:
    - heavy metals, polybrominate diphenyl ethers (PBDEs), polychlorinated biphenyls (PCBs), organochlorine pesticides, organophosphate insecticide metabolites, and perfluorooctane sulfonate (PFOS).

- Accu-Chem Laboratories in Richardson, Texas, conducted the analysis for:
    - volatile and semi-volatile organic compounds (VOCs).

VOCs

Compounds	Benzene, Toluene, Ethylbenzene, M.P. Xylenes, O-Xylene, Styrene, 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene, Chloroform, Dichloromethane, 1,1,1-Trichloroethane, Trichloroethene, Tetrachloroethane, 1,2-Dichlorobenzene, 1,3-Dichlorobenzene, 1,4-Dichlorobenzene, Bromodichloromethane, Carbon Tetrachloride, 1,1-Dichloroethene, Trans-1,2-Dichloroethene, MTBE, Cis-1,2-Dichloroethene, 1,2-Dichloroethane, 1,2-Dichloropropane, 1,1,2-Trichloroethane, Dibromochloromethane, Chlorobenzene, Tetrachloroethylene
Specimen	Whole blood
Specimen container	Two 7 mL Lavender top (EDTA) Becton Dickinson Vacutainers
Transport temperature	Refrigerate before shipping. Include ice pack.
Methodology	High Resolution Gas Chromatography/ Mass Spectrometry (GC/MS)
Detection limit	0.3 ng/mL (ppb)

PFOS

Compounds	Perfluorooctane sulfonate
Specimen	Plasma
Specimen collection container	10 mL Lavender top (EDTA) Becton Dickinson Vacutainers (glass)
Specimen collection	Immediately invert tube 8 to 10 times. Cool slowly to 4°C. Centrifuge for 10 minutes. Transfer plasma using a plastic transfer pipette into shipping container.
Shipping container	7 mL screw-cap polypropylene tube
Storage	4°C (samples to reach laboratory within 3 days)
Shipping	Shock-resistant cooler. Include ice pack.
Methodology	HPLC-MS-MS
Detection limit	0.1 µg/L (ppb)

PCBs, Organochlorine Pesticides, PBDEs

Compounds	**PCBs:** PCB Aroclor 1260, PCB-28, PCB-52, PCB-99, PCB 101, PCB-105, PCB-118, PCB 128, PCB 138, PCB-153, PCB-156, PCB 163, PCB-170, PCB-180, PCB 183, PCB 187 **Organochlorine pesticides:** Aldrin, -chlordane, -chlordane, -HCH, Cis-nonachlore, p,p'-DDT, p,p'-DDE, Hexachlorobenzene, Oxychlordane, Mirex, Trans-nonachlore, toxaphene 26, Toxaphene 50 **PBDEs:** PBDE 47, PBDE 99, PBDE 100, PBDE 153, PBB 153
Specimen	Plasma
Specimen collection container	10 mL glass Lavender top (EDTA) Becton Dickinson Vacutainers
Specimen collection	Immediately invert tube 8 to 10 times. Cool slowly to 4°C. Centrifuge for 10 minutes. Transfer plasma using a plastic transfer pipette into shipping container.
Shipping container	Pre-cleaned 7 mL screw-cap glass tube with Teflon disc
Storage	4°C (samples to reach laboratory within 3 days)
Shipping	Shock-resistant cooler. Include ice pack.
Methodology	Gas Chromatography Mass Spectrometry (GC-MS)
Detection limit	0.01 µg/L (ppb)

Organophosphate Insecticide Metabolites

Compounds	Diethyl phosphate, Dimethyl phosphate, Diethyl thiophosphate, Dimethyl thiophosphate, Diethyl dithiophosphate, Dimethyl dithiophosphate
Specimen	Urine
Specimen container	125 mL polyethylene bottle
Storage	20°C
Shipping	Shock-resistant cooler. Include ice pack.
Methodology	Gas Chromatography Mass Spectrometry (GC-MS)
Detection limit	1 µg/g cre (ppm)

Heavy Metals

Compounds	Arsenic, Beryllium, Bismuth, Cadmium, Cobalt, Copper, Lithium, Manganese, Molybdenum, Nickel, Lead, Silver, Tellurium, Tin, Thallium, Uranium, Zinc, Selenium, Mercury
Specimen	Whole blood
Specimen container	6 mL Lavender top (EDTA) Becton Dickinson Vacutainers (plastic)
Specimen collection	Immediately invert tube eight to 10 times.
Storage temperature	4°C (maximum 1 month)
Shipping	Shock-resistant cooler. Include ice pack.
Methodology	Inductively Coupled Plasma Mass Spectrometry (ICP-MS)
Detection limit	Variable, see below.

Element	Whole Blood Detection Limit
Arsenic	3 nmol/L
Beryllium	0.05 µmol/L
Bismuth	0.07 nmol/L
Cadmium	0.4 nmol/L
Cobalt	0.9 nmol/L
Copper	0.01 µmol/L
Lead	0.001 µmol/L
Lithium	0.02 µmol/L
Manganese	7 nmol/L
Mercury	0.5 nmol/L
Molybdenum	1 nmol/L
Nickel	6 nmol/L
Selenium	0.1 µmol/L
Silver	10 nmol/L
Tellurium	8 nmol/L
Thallium	0.07 nmol/L
Tin	2 nmol/L
Uranium	0.008 nmol/L
Zinc	0.01 µmol/L

Appendix 2: List of Chemicals Tested

Volatile Organic Compounds (VOCs) (28)

Benzene
Toluene
Ethylbenzene
M.P. Xylenes
O-Xylene
Styrene
1,2,4-Trimethylbenzene
1,3,5- Trimethylbenzene
Chloroform
Dichloromethane
1,1,1-Trichloroethane
Trichloroethene
Tetrachloroethane
1,2-Dichlorobenzene
1,3- Dichlorobenzene
1,4- Dichlorobenzene
Bromodichloromethane
Carbon Tetrachloride
1,1-Dichloroethene
Trans-1,2-Dichloroethene
MTBE
Cis-1,2-Dichloroethene
1,2-Dichloroethane
1,2-Dichloropropane
1,1,2-Trichloroethane
Dibromochloromethane
Chlorobenzene
Tetrachloroethylene

Polybrominated Diphenyl Ethers (PBDEs) (5)

PBDE 47
PBDE 99
PBDE 100
PBDE 153
PBB 153

Heavy Metals (19)

Arsenic
Beryllium
Bismuth
Cadmium
Cobalt
Copper
Lithium
Manganese
Molybdenum
Nickel
Lead
Silver
Tellurium
Tin
Thallium
Uranium
Zinc
Selenium
Mercury

Organophosphate Insecticide Metabolites (6)

Diethyl phosphate
Dimethyl phosphate
Diethyl thiophosphate
Dimethyl thiophosphate
Diethyl dithiophosphate
Dimethyl dithiophosphate

Perfluorinated Compounds (1)

Perfluorooctane sulfonate (PFOS)

Organochlorine Pesticides (13)

Aldrin
α-chlordane
γ-chlordane
β-HCH
Cis-nonachlore
p,p'-DDT
p,p'-DDE
Hexachlorobenzene
Oxychlordane
Mirex
Trans-nonachlore
Toxaphene 26
Toxaphene 50

Polychlorinated Biphenyls (PCBs) (16)

PCB Aroclor 1260
PCB-28
PCB-52
PCB-99
PCB 101
PCB-105
PCB-118
PCB 128
PCB 138
PCB-153
PCB-156
PCB 163
PCB-170
PCB-180
PCB 183
PCB 187

toxic nation

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