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Our Health, Our Environment:

A Snapshot of Environmental Health in Canada



Health Canada is the federal department responsible for helping the people of Canada maintain and improve their health.

We assess the safety of drugs and many consumer products, help improve the safety of food, and provide information to Canadians to help them make healthy decisions. We provide health services to First Nations people and to Inuit communities. We work with the provinces to ensure our health care system serves the needs of Canadians.

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TABLE OF CONTENTS

INTRODUCTION: OUR HEALTH, OUR ENVIRONMENT	3
TRACKING CANADIANS' EXPOSURE TO CHEMICAL SUBSTANCES USING BIOMONITORING	7
LEAD	17
INDOOR AIR QUALITY AT HOME	25
OUTDOOR AIR QUALITY	37
DRINKING WATER QUALITY	49
LIST OF ACRONYMS	67





INTRODUCTION

OUR HEALTH, OUR ENVIRONMENT

Today it is widely recognized that human health is affected by changes to our environment and that these changes can have a positive or negative impact on our health. Developments such as the expansion of urban living environments and advanced sanitation systems have greatly contributed to improvements in population health over the last century, namely by increasing access to safe food and water. Similarly, pollution, climatic uncertainties and some significant aspects of industrial and urban development have had some negative impacts on our health.

Since our health is linked to the places in which we live, the water that we drink and the air that we breathe, environmental health has a direct impact on our physical well-being. According to the World Health Organization (WHO),

environmental health “addresses all the physical, chemical, and biological factors external to a person, and all the related factors impacting behaviours.” Environmental health is a very broad topic, including many challenges and opportunities. This publication focuses on the aspects of human health that are determined by the presence or absence of different substances in the environment, both synthetic and natural, as well as living organisms. These include chemical substances, dust mites, mould and microorganisms found in the home and the community.

The past century’s technological advances have led to significant improvements for our society. However, along with some major benefits, advances in technology have introduced new substances into the environment and have also increased the amount of some naturally occurring substances (e.g., lead and mercury). In some instances, the production and use

of these substances exceed our knowledge of possible health risks they could pose. While many substances are found at concentrations below the level at which scientists consider them to be a risk, exposure to some substances is linked to respiratory, cardiovascular, neurological and reproductive problems, as well as some cancers.

As knowledge of the possible short- and long-term health risks posed by substances or living organisms in our environment increases, so too do actions to limit our exposure. For example, a greater understanding of the negative health effects of lead resulted in actions to reduce its use and release in Canada. Lead was removed from gasoline and its release into the air from mining and smelting activities was restricted. As a result, findings from a recent biomonitoring survey show that the amount of lead in Canadians' blood has decreased significantly over the past thirty years.

The purpose of this publication is to provide Canadians with information on how their health is affected by their living environment and how health risks can be reduced. Each of the five sections outlined below offers information on environmental health risks, current trends, and actions to protect and promote environmental health in Canada.

Biomonitoring: This section explains what biomonitoring is and how it helps assess Canadians' exposure to chemical substances. This section also describes how biomonitoring identifies chemical substances that may require further action to protect the health of Canadians. The information collected from observing trends in exposure helps the Government of Canada develop policies and programs to protect the health of Canadians.

Lead: This section summarizes the current knowledge of the health effects associated with this heavy metal, which is found in many different sources within Canadian living environments. Although Canada has made much progress in reducing the amount of lead released into the environment, there is still work to be done to reduce exposure levels further, especially for small children. The level of exposure and the effect lead has on your health is dependent on many factors, including where you live, your age and behaviour and the hobbies in which you are involved.

Indoor Air Quality at Home: This section explains some of the most common indoor air health concerns and how to improve the quality of the air in homes. In general, Canadian homes have good air quality, measuring below the recommended limits for levels of pollution established by Health Canada in the Residential Indoor Air Quality Guidelines. However, indoor air pollutants like mould, dust mites and radon, as well as how a house is built and maintained, can all affect indoor air quality.

Outdoor Air Quality: This section outlines sources of outdoor air pollution, associated health effects and measures to protect your health and reduce emissions of air pollutants. Despite having relatively good air quality, some Canadians experience considerable adverse health effects from air pollution (such as cardiovascular and respiratory diseases).

Drinking Water Quality: This section explains who is responsible for the safety of drinking water in Canada, the factors influencing drinking water quality, and highlights some recent or on-going initiatives to help protect and improve the quality of drinking water. Canada's drinking water quality record is the result of a long-standing collaborative effort by key players and stakeholders in every jurisdiction in the country.

Government of Canada's management of environmental health

At the national level, the Ministers of Environment and Health provide leadership for managing most environmental health issues. In addition, since all federal government departments are responsible for protecting our environment and health, the Government of Canada has many laws and programs dedicated to protecting human health. The key legislation include:

- *Canadian Environmental Protection Act, 1999 (CEPA)*: governs pollution prevention and protection of the environment and human health, all within the context of sustainable development goals. Both Environment Canada and Health Canada are responsible for administering this Act.
- *Canada Consumer Product Safety Act (CCPSA)*: promotes protection of the public through addressing or preventing dangers to human health or safety that are posed by consumer products in Canada, including those that circulate within Canada and those that are imported. Health Canada is responsible for administering this Act.
- *Hazardous Products Act (HPA)*: promotes protection of workers through establishing requirements for labelling and provision of safety information for workplace hazardous materials. Health Canada is responsible for administering this Act.
- *Food and Drugs Act (FDA)*: governs the importing, selling, packaging, labelling and advertising of food, cosmetics and therapeutic products. Health Canada and the Canadian Food Inspection Agency share responsibility for administering this Act.
- *Pest Control Products Act (PCPA)*: protects human health and the environment from risks associated with pest control products and their use. Health Canada is responsible for administering this Act.
- *Canadian Environmental Assessment Act, 2012 (CEAA)*: sets out the federal environmental assessment process for proposed projects. Changes to the environment that can affect human health are examined during the assessment process. The Canadian Environmental Assessment Agency, the Canadian Nuclear Safety Commission and the National Energy Board are responsible for conducting these assessments.
- *Transportation of Dangerous Goods Act (TDGA)*: promotes public safety in the transportation of dangerous goods. Transport Canada is responsible for administering this Act.



TRACKING CANADIANS' EXPOSURE TO CHEMICAL SUBSTANCES USING BIOMONITORING

Introduction

Our health can be influenced by many factors, such as exposure to both natural and man-made chemical substances in our environment. Many chemical substances are part of the daily lives of Canadians, however, under some circumstances (such as high-level or long-term exposure) certain chemical substances in natural and built environments can adversely affect human health. Biomonitoring is an important tool that can be used to assess human exposure to chemical substances, which contributes to a greater understanding of environmental factors

that affect health. This section uses data from the Canadian Health Measures Survey (CHMS) and Northern Contaminants Program (NCP) to illustrate how biomonitoring can be used to provide information on the current state of exposure to chemical substances in Canada.

What is biomonitoring?

Chemical substances are found in air, soil, water, products, and food, and can enter the body through ingestion, inhalation, and skin contact (Figure 1). Human exposure to chemical substances can be estimated indirectly by

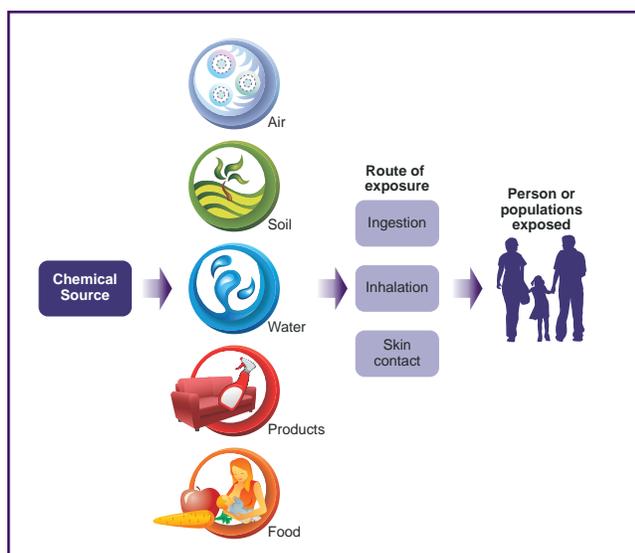


Figure 1: Exposure to chemical substances.

measuring substances in the environment, food, or products, or directly using biomonitoring. Biomonitoring is the measurement, in people, of a chemical substance or the products a chemical substance makes when it breaks down. This measurement is usually taken in blood and urine, or sometimes other tissues and fluids such as hair, nails, and breast milk. This measurement indicates how much of a substance is present in a person. Biomonitoring is a useful tool because it provides an estimate of chemical exposure from any or all sources in the environment.

What does biomonitoring say about health risk?

Although biomonitoring provides an estimate of exposure, a chemical substance's presence alone will not necessarily result in adverse health effects. The risk a chemical substance poses is determined by evaluating both its hazard and the levels to which people may be exposed. For chemical substances such as lead or mercury, scientific studies have provided a good understanding of the potential health risks associated with elevated levels in blood. The Government of Canada has developed guidance

values for lead and mercury in blood to indicate what levels of exposure may be of concern. If a person's measured levels are above these guidance values, actions may be considered to reduce exposure. Further research is needed to understand what health effects, if any, are related to different concentrations of many other chemicals in blood, urine, or other tissues and fluids.

Uses of biomonitoring data

Human biomonitoring data can be used by government, researchers, and health practitioners to do the following:

- Establish baseline levels of chemical substances in the Canadian population for tracking changes over time;
- Compare exposure to chemical substances among different populations;
- Help identify priority chemicals for which further action should be taken to protect the public's health;
- Assess the potential risks to human health posed by chemical substances;
- Assess the effectiveness of risk management actions intended to reduce exposure to specific chemical substances and their associated health risks; and
- Support future research on potential links between exposure to certain chemical substances and specific health effects.

Current biomonitoring activities

Canada supports a number of biomonitoring activities designed to help expand the understanding of exposure to environmental chemicals. Activities include:

- National biomonitoring programs;
- Biomonitoring studies targeting sub-populations of interest (e.g., women of child-bearing age, individuals living in northern communities); and
- Research to advance biomonitoring methods and develop tools to better understand, interpret, and communicate biomonitoring results.

Below are a few examples of biomonitoring programs currently underway in Canada.

Canadian Health Measures Survey

The Canadian Health Measures Survey (CHMS) is the most comprehensive health measures survey ever conducted in Canada. It collects information on the general health and lifestyles of Canadians through interviews and direct physical measurements (e.g., weight and height). The CHMS includes a biomonitoring component, which collects blood and urine samples that are analysed to provide information on exposure to selected environmental chemicals. The first cycle collected information from 5,600 Canadians aged 6 to 79 years during 2007–2009. The second cycle (2009–2011) includes children as young as 3 years of age.

This first set of national data provides us with a baseline, or starting point, for levels of chemicals in Canadians and also provides the basis for future monitoring and research activities. Compiling data from future cycles of the CHMS will allow Health Canada to track changes in exposure to chemicals in the Canadian population over time. This biomonitoring information will assist in the assessment and management of environmental chemicals in Canada. The Report on Human Biomonitoring of Environmental Chemicals in Canada provides the results of the first cycle of the CHMS. The chemicals measured include: metals (e.g., lead, cadmium, mercury), organochlorines (e.g., chlordane, DDT, toxaphene), polychlorinated biphenyls (PCBs), polybrominated flame retardants (PBDEs), perfluorinated compounds (PFCs), bisphenol A (BPA), pesticides (e.g., 2,4-D), and cotinine.

First Nations Food, Nutrition, and Environment Study

Health Canada is collaborating with the University of Northern British Columbia, University of Montreal, and the Assembly of First Nations on the First Nations Food, Nutrition, and Environment Study (FNFNES). This ten-year study (2008–2018) documents the nutritional benefits and environmental challenges related to the diets of First Nations people living on reserves, and contains a biomonitoring component to measure this population's exposure to mercury.

First Nations Biomonitoring Initiative

The First Nations Biomonitoring Initiative (FNBI) is a five year (2008–2012) cross-Canada health survey designed to establish a baseline of First Nations' exposure levels to environmental chemicals. This initiative is a partnership between Health Canada and the Assembly of First Nations (AFN). The FNBI is exclusive to First Nations living on reserve (south of the 60th parallel) and serves to complement the CHMS. Randomly selected First Nations communities across Canada participated in the fall of 2011 (over 500 participants) and results are expected to be released in the summer of 2012. Components of the FNBI include a household questionnaire, direct physical measurements, and biospecimen collection (blood and urine). Chemicals measured include: metals (e.g., lead, mercury, cadmium), organochlorines, polychlorinated biphenyls (PCBs), polybrominated flame retardants (PBDEs), perfluorinated compounds (PFCs), bisphenol A (BPA), pesticides, and cotinine.

Maternal-Infant Research on Environmental Chemicals

The Maternal-Infant Research on Environmental Chemicals (MIREC) study is a collaborative effort among Health Canada scientists, Sainte-Justine Hospital in Montreal and clinical researchers from the other participating cities. The study measures the extent to which pregnant women and their babies are exposed to environmental chemicals and assesses what pregnancy health risks, if any, are associated with exposure to the heavy metals lead, mercury, cadmium, and arsenic. In addition to measuring chemicals in blood and urine, the study measures the levels of chemicals in breast milk as well as its beneficial components (nutritional and immune constituents).

Northern Contaminants Program

The Northern Contaminants Program (NCP) was established by the Government of Canada in 1991 in response to concerns about human exposure to elevated levels of environmental chemicals in wildlife species that are important to the traditional diets of northern Aboriginal peoples. Populations living in northern regions have a greater potential for exposure because chemical substances can be transported long distances to the Arctic and deposited, subsequently accumulating in traditional food sources (e.g., fish and marine mammals). Data have been collected on many chemical substances, primarily in the blood of pregnant women (maternal blood) in the North, including heavy metals such as mercury, lead, and cadmium, and persistent organic pollutants (POPs) such as chlordane, DDT, toxaphene, and polychlorinated biphenyls (PCBs). Levels of emerging contaminants, such as polybrominated diphenyl ethers (PBDEs) and perfluorinated compounds (PFCs), have also been measured in some of the most recent studies. Initial baseline monitoring was undertaken in the 1990s, with follow-up studies about ten years later, to assess changes in the levels of selected environmental contaminants in northern populations.

Status and trends in Canada

Data from the CHMS and the NCP illustrate how biomonitoring can be used to provide information on the current state of exposure to chemical substances in Canada. The following sections will highlight the status and trends in Canada for some selected chemical substances:

- Mercury, a metal of concern;
- Polychlorinated biphenyls (PCBs), a group of chemical substances of concern; and
- Bisphenol A (BPA), a chemical substance of recent interest.

Mercury biomonitoring

Mercury exposure and its related health effects came to the attention of the Canadian public almost forty years ago, when mercury was released from a pulp and paper mill in Dryden, Ontario into the nearby Wabigoon River system. As a result, people in First Nations communities living near the river system, and relying on it as a major food source, were found to have significantly higher exposures to mercury through their consumption of local fish. This

situation highlighted the potential impacts of environmental mercury contamination and emphasized the importance of exposure monitoring. Since this time, biomonitoring has proven to be a useful tool to monitor mercury exposure.

Mercury is a chemical substance of concern because it is harmful to human health, does not break down in the environment and can accumulate in living things. After it is released into the environment, mercury can be changed by microorganisms into a form called methylmercury, which is especially harmful to both wildlife and humans through effects on the nervous system. Methylmercury tends to accumulate in fish and marine mammals. Exposure of the general population is primarily to methylmercury, which occurs through the consumption of fish and seafood. To a much lesser extent, the general population is exposed to other forms of mercury from sources such as dental fillings. Exposure can also occur when mercury-containing products are broken, resulting in the release of mercury in the home or workplace.

The 2007–2009 CHMS, which measured total mercury in the blood and urine of people aged 6 to 79 years, provides the first national data

Mercury: who is at risk?

Certain populations that consume large amounts of fish and marine mammals as part of their regular diet may be exposed to higher levels of mercury. The developing fetus and children of women who have consumed large amounts of fish and marine mammals during pregnancy are the most susceptible to health problems. However, exposure to methylmercury from fish consumption is generally so low that it is difficult to measure any potential adverse health effects. Any such health effects, however, should be weighed against the nutritional and socio-cultural benefits of fish consumption.

Mercury Levels in Canadians

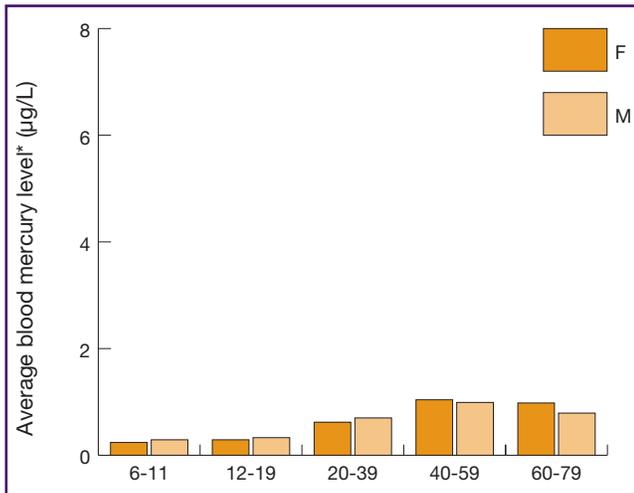


Figure 2: Average blood mercury level (total mercury measured in µg/L) in the Canadian population (CHMS, 2007–2009). *Average level is calculated as the geometric mean.

on the levels of mercury in Canadians. Figure 2 shows the average level of blood mercury for each of the age groups measured in the CHMS. Levels are consistent with those reported in the United States and are well below the current Health Canada blood guidance value of 20 micrograms per litre (µg/L) for the general adult population. More recently, to further protect potentially vulnerable populations, a revised guidance value of 8 µg/L has been proposed for children, pregnant woman and women of child-bearing age.

In Arctic regions, a significant part of the traditional diet may include large quantities of fish and marine mammals, which can expose northerners to higher levels of mercury. The

Mercury Levels in Pregnant Women from Inuvik, Baffin and Nunavik Regions

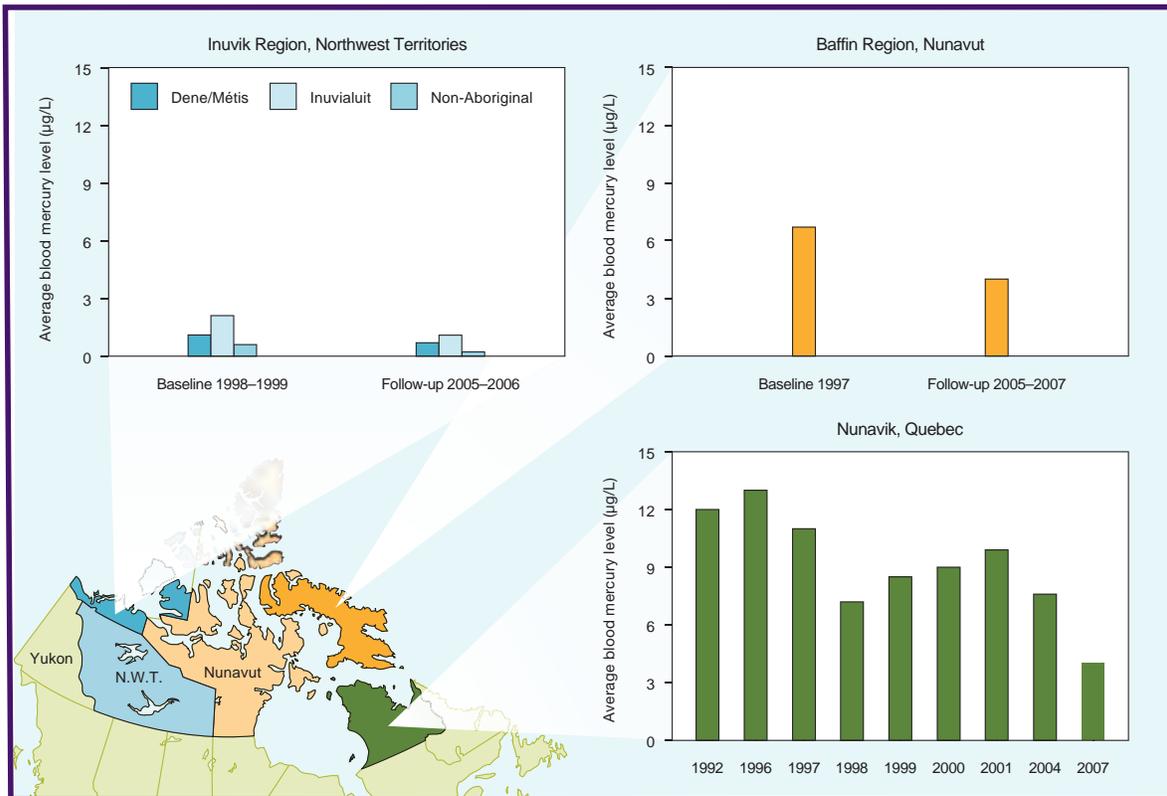


Figure 3: Average blood mercury level (total mercury measured in µg/L) in pregnant women from Inuvik region (N.W.T.), Baffin region (Nun.) and Nunavik region (Que.) (Canadian Arctic Contaminants and Health Assessment Report, 2009). *Average level is calculated as the geometric mean.

biomonitoring data collected under the NCP show that the total blood mercury levels measured in 15 to 45 year-old pregnant women from Inuvik, Baffin and Nunavik decreased between the 1990s and the mid-2000s (Figure 3). Nonetheless, levels in northern populations remain higher than in the overall Canadian population, as measured in the CHMS.

Polychlorinated biphenyl biomonitoring

Polychlorinated biphenyls (PCBs) are a group of synthetic substances produced up to the late 1970s for use in various industrial and commercial applications. PCBs were widely used in hundreds of different ways because of their unique traits, including non-flammability, chemical stability, high boiling point, and electrical insulating properties. Unfortunately, the same characteristics that make PCBs so useful are also responsible for making them break down very slowly and persist in the environment for many years. As a result, low levels of PCBs can still be found in the environment and in food, making them priority substances for biomonitoring. In addition, animal studies have shown that high levels of PCBs can

have effects on the liver, endocrine system, skin, immune system, nervous system, reproductive system and fetal development, and may be linked to liver and kidney cancer.

The 2007–2009 CHMS measured 24 different types of PCBs in the blood of people aged 20 to 79 years. Figure 4 shows the average level of PCB 153, one of the most common PCBs found in human tissues, for each of the age groups measured in the CHMS. In general, levels of PCBs in the Canadian population are consistent with those reported in the United States. PCBs accumulate over time. As a result, levels increase with age. This can be seen in Figure 4 where the 60–79 year-old age group had higher levels of PCB 153 compared to the younger age groups.

In the Canadian Arctic, comparison of NCP studies performed in the 1990s and 2000s show a decreasing trend in the levels of PCB 153 in the blood of pregnant women (aged 15 to 45 years) in the regions of Inuvik, Baffin, and Nunavik (Figure 5). However, PCB levels in this age group

PCBs: who is at risk?

Everyone is exposed to very low levels of PCBs through food, and to a lesser extent, through air, dust, soil and water. However, these low levels are unlikely to cause adverse health effects. Certain populations such as anglers, hunters, and Aboriginal peoples may be exposed to higher levels of PCBs due to their increased consumption of certain fish, wild game and marine mammals.

PCB Levels in Canadians

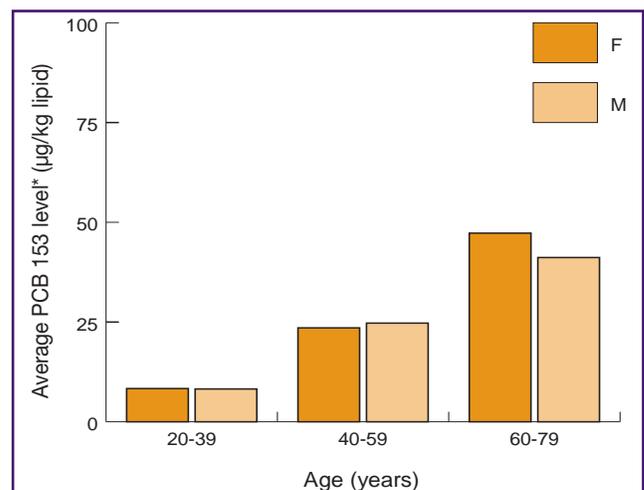


Figure 4: Average PCB 153 level in blood plasma (µg/kg lipid) in the Canadian population (CHMS, 2007–2009). *Average level is calculated as the geometric mean.

remain two to five times higher than in women from the same age group across Canada, as measured in the CHMS.

Bisphenol A biomonitoring

Bisphenol A (BPA) is a synthetic chemical used to make polycarbonate plastic and epoxy resins. Polycarbonate is used in the manufacture of food and beverage containers, such as repeat-use water bottles and storage containers. Prior to new regulations, it was also used to make

plastic infant bottles. Epoxy resins are used as a protective lining for food and beverage cans. Plastics and resins made from BPA can also be used in a range of other products including medical devices (e.g., blood oxygenators, incubators, and respiratory devices), some dental fillings and sealants, sporting and safety equipment (e.g., hockey helmets), electronics (e.g., alarm devices, mobile phone housings, and computers), and automotive parts (e.g., headlights, bumpers, and inside lights). Some laboratory studies on animals suggest that BPA

PCB Levels in Pregnant Women from Inuvik, Baffin and Nunavik Regions

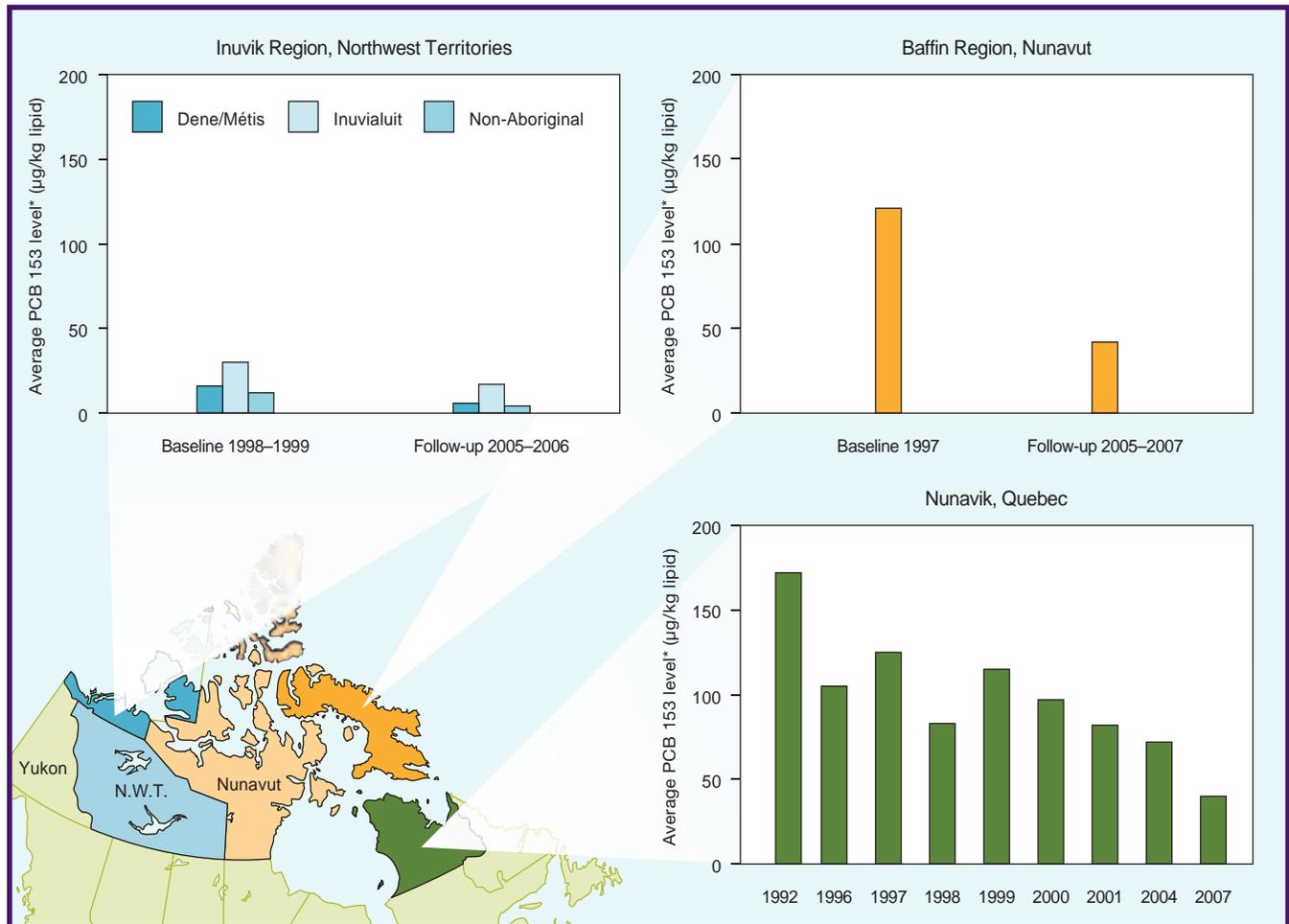


Figure 5: Average polychlorinated biphenyl (PCB) 153 level in blood plasma (µg/kg lipid) in pregnant women from Inuvik region (N.W.T.), Baffin region (Nun.), and Nunavik region (Que.) (Canadian Arctic Contaminants and Health Assessment Report, 2009). *Average level is calculated as the geometric mean.

BPA: who is at risk?

While most Canadians are exposed to low levels of BPA, newborns and infants are estimated to have the highest potential exposures. Therefore, as a precaution, risk management activities are focused on decreasing the potential for exposure of this age group.

at low levels of exposure can affect neural development and behaviour when experimental animals are exposed in very early life. Health Canada supports the need for additional research in these areas, and scientists continue to evaluate new scientific evidence as it emerges.

The 2007–2009 CHMS is the first national survey to measure BPA in Canadians. BPA was detected in the urine of 91% of 6 to 79 year olds, which is comparable to the United States, where BPA was detected in 93% of the population (aged 6 years and older). Figure 6 shows the average level of BPA for each of the age groups measured in the CHMS. The geometric mean for the overall 6 to 79 year old Canadian population was 1.16 µg/L compared to 2.08 µg/L reported in the United States for people 6 years of age and older (2007–2008).

Biomonitoring and environmental health

Biomonitoring is a valuable tool used to estimate exposure to chemical substances. Baseline measures, such as those obtained in the CHMS, are important starting points for future monitoring and research related to chemical exposure. Observing trends in exposure to

BPA Levels in Canadians

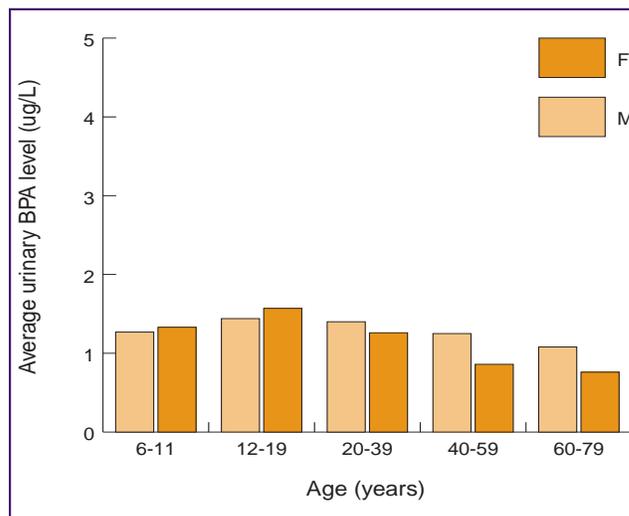


Figure 6: Average level of bisphenol A (BPA) in the Canadian population (CHMS, 2007–2009). *Average level is calculated as the geometric mean.

chemical substances, as seen in data from the NCP, can help us assess the effectiveness of management actions and identify future areas of concern. This information will continue to help expand the knowledge and understanding of exposure to chemical substances, and will contribute to the development of policies and programs to protect the health of Canadians.

Additional resources

The following links provide information on biomonitoring activities underway in Canada and the United States.

- Monitoring and Surveillance Activities under Canada's Chemicals Management Plan (www.chemicalsubstanceschimiques.gc.ca/plan/surveil/index-eng.php)
- Canadian Health Measures Survey (www.hc-sc.gc.ca/ewh-sem/contaminants/human-humaine/chms-ecms-eng.php)

- Report on Human Biomonitoring of Environmental Chemicals in Canada (www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/chms-ecms/index-eng.php)
- Northern Contaminants Program—Indian and Northern Affairs Canada (www.aadnc-aandc.gc.ca/eng/1100100035611/1100100035612)
- First Nations, Food, Nutrition, and Environment Study (www.infnes.ca)
- Maternal-Infant Research on Environmental Chemicals Study (www.hc-sc.gc.ca/ewh-semt/contaminants/human-humaine/mirec-eng.php)
- First Nations Biomonitoring Initiative—Assembly of First Nations (www.afn.ca/index.php/en/honoring-earth#3)
- U.S. National Health and Nutrition Examination Survey (www.cdc.gov/nchs/nhanes.htm)

The following links provide information on what the Government of Canada is doing to manage and monitor mercury, PCBs, and BPA, and also advice on what you can do to reduce your exposure.

- It's Your Health: Mercury and Human Health (www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/merc-eng.php)
- Chemicals at a Glance: Mercury and its Compounds (www.chemicalsubstanceschimiques.gc.ca/fact-fait/mercury-mercure-eng.php)
- Food and Nutrition: Mercury (www.hc-sc.gc.ca/fn-an/securit/chem-chim/environ/mercur/index-eng.php)

- Mercury in Fish: Consumption Advice (www.hc-sc.gc.ca/fn-an/securit/chem-chim/environ/mercur/cons-adv-etud-eng.php)
- It's Your Health: PCBs (www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/pcb-bpc-eng.php)
- Chemicals at a Glance: Polychlorinated Biphenyls (PCBs) (www.chemicalsubstanceschimiques.gc.ca/fact-fait/pcb-bpc-eng.php)
- Food and Nutrition: Polychlorinated Biphenyls (PCBs) (www.hc-sc.gc.ca/fn-an/securit/chem-chim/environ/pcb-bpc/index-eng.php)
- Chemicals at a Glance: Bisphenol A (www.chemicalsubstanceschimiques.gc.ca/fact-fait/bisphenol-a-eng.php)
- Questions and Answers on Bisphenol A (www.chemicalsubstanceschimiques.gc.ca/fact-fait/bisphenol-a_qa-qr-eng.php)
- Food and Nutrition: Bisphenol A (www.hc-sc.gc.ca/fn-an/securit/packag-embal/bpa/index-eng.php)



LEAD

Introduction

Lead is a heavy metal found naturally in the Earth's crust, yet much of the lead in the environment to which we are exposed is the result of widespread human activity. In Canada, the amount of lead released into the environment over the past 30 years has been greatly reduced through the work of federal, provincial and territorial governments, as well as industry and civil society. Because of the better understanding of the effects of lead on human health, especially on that of children, the Government of Canada is working to reduce further exposure to better protect all Canadians.

This section highlights the common sources of exposure and the health effects of lead. It also includes simple steps to help reduce your exposure to lead.

What are the main sources of lead exposure?

Exposure to lead depends on factors such as age and behaviour patterns, location of residence, lifestyle choices and culture. Before leaded gasoline was phased out in Canada, lead in the air was the predominant source of exposure for Canadians. Today, the primary source of exposure to lead for Canadians is from food and drinking water although several factors, such as whether your home has lead, copper or plastic service lines (water pipes that link the house to the main water supply), can affect your exposure level. For infants and toddlers, ingestion of soil and dust containing lead, along with food and drinking water, are the greatest sources of exposure to lead in the environment. Following is a review of the main sources of exposure.

Food

Lead is not permitted to be deliberately added to foods. However, since lead is present in the environment, it can be found in many foods, generally at very low levels. Lead can be introduced to foods through uptake from soil into plants and by airborne lead falling onto plant surfaces. Also, fish can absorb lead from water and sediments while other animals may be exposed to lead through the foods they eat. Since food may be imported from countries where leaded gasoline is still used, lead in air and soil may result in higher levels of lead in those food crops. In Canada and most other countries, food manufacturers have eliminated the use of lead-soldered food cans, which has contributed to a significant decrease in dietary exposure to lead observed in Canadians since the 1980s.

Drinking water

In most of Canada, the amount of lead in natural water sources is very low. However, under the right conditions, lead can be leached into the drinking water from lead service lines, lead solder in plumbing, or brass fittings such as faucets. The amount of lead that is released (leached) into drinking water is affected by a number of factors, including the age of the plumbing system, the chemistry of the water and the length of time the water sits in the pipes.

Pre-1990's plumbing and distribution systems may have been a source of lead. In Canada, lead was an acceptable material for drinking water service pipes until 1975 and lead solder until 1986. Regulations regarding lead used in plumbing materials were phased-in across the country and the timing of when lead service lines and other lead-based plumbing materials stopped being used differs depending on where you live.

To find out if service water lines contain lead, contact your local water utility or municipality. As well, a plumber can check the lines entering the home. Pipes that are soft or easily dented when scraped with a knife (leaving a greyish-black line) likely contain lead. For more information, see the section in this report on drinking water quality.

Soil and dust

Past and present releases of lead into the air produce fine particles of lead that fall onto the ground where they remain as ongoing sources of exposure in soil. Soil and dust that are contaminated with lead can be a significant source of exposure for toddlers and children due to their behavioural pattern and activities, such as playing and crawling on the floor, as well as more frequent hand-to-mouth activity. Their tendency to eat food items or mouth other objects dropped or found on the floor can result in soil and dust ingestion. Lead in house dust may come from a variety of sources such as soil contaminated with lead that is tracked indoors, deteriorating lead-based paint, renovations that disturb old paint or building materials, consumer products, lead-contaminated dust from the workplace or hobby activities (e.g., stained glass work and ceramics) or smoking. Levels of lead in soil tend to be higher in cities, in former industrial areas, in buildings used for automotive work or farming, near roadways and around industrial sources such as incinerators, smelters or mines, or next to buildings where crumbling leaded paint has fallen into the soil.

Air

Over the last few decades, lead levels in the air of most Canadian cities have dropped significantly due to the introduction of unleaded gasoline in Canada in 1975, and the subsequent prohibition on using leaded gasoline in the 1990s. Lead is still released into the air through smelters, industrial emissions and waste incineration. However, regulations have been put in place to limit the amount of lead that can be released into the air from these sources to protect human health and the environment. People living near these sources may be exposed to higher levels of lead.

Lead-based paint

The likelihood that your home contains lead-based paint depends on when it was built and painted. Homes built and painted before 1960 probably contain lead-based paint. Homes built and painted between 1960 and 1990 may have small amounts of lead in some of the painted indoor surfaces. The highest amounts of lead were used in exterior paints. There is little concern about lead-based paint in homes built and painted in 1991 or later because most consumer paints produced in Canada and the United States since that time contain no more than background levels of lead (i.e., lead has not been intentionally added). The Government of

Canada has continued to reduce the amount of lead permissible in paints.

It is not always in your best interest to remove lead-based paint. In some situations, leaving the painted surface alone (as long as it is not chipping or within the reach of children) is safer than trying to remove it. Covering the painted area with vinyl wallpaper, wallboard or paneling can provide extra safety.

However, lead-based paint in your home is a serious health hazard if it is chipping or flaking, or if it is within the reach of children who might chew on it. In these cases, you should remove the paint following Health Canada's guidelines (for more information, visit the websites under Additional Resources: Renovations and Paint found at the end of this section).

Other sources of lead exposure

A newborn and infant's primary source of lead exposure comes from the mother. Lead can be passed from the mother to the infant through the placenta during development and later through breast milk.

Tobacco smoke and second-hand smoke contain lead and can be a source of lead exposure. People exposed to second-hand smoke can have higher levels of lead in their bodies than those in a smoke-free environment.

Testing for lead in your home

Samples of paint, paint dust, water and soil can be tested for the presence of lead. Lists of accredited commercial testing laboratories are available through the Standards Council of Canada (www.scc.ca) or the Canadian Association for Laboratory Accreditation (www.cala.ca).



The level of lead in many consumer products, especially those intended for children, is strictly limited in Canada. Domestic and imported products that have been found to contain higher levels of lead than are allowed in Canada are subject to enforcement action.

Occupations or hobbies that use lead solder or involve smelting lead, such as in making stained glass, lead shot or lead fishing weights, may increase one's exposure to lead.

What are the health risks?

Recent scientific studies on lead show that adverse health effects are occurring at lower levels of exposure to lead than previously thought. At low levels of exposure to lead, the

main health effect observed is to the nervous system. Specifically, exposure to lead may have subtle effects on the intellectual development of infants and children. Infants and toddlers are particularly susceptible to the harmful effects of lead because they are undergoing a period of rapid development. Furthermore, their growing bodies absorb lead more easily and excrete lead less efficiently than adults. In addition, infants and young children are more likely to ingest lead because of their natural habit of putting objects into their mouths.

In adults, the strongest scientific evidence to date suggests low levels of lead exposure may cause a small increase in blood pressure. Other health effects, including altered kidney function and reproductive outcomes, have been observed at low levels of lead exposure.

The health risks associated with exposure to lead can vary depending on the age of the exposed individual, activity and behaviour patterns, overall health status, the amount of lead to which an individual is exposed, as well as the duration of exposure.

Once in the body, lead circulates in the blood and either builds up in bone or is eliminated from the body, mostly in urine. Lead can stay in the body for over 30 years following exposure. Lead stored in bones can be released back into the blood stream as a result of bone deterioration due to stress, illness, pregnancy, breast feeding, menopause and post-menopausal life stages.

Although it is rare in Canada today, exposure to very high levels of lead can cause severe health effects including lack of coordination, convulsions, vomiting, diarrhea, chronic kidney failure, coma and even death. Very high levels of exposure during pregnancy increase the risk of miscarriage or stillbirth.

Status and trends in Canada

Most of what we know about the level of exposure to lead in Canada comes from monitoring lead levels in the Canadian population and the environment, from targeted scientific studies, and by comparing Canadians' lead levels with those of other populations, such as the United States. Provincial or municipal authorities may monitor the levels of lead in communities that use lead in industrial processes, like smelting. More information on assessing human exposure to chemicals can be found in the section on biomonitoring.

Based on the recent Canadian Health Measures Survey (CHMS) blood lead biomonitoring data, exposure to lead in Canada has declined dramatically over the last 30 years. The average blood lead level in Canadians today is less than one third of what it was in 1979 (Figure 1).

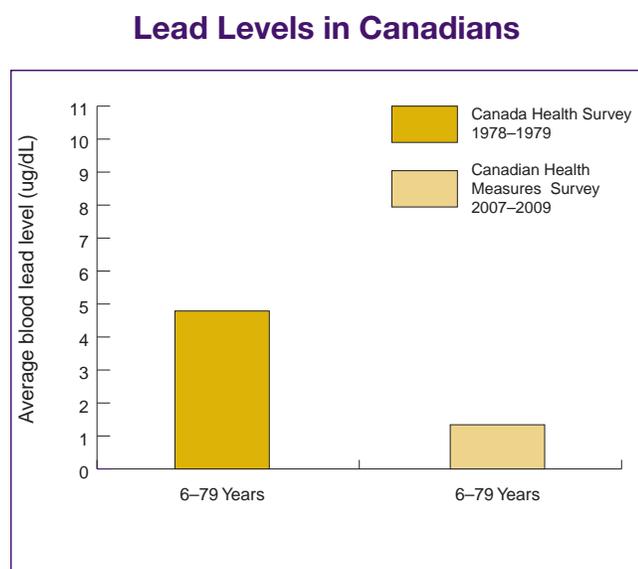


Figure 1: Average (geometric mean) blood lead level in Canadians aged 6 to 79 years (Canada Health Survey 1978-1979; CHMS, 2007-2009).

Blood lead levels in Canadians show characteristic age trends. Blood lead levels tend to rise after infancy, peak in children aged 1 to 3 years, decline slightly during childhood and adolescence, before rising again with age. According to the CHMS, older adults (aged 60 to 79 years) have the highest blood lead levels of all people surveyed. Although children under 6 years of age were not included in the first cycle of the CHMS, their blood lead levels are expected to be similar to those reported in the United States. The lowest concentrations of blood lead measured by the CHMS were in children aged 6 to 11 years of age and in teens aged 12 to 19 years (Figure 2). In general, males have higher blood lead levels than females. A major factor contributing to the decline in the average Canadian blood lead level is the reduction of lead released into the air (Figure 3).

Lead Levels in Canadians by Age Group

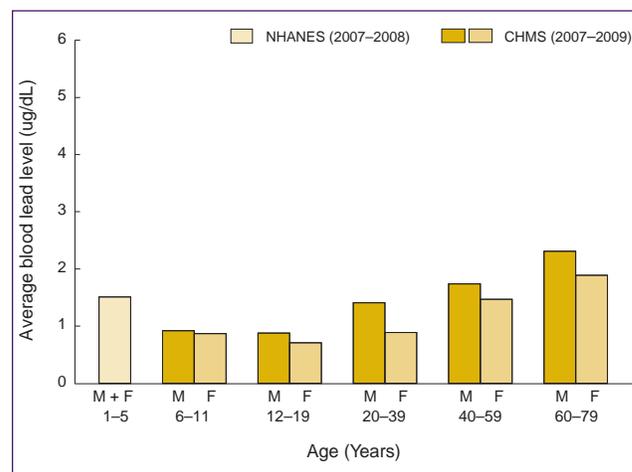


Figure 2: Average (geometric mean) blood lead level in Canadians aged 1 to 79 years old by sex (CHMS, 2007-2009; U.S. National Health and Nutrition Examination Survey (NHANES), 2007-2008).

Notes: The darker orange bars show levels in Canadians aged 6 to 79 years by sex. The light orange bar represents blood lead levels in children aged 1 to 5 years. *As there is no national Canadian blood lead data on children under 6 years old, blood lead data from the U.S. National Health and Nutrition Examination Survey (NHANES) was used as a surrogate for Canadian children.*

Atmospheric Lead Emissions in Canada

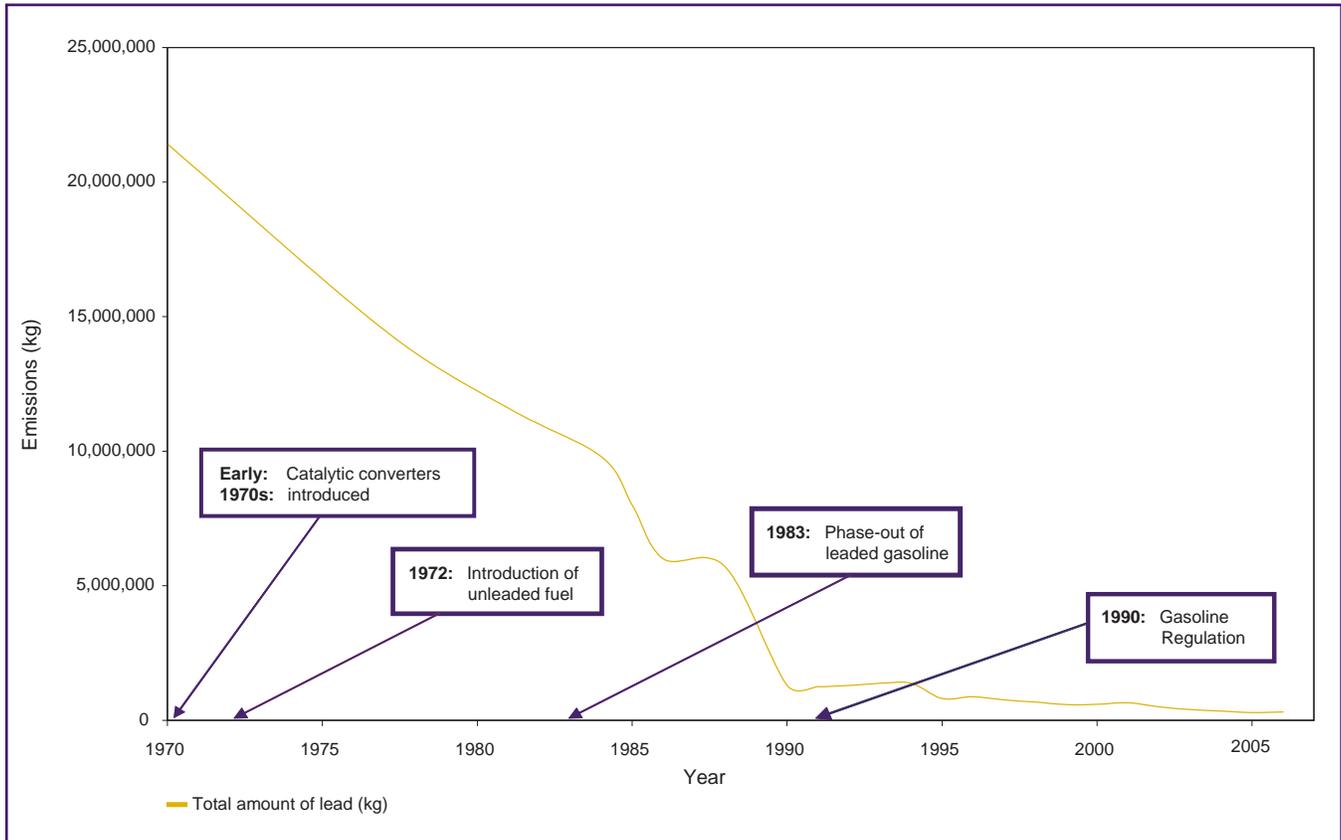


Figure 3: The level of lead released into the air (Kg) in Canada (1970–2006) (The State of Canada’s Environment, 1996; National Pollutant Release Inventory—Air Pollutant Emission Summaries and Trends, 2009; and Environment Canada, 1974).

Lead concentrations in foods are currently low. Health Canada’s Total Diet Study results show that the dietary intake of lead (ug/kg body weight/day) by Canadians of all ages and sexes has decreased since 1981 (Figure 4). The major reason for this decrease has been the replacement of lead-soldered cans for food packaging with lead-free cans.

Health Canada recently completed a national baseline study for lead concentrations in dust sampled from urban households, entitled the Canadian House Dust Study (2007–2010). All of the homes sampled in the study had measurable concentrations of lead in their house dust. Health Canada has not yet set

Dietary Intake of Lead in Canadians

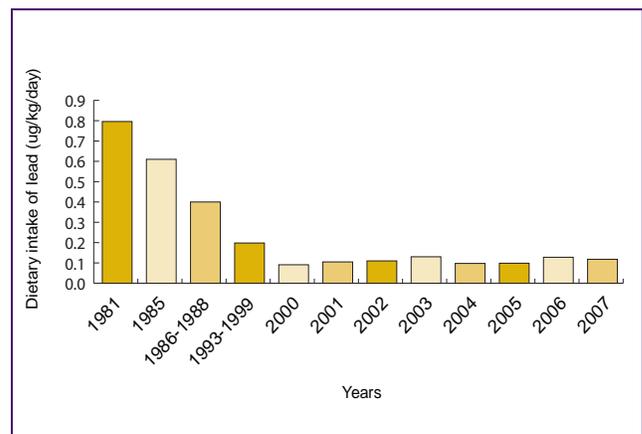


Figure 4: Average dietary intake of lead in Canadians (Canadian Total Diet Study, 1981–2007).

reference levels for lead in house dust, so the measurements are an important starting point for future research and risk management activities related to lead exposure in indoor environments.

What is being done?

The Government of Canada has been working to reduce exposure to lead and minimize health risks to Canadians for many years. The significant decline of lead in the Canadian environment and in Canadians since the 1970s is primarily due to the successful phase-out of lead in gasoline and solder used in food cans, in addition to other government regulation and industry action over this time period.

The federal government has put in place numerous regulations and guidelines directed toward the reduction of lead in consumer products, cosmetics, drinking water, food, natural health products, pharmaceutical products, tobacco, industrial releases, and other sources such as soil and air. For example, the Government's *Lead Risk Reduction Strategy for Consumer Products* is intended to reduce lead exposure risks to children by limiting the lead content of consumer products to which children are most likely to be exposed.

Health Canada continues to assess new scientific evidence on the effects of relatively low levels of lead and to modify the risk management actions to protect the health of Canadians.

What can I do?

By following the tips below, you may be able to reduce your exposure to lead.

Check drinking water. If you have lead pipes or solder, reduce your exposure by only using cold water from the tap for drinking, cooking

and making baby formula since hot tap water is likely to contain more lead. Lead levels in your tap water can increase as it sits, or stagnates, in the pipes when the water is not used for several hours, such as overnight or during working hours. Running cold water first thing in the morning or any other time the plumbing system hasn't been used for a number of hours flushes out the lead. You can also flush the water pipes by taking a shower, starting the washing machine, flushing the toilet or letting the water run. To more permanently address any lead issues with your drinking water, you can remove some of the sources of lead that are entering your water. Consider replacing lead pipes or lead solder if the level of lead in your water is high. If the portion of the lead service line from the curb to your house is lead-based, you are responsible for its replacement. Periodically check the aerator screen on your tap and rinse out bits of trapped grit as they may contain lead particles, especially if work has been done on the water system in your neighbourhood or home. If you use a water filter, be sure to replace the filter on a regular basis. Contact your local water utility or public health department to find out how to get your water tested.

Eat a healthy diet. If you are not getting enough calcium or iron in your diet, your body may absorb more lead. Eat a healthy, balanced diet, according to *Canada's Food Guide* (www.hc-sc.gc.ca/fn-an/food-guide-aliment/index-eng.php).

Keep your paint in good condition, especially for homes painted before 1991. Painted surfaces that contain lead, which are in good condition may be left alone or covered with a new layer of paint, vinyl wallpaper, wallboard or paneling. Remove indoor or outdoor paint that is chipping, flaking or worn down or on a surface that a child might chew. Take safety precautions when removing lead-based paint (see websites listed under Additional Resources: Renovations and paint for more information).

Control house dust. Children playing on the floor may be exposed to lead dust that can build up in household dust. To keep dust levels down, remove shoes when entering a house and damp mop and damp dust regularly.

Protect children. Discourage children from putting non-food items into their mouths and make sure to wash their hands frequently, especially before eating. Note that products not intended specifically for children may contain higher levels of lead. Also, check the Health Canada recalls website often for information on toys, children's jewellery, and other products that have been recalled in Canada because they contain elevated amounts of lead (<http://cpsr-rspc.hc-sc.gc.ca/PR-RP/home-accueil-eng.jsp>).

Be Smoke-Free. Do not allow people to smoke indoors, in the car, or around children or pregnant women. Tobacco smoke and second-hand smoke contain lead, which is easily absorbed into the body when inhaled.

Ask your doctor. If you are concerned about lead exposure, a doctor or public health unit can order a simple blood test to measure your blood-lead level. Your doctor may recommend corrective action if the levels are elevated. Your doctor or public health unit can help you identify sources of exposure to lead and help you understand what to do.

Additional resources

- It's Your Health: Lead and Human Health (www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/lead-plomb-eng.php)
- Health Canada Consumer Product Recalls (<http://cpsr-rspc.hc-sc.gc.ca/PR-RP/home-accueil-eng.jsp>)
- Food and Nutrition: Lead (www.hc-sc.gc.ca/fn-an/securit/chem-chim/envIRON/lead_plomb-eng.php)
- HazardCheck (www.hc-sc.gc.ca/ewh-semt/hazards-risques/index-eng.php)
- Lead Information Package (www.hc-sc.gc.ca/ewh-semt/contaminants/lead-plomb/asked_questions-questions_posees-eng.php)
- It's Your Health: The Safe Use of Cookware (www.hc-sc.gc.ca/hl-vs/iyh-vsv/prod/cook-cuisinier-eng.php)
- It's Your Health: Lead Crystalware and Your Health (www.hc-sc.gc.ca/hl-vs/iyh-vsv/prod/crystal-cristal-eng.php)
- Environmental and Workplace Health (www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/lead-plomb/index-eng.php)
- Water Talk: Minimizing Exposure to Lead from Drinking Water Distribution Systems (www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/lead-plomb-eng.php)

Renovations and paint

- It's Your Health: Lead-Based Paint (www.hc-sc.gc.ca/hl-vs/iyh-vsv/prod/paint-peinture-eng.php)
- It's Your Health: The Safe Use of Paint Strippers (www.hc-sc.gc.ca/hl-vs/iyh-vsv/prod/strippers-decapants-eng.php)
- Lead Paint Safety: A Field Guide for Painting, Home Maintenance, and Renovation Work (www.hud.gov/offices/lead/training/LBPguide.pdf)



INDOOR AIR QUALITY AT HOME

Introduction

The quality of the air in homes can affect human health. Canadians spend 90% of their time indoors, where they are exposed to a number of air pollutants. Asthma, allergies and other respiratory ailments have all been linked to pollutants in the home and known cancer-causing agents (or carcinogens), such as benzene, have even been found in some homes.

There is no single measure of indoor air quality in the home, since there are a number of factors that can affect the quality of air indoors. These factors include:

- Pollutants that enter the home from outside, both from the air (e.g., ozone, particulate matter) and in some cases from the soil or groundwater below it (e.g., radon);
- What we do in our homes and the products we use; and
- How the home is built and maintained.

As homes are made increasingly air-tight to reduce heat loss and conserve energy, indoor air quality can be negatively affected by reduced ventilation and increased humidity.

While the sources of air pollutants are numerous and diverse, individuals have a strong degree of personal control over the quality of air in their homes. There are some simple steps that can greatly improve indoor air quality and help protect health. The following section highlights some of the common indoor air pollutants found in Canadian homes, their potential health effects and what can be done to reduce exposure to them.

What are the main sources of air pollution in the home?

There are many different indoor air pollutants found in the home including:

- **Biological pollutants**, living organisms such as bacteria, mould and dust mites;
- **Chemical pollutants**, gases and particles that come from appliances that burn oil, gas or wood (e.g., furnaces, woodstoves), tobacco smoke, household cleaners and personal care products, various building

materials and from outside the home; and

- **Radiological pollutants**, specifically radon.

Some of these potential pollutants are illustrated in Figure 1.

What are the health risks?

The potential health effects associated with some common indoor air pollutants are presented in Figure 2. The actual effects that people may experience depend on the levels to which they are exposed and the length of that exposure.

Sources of Air Pollution in the Home

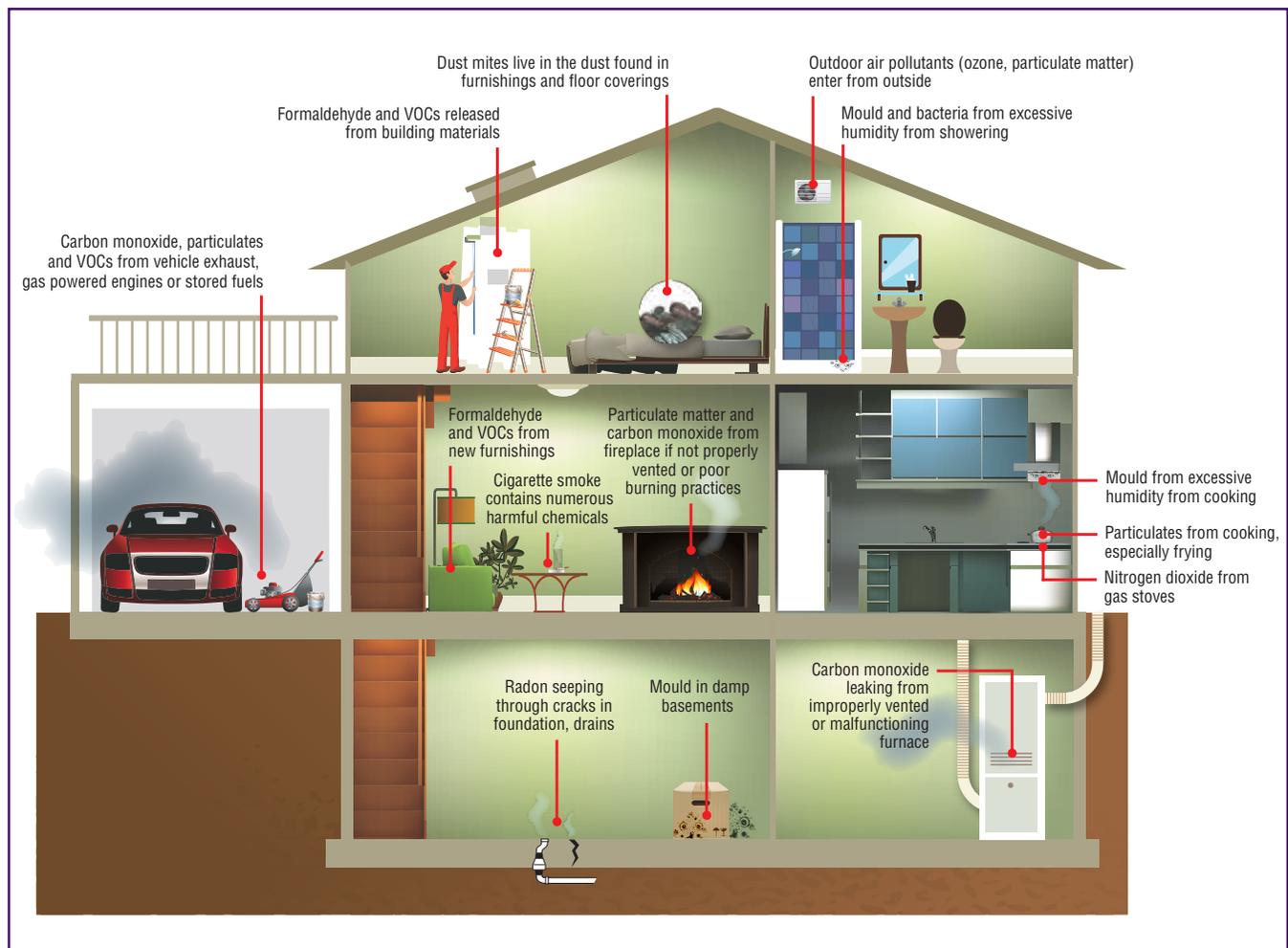


Figure 1: Potential sources of indoor air pollution in the home.

Concerned about air quality at work?

Many of the pollutants found in homes may also be found in the workplace or in public buildings. However, within each environment there may be differences in the levels and sources of pollutants, the length of exposure, and the types of people who are exposed to them. For example, workplaces have fewer children and elderly people, who may be more susceptible to indoor air pollutants. Air quality at work may also be affected by industry-specific processes and pollutants which are unlikely to be found in homes. For these reasons, indoor air issues at work are addressed in a different manner than at home.

For most workplaces, health and safety is regulated by provincial governments. For more information please contact your workplace's occupational health and safety representative or committee, the appropriate provincial agency or the federal Labour Program (www.labour.gc.ca)

Pollutant	Known or suspected health effect
a) Biological Pollutants	
Mould	Asthma trigger & allergen Increased risk of respiratory problems
Dust mites	Asthma trigger & allergen May cause asthma to develop in susceptible individuals
b) Chemical pollutants released from combustion	
Carbon Monoxide (CO)	Progressing from flu-like symptoms to loss of consciousness and death Cardiovascular effects in people with heart problems at lower levels
Nitrogen Dioxide (NO ₂)	Respiratory irritant
Particulate Matter (PM)	Respiratory and cardiovascular effects
c) Chemical pollutants primarily released from products	
Formaldehyde	Irritant of eyes, nose, throat and lungs Asthma trigger and increased risk of respiratory problems Carcinogen, but negligible risk at levels found in homes
Volatile Organic Compounds (VOCs)	Some are eyes, nose, and throat irritants Some known and suspected carcinogens (e.g. benzene, trichloroethylene), but low or negligible risk at levels generally found in homes
d) Radiological pollutants	
Radon	Carcinogen, a risk factor for lung cancer

Figure 2: Summary of potential health effects for common indoor air pollutants found in Canadian homes.

What is an allergen?

Allergens are substances that trigger the body's immune response. Indoors, they may include mould, dust mites and pet dander.

Individual susceptibility to pollutants also varies, so the level at which health effects occur differs depending on the person. Given the uncertainty about health effects for some substances, and that health risks increase with greater exposure, the best precaution is to control sources of pollutants in the home as much as possible. This is especially true for groups likely to be the most susceptible to the potential health effects: children, the elderly and people with existing health problems. The "What can I do?" segment at the end of this section of the report provides practical information on what individuals can do to improve indoor air quality.

The following section describes the health effects of some common indoor air pollutants.

Mould

Mould is a natural part of our environment and can be found nearly everywhere. It can become a health problem if it finds a damp place to grow inside a home. In the 2009 Household and Environment Survey conducted by Statistics Canada, 13% of Canadians reported having mould in their home. Other scientific surveys have reported that half of North American homes may have mould and/or dampness problems.

Studies show that people living in homes with mould and damp conditions are more likely to show the following symptoms:

- Eye, nose and throat irritation;
- Coughing and phlegm build-up;
- Wheezing and shortness of breath;
- Aggravated asthma symptoms; and
- Other allergic reactions.

It has been estimated that mould and dampness in a home may increase the likelihood of a susceptible individual having respiratory symptoms by 30–50%. Some airborne moulds can cause serious infections in people with severely weakened immune systems, such as those with leukemia or AIDS or transplant recipients.

People have different levels of sensitivities to mould, making it difficult to establish a safe level of exposure. To avoid potential health problems, Health Canada's Residential Indoor Air Quality Guideline for Mould recommends removing any mould in the home and fixing the underlying moisture problem that allowed its growth.

Dust mites

Dust mites are tiny invertebrates, nearly invisible to the naked eye, that live primarily in house dust, carpets, and furniture upholstery. They are

Are some moulds toxic?

Some moulds may naturally produce low levels of toxic substances known as mycotoxins. Moulds growing in homes may also produce mycotoxins, but there is little evidence to suggest that any particular type of mould poses an increased risk to health. All mould species found in homes may pose a risk of respiratory problems in susceptible individuals, and should be removed.

found across Canada and are present in most, if not all, homes to varying degrees. Dust mites like warm, humid environments and the increased sealing of homes to prevent drafts has created a perfect environment for them to thrive.

Dust mites produce allergens and are one of the most commonly reported asthma triggers. Exposure to dust mites may also lead to the development of asthma in people with a pre-existing, genetic susceptibility to the disease.

Pollutants from combustion

Burning fuel, such as oil, natural gas, propane or wood produces a number of air pollutants as by-products. Appliances that burn fuel—furnaces, fireplaces, wood stoves, gas stoves, and hot water heaters—can release these pollutants into your home, especially if they are not properly installed, maintained or vented to the outside. Car exhaust is also a source of these pollutants, and can enter your home from an attached garage or from outside. Many of the pollutants from combustion are the same as those found in outdoor air pollution and smog (see Outdoor Air Quality section), and have similar effects on health.

Carbon monoxide (CO) reduces the ability of blood to carry oxygen throughout the body and is a major pollutant of concern. The symptoms of CO poisoning get worse as levels increase.

- At low levels, symptoms include headaches, drowsiness, shortness of breath, and impaired motor functions. These symptoms may feel like the flu.
- At high levels, or if people are exposed to low levels for long periods of time, they can experience dizziness, chest pain, drowsiness, poor vision, and difficulty thinking.
- At very high levels, CO can cause convulsions, coma, and even death.

Because CO is colourless, odourless and tasteless, it is difficult to notice without a CO detector. CO can cause health problems before people even notice its presence.

People with heart conditions may be more susceptible to the effects of CO and may experience heart irregularities at levels below those that cause poisoning or would trigger a CO detector. To protect this susceptible group, Health Canada's Residential Indoor Air Quality Guideline for Carbon Monoxide recommends that levels in the home be kept below 11.5 mg/m³ (10 parts per million [ppm]). CO levels in Canadian residences

Attached Garages and Benzene

Vehicle exhaust and fumes from fuels stored in garages can affect air quality inside the home. Pollutants that come from attached garages include combustion by-products (like CO) and VOCs associated with gasoline, such as benzene (a carcinogen) or toluene.

Studies conducted by Health Canada clearly show the potential effect of attached garages on indoor air quality. Benzene levels in homes with attached garages were, on average, more than double the level in homes with a detached garage or no garage at all. And in some homes with attached garages the level was 5 to 10 times higher. The amount of benzene coming from the garage will depend on what we do in it. Allowing a car to idle or running a lawn mower inside the garage, for example, will likely increase the amount of benzene and other VOCs in the air, as will storing gasoline, paints and solvents in the garage.

with properly functioning fuel-burning appliances are usually well below this recommended limit (see Figure 3).

Particulate matter (PM) indoors affects health in the same way as outdoor PM, namely by harming the respiratory and cardiovascular systems (see Outdoor Air Quality section). While much of the PM indoors comes from outside, there are indoor-specific sources, like smoking and cooking.

Nitrogen dioxide is a respiratory irritant that may cause coughing, wheezing and difficulty breathing, particularly in people with asthma. Gas stoves can be a major source of nitrogen dioxide in homes, particularly when used without an exhaust fan venting to the outside.

Ground-level ozone is a major outdoor air pollutant that forms when nitrogen dioxide reacts with other compounds, and is a key ingredient of smog. Most of the ozone in your home comes from outside, although there are some potential indoor sources, such as air cleaners, that are designed to generate ozone. Health Canada recommends against using air cleaners that purposely release ozone into your home.

The effects of ground-level ozone exposure range from coughing and shortness of breath to chest discomfort (see Outdoor Air Quality section). Health Canada has established a Residential Indoor Air Quality Guideline for ozone that recommends levels in homes are kept below 40 $\mu\text{g}/\text{m}^3$ (micrograms per cubic metre) or 20 parts per billion (ppb) to prevent respiratory irritation. Levels of ozone indoors are generally much lower than outside and usually below the recommended guideline level (see Figure 3).

Pollutants released from products

Formaldehyde is a colourless gas that is emitted mainly from products in our homes (e.g., pressed wood furniture and building materials, paints, adhesives and insulations), but it is also a by-product of combustion. Low levels of formaldehyde in indoor air are actually very common. At high levels, formaldehyde can cause irritation of the eyes, nose and throat and can worsen asthma symptoms in children and infants.

Health Canada has established a Residential Indoor Air Quality Guideline which recommends that long-term exposure levels be kept below 50 $\mu\text{g}/\text{m}^3$ (or 40 ppb). Above this level, susceptible individuals, such as children with asthma, have an increased risk of breathing problems. Measurements conducted by Health Canada in different cities across Canada show that most homes are well below this recommended level (see Figure 3).

Volatile organic compounds (VOCs) are a diverse family of chemical substances that become gases at room temperature. They can be released into the air from building materials and furniture, from vehicle exhaust entering from attached garages or outside, in air fresheners, cleaning products and other household products. All homes contain many VOCs, though most are found at very low levels.

Individual VOCs vary greatly in their toxicity and the types of health effects they may cause. Most of the known health effects of VOCs occur at high levels sometimes found in industrial settings. Levels in homes are generally far lower than those found in industrial settings. However, research into the potential health effects of being exposed to VOCs in homes over a long period of time remains an area of active research in Canada and internationally.

As with all chemicals, the health risk, if any, will depend on the levels to which people are exposed, the length of time they are exposed and their individual sensitivity to the chemical substance. Since the risk increases with exposure, it is a good idea to reduce VOC levels wherever possible, as a precaution.

Radon

Radon is a radioactive gas found naturally in the environment everywhere. It is produced by the decay of uranium found in rocks and soil. Because radon is a gas, it can move freely through the soil enabling it to escape into the atmosphere or seep into buildings. It is invisible, odourless and tasteless, but can be measured. Radon represents over 50% of a person's exposure to naturally occurring radiation.

Outdoors, the concentration of radon gas in the air is diluted, eliminating its health risk. However, radon that enters an enclosed space, such as a home or building, can potentially accumulate to high levels. The risk from radon exposure is long-term and depends on the level of radon in the home, length of exposure and smoking habits. Long-term exposure to elevated levels of radon in the home increases an individual's risk of developing lung cancer, especially for smokers. It is estimated that about 10% of all lung cancers worldwide are related to radon exposure.

Health Canada's Canadian Radon Guideline recommends that remedial measures be taken in a dwelling whenever the average annual radon concentration exceeds 200 becquerels per cubic meter (Bq/m³) in the normal occupancy area (a becquerel is a measure of radioactivity). When remedial action is taken, the radon level should be reduced to a value as low as practicable. The 2010 Canadian National Building Code includes new measures for the construction of homes that require techniques that will minimize

radon entry and will facilitate post-construction radon removal, should this subsequently prove necessary.

Status and trends in Canada

For most homes, the air quality is generally good. When asked, 89% of Canadians reported the air quality in their home as excellent or good. As part of its research program on indoor air quality, Health Canada has measured indoor air pollutants in single-family homes in different cities across Canada to gain a better understanding of their levels and sources of indoor air pollutants. Few homes had levels of chemical pollutants with known health effects above the recommended limits established by Health Canada in the Residential Indoor Air Quality Guidelines (see Figure 3).

Health Canada recently completed a two year cross-Canada survey of radon concentrations in homes. Approximately 14,000 homes across the country were tested using long-term (3 month +) radon detectors. The results of the study indicate that 6.9% of Canadian homes have a radon concentration above the guideline level of 200 Bq/m³. Radon levels vary across the country depending on a number of factors including geology. The survey findings confirm that almost all homes in Canada will have some level of radon, that the levels can vary significantly and that the only way to know the level in a home is to test it (Figure 4).

To assist First Nations in identifying communities with higher potential for elevated levels of radon, Health Canada measured the radon levels in facilities on reserves that it funds, as well as on reserve public buildings as part of the National Strategy to Address Radon in First Nations Communities. Public buildings included health

centres, treatment centres, schools, daycares, group/seniors facilities and hospitals. Health Canada is available to provide information on radon mitigation measures and public education

and awareness materials to community members, including in communities where testing of public buildings showed elevated levels of radon.

Percentage of Homes above or below the Canadian Residential Indoor Air Quality Guidelines for Formaldehyde, Toluene, Carbon Monoxide and Ozone

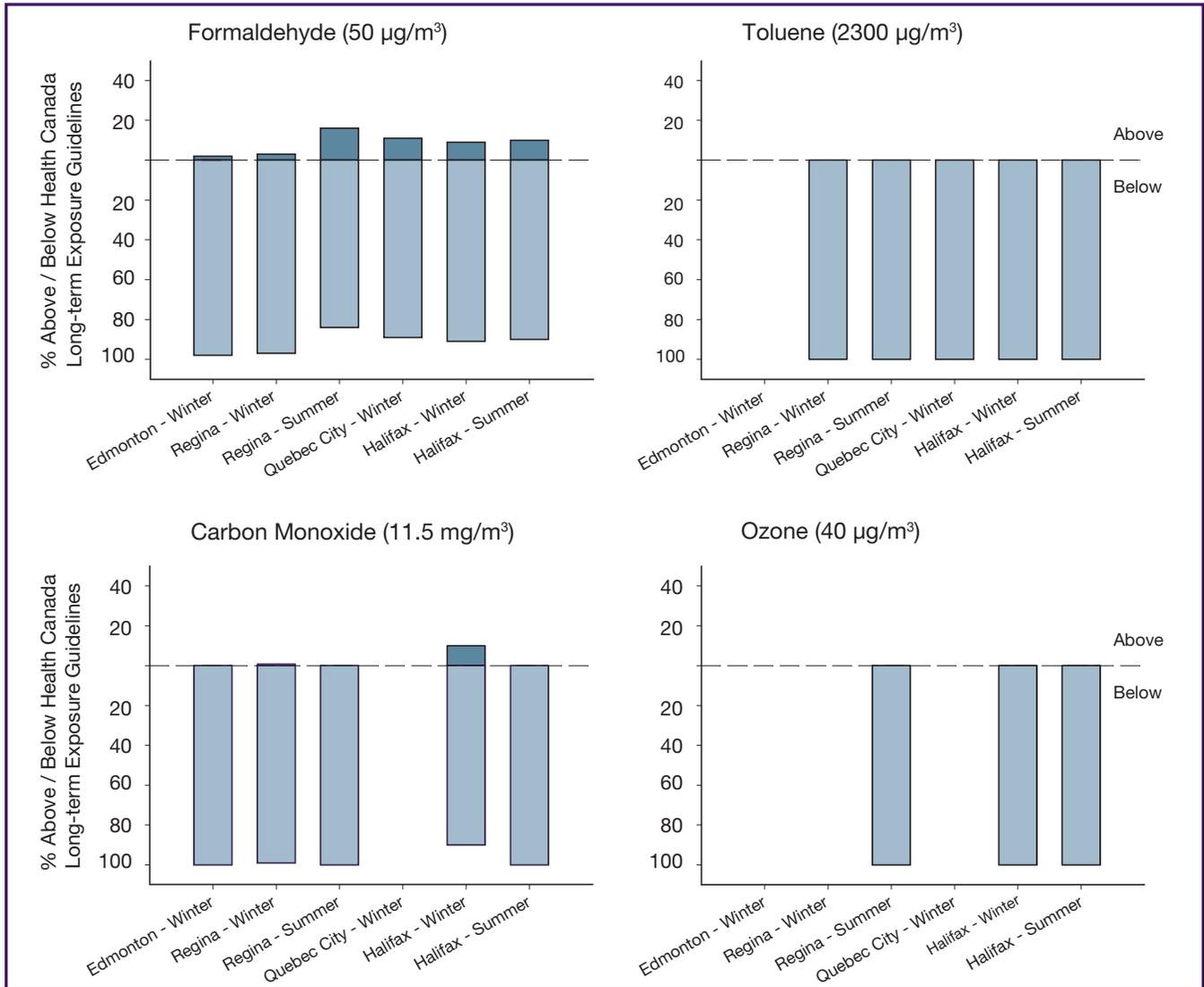


Figure 3: Percentage of single-family homes studied in cities across Canada (summer and winter) that were above or below the long-term exposure limit in Health Canada’s Residential Indoor Air Quality Guideline (indicated in parenthesis) for formaldehyde (50 µg/m3), the volatile organic compound toluene (2300 µg/m3), carbon monoxide (11.5 mg/m3) and ozone (40 µg/m3) (Health Canada, 2005–2010).

Note: Where no bar is shown, data were not collected.

Percentage of Homes above the Canadian Radon Guideline Level

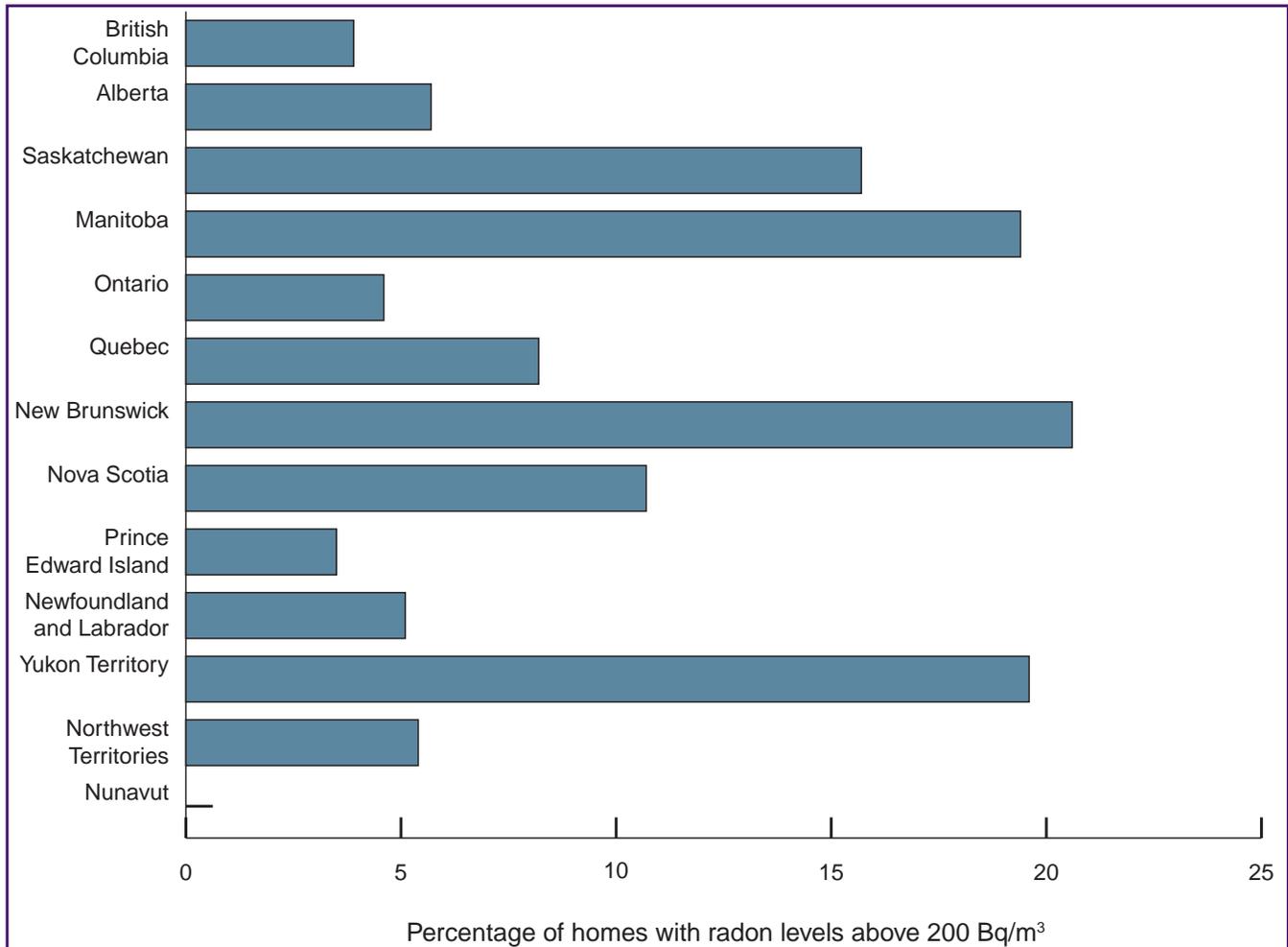


Figure 4: Percentage of homes that are above the radon guideline of 200 Bq/m³ in each Canadian province and territory.

Note: Where no bar is shown, data were not collected.

What is being done?

There are no direct regulations governing indoor air quality in private homes. The Government of Canada can, however, influence indoor air quality indirectly by:

- Managing the risks posed by indoor air pollutants through building codes;
- Regulating consumer products;
- Investigating the causes of poor indoor air quality and its effects on human health; and

- Providing guidance on how to improve the quality of the air in homes.

Under the Chemicals Management Plan, for instance, scientists at Health Canada and Environment Canada assess chemical substances found in consumer products, building materials and other chemical substances found in the environment to determine if they pose a risk to human health and/or the environment. Based on the findings of these assessments, the Government of Canada may decide to regulate chemical substances found in the home that can

contribute to poor indoor air quality under the *Canada Consumer Product Safety Act (CCPSA)*, the *Canadian Environmental Protection Act*, and/or the *Pest Control Products Act*.

The research Health Canada conducts on the health effects of indoor air quality in Canadian homes is a key component in setting Residential Indoor Air Quality Guidelines and the Canadian Radon Guideline. These guidelines serve as the scientific basis for activities to reduce the risk from indoor air pollutants. Health Canada also collaborates with provincial and territorial governments to reduce health impacts through public education and awareness programs.

The National Research Council Canada (www.nrc-cnrc.gc.ca) develops technologies, tools, and recommendations for the design and operation of cost-effective, energy-efficient indoor environments that optimize the comfort, satisfaction and health of building occupants.

The Canada Mortgage and Housing Corporation (CMHC) (www.cmhc-schl.gc.ca) provides helpful information on how to maintain good indoor air quality in homes, through its research and outreach activities.

Indoor air quality in First Nations communities

Indoor air quality issues in First Nations communities are a shared responsibility between Aboriginal Affairs and Northern Development Canada (AANDC), CMHC, Health Canada and First Nations communities. AANDC and CMHC provide financial assistance to First Nations communities to address housing needs, while First Nations are responsible for the allocation of funds and day-to-day housing management. Upon request of community representatives, Health Canada provides visual public health inspections of housing, including assessments

of indoor air quality, recommendations on remedial actions, and information and awareness materials, as required.

What can I do?

The Basics

Canadians have a large amount of control over air quality in their homes. Proper maintenance of your home and regular cleaning can go a long way to ensure a healthy living environment, and it does not necessarily require any special equipment or technical expertise. You also do not generally need to test the air in your home for indoor air pollutants, except for radon and carbon monoxide. Instead focus on removing the sources of air pollutants from your home. Below are a few basic steps that can help improve the indoor air quality at home.

- ***Do not smoke in the house.*** Tobacco smoke contains a large number of air pollutants and has a clear impact on health. Not allowing smoking in your home greatly improves indoor air quality and protects the health of those who live there.
- ***Do not use ozone-producing air cleaners.*** Health Canada recommends that you not use any device that claims to clean the air by releasing ozone into an occupied area. Ozone is an irritant that can affect your lungs.
- ***Fix moisture problems.*** Excessive moisture can lead to mould growth and can encourage population growth in dust mites. Simple steps such as fixing leaks, properly cleaning up after floods, controlling humidity levels, using exhaust fans in bathrooms and over stoves, and venting dryers to the outside can greatly improve indoor air quality.

- **Reduce dust.** Frequent household cleaning and vacuuming can help reduce dust mites and other allergens. When combined with the control of other asthma triggers, such as second-hand smoke and mould, asthma symptoms may be reduced.
- **Inspect and maintain combustion appliances.** Combustion appliances—furnaces, hot water heaters, stoves and fireplaces that burn fuel (oil, gas, propane or wood)—that are not properly vented can release pollutants into your home including CO, nitrogen dioxide and PM. Only use devices that burn fuel in your home if they are vented to the outside. Do not use barbecues, kerosene heaters, diesel generators or other devices that are meant only for outdoor use inside your home.
- **Get a CO detector.** Health Canada recommends installing a Canadian Standards Association-approved CO detector with an audible alarm that will alert you to potentially dangerous levels of carbon monoxide in your home. A detector should be installed outside of all sleeping areas and follow the manufacturer's instructions on how to install and maintain the detector.
- **Ventilate properly.** This means bringing in sufficient fresh air from outside to prevent indoor pollutants from building up to levels that may affect your health. It also means venting sources of indoor pollutants to the outside. This can be as simple as opening windows when using paints or glues or using an exhaust fan over a stove when cooking or in the bathroom while showering or bathing. In some cases, the addition of mechanical forms of ventilation (e.g., a heat-recovery ventilator) may be required. In the 2009 Household and the Environment

Survey from Statistics Canada, 25% of homes reported using a furnace fan or heat-recovery ventilator to improve air circulation.

- **Do not idle!** Idling should be avoided whenever possible, but never let motor vehicles or other gas powered engines run in attached garages, even with the garage door open.

Use chemicals properly and safely

Use these tips to limit the amount of chemical substances released into the air wherever possible:

- Follow all usage and safety instructions when using chemical products by wearing proper protective clothing and using devices as instructed;
- Buy only what you need, store it properly, and safely dispose of any excess or unnecessary chemical products;
- When using chemical-releasing products (e.g., paints, varnishes, paint strippers, cleaning products) increase ventilation by opening a nearby window; and
- Where possible, let new furnishings such as pressed wood-furniture, curtains, or rugs, sit outside or in a well ventilated room after bringing them home, and ventilate your home during and just after construction or renovations. Formaldehyde and VOC emissions are highest when products are new, and decrease over time.

Test radon levels

The only way to know if you have a radon problem is to test your home. It is simple and inexpensive to test; you can purchase do-it-yourself test kits or hire a radon measurement professional. If you choose to perform the test

yourself, radon detectors can be purchased over the phone, from the internet or from some home improvement retailers. If you choose to hire a service provider to perform the radon test, it is recommended that you ensure they are certified and will conduct a long-term test. Health Canada recommends the use of a long-term test device for a minimum of three months, ideally during the fall/winter timeframe when your windows are closed.

If the radon level in your home is above the Canadian guideline of 200 Bq/m³, you should take steps to reduce the level:

- Use mechanical ventilation such as an air exchanger or a heat-recovery ventilator (HRV) to increase the exchange of air;
- Seal all cracks and openings in foundation walls and floors, and around pipes and drains; and
- Ventilate the basement sub-slab by installing a small pump to draw the radon from below the concrete slab to the outside before it can enter your home. This is called active sub-slab depressurisation (ASD) and is typically performed by a contractor. Health Canada recommends hiring a contractor with radon remediation certification.

Additional resources

For more information on indoor air, please see the following online resources:

Health Canada (www.hc-sc.gc.ca)

- Indoor and Outdoor Air (www.healthcanada.gc.ca/air)
- Mould (www.hc-sc.gc.ca/fniah-spnia/promotion/public-publique/home-maison/mould-moisissure-eng.php)

- Hazardcheck – Hazards in Your Environment (www.healthycanadians.gc.ca/hazardcheck)
- It's Your Health factsheets:
 - Asbestos (www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/asbestos-amiante-eng.php)
 - Formaldehyde (www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/formaldehyde-eng.php)
 - Mould, Dampness and Indoor Air: (www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/air-eng.php)
 - Radon (www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/radon-eng.php)
 - Road Traffic and Air Pollution (www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/traf-eng.php)
 - Second-hand smoke (www.hc-sc.gc.ca/hl-vs/iyh-vsv/life-vie/shs-fs-eng.php)
 - Wood Smoke (www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/wood-bois-eng.php)

Public Health Agency of Canada

(www.phac-aspc.gc.ca)

- Asthma (www.phac-aspc.gc.ca/cd-mc/crd-mrc/asthma-asthme-eng.php)

Canada Mortgage and Housing Corporation

(www.cmhc.gc.ca)

- Indoor Air Quality (www.cmhc.ca/en/co/maho/yohoyohe/inaiqu/index.cfm)
- Moisture and Mould (www.cmhc.ca/en/co/maho/yohoyohe/momo/index.cfm)

National Collaborating Centre on Environmental Health (www.ncceh.ca)

- Health Effects from Mould Exposure in Indoor Environments (www.ncceh.ca/en/practice_policy/nceeh_reviews/mould_and_health_effects)



OUTDOOR AIR QUALITY

Introduction

Overall, Canadians enjoy good air quality in comparison to air quality elsewhere in the world. Stronger regulations for fuel quality and industrial processes have reduced emissions of many pollutants and improved air quality across Canada. Yet significant sources of air pollutants remain, ranging from industrial activities to personal every day actions, such as driving and heating our homes.

Outdoor air pollution, therefore, continues to affect the health of many Canadians, especially those with health problems such as asthma, heart disease or diabetes that make them more susceptible to the negative effects of air pollutants. A study by the Canadian Medical Association estimated that outdoor air pollution contributed to as many as 21,000 premature deaths in Canada in 2008. Many more people suffer from heart and breathing problems that

are also linked to air pollution. As Canada's population increases and ages, the size of the population that is most susceptible to outdoor air pollution is also expected to increase. As a result, even if air pollutants are maintained at levels measured in 2008, the health impacts on the Canadian population would increase. Consequently, outdoor air quality continues to be a subject of considerable interest for public health officials and policy makers trying to improve the health of Canadians.

The following section highlights the main outdoor air pollutants, their sources, trends and their effects on health. It also provides information on what the Government of Canada is doing to address air pollutants and what you can do to reduce your personal impact on air quality, and how you can reduce your risk from air pollutants.



Aerial view of a high-smog day in Toronto

What are the main pollutants in outdoor air?

Ozone and particulate matter (PM) are the air pollutants most often linked to health problems. They are also the two main components of smog, a term used to describe a mixture of gases and particles in the air that often causes reduced visibility.

Ozone is a gas that occurs naturally in the Earth's atmosphere, and when found at high altitudes (15 to 50 km above the ground) it forms a protective screen against harmful ultraviolet rays. At low altitude, however, ozone is an air pollutant that has adverse health and environmental impacts. This "ground-level" ozone is formed by a reaction that occurs when certain air pollutants are exposed to sunlight. The source pollutants for ozone come from both natural and human-made sources (e.g., fossil fuel burning, industrial processes), both within and outside Canada. As it takes time for ozone to form, ground-level ozone levels are often highest at a distance (metres or even kilometres) from where the source pollutants are produced. Ozone levels are also highest in the afternoon after several hours of sunshine.

Particulate matter is a complex mixture of airborne liquid and solid particles that are microscopic in size. It can be directly emitted into the air (called primary PM) or it may be formed in the atmosphere (called secondary PM) through chemical reactions involving other air pollutants, such as nitrogen oxides, sulphur oxides, ammonia and volatile organic compounds (VOCs). PM originates from some natural sources (e.g. windblown soil, sea salt spray, volcanic dust), but most of the PM which affects health is the result of human causes (e.g., fossil fuel burning, industrial processes), both within and outside Canada.

The make up of PM can be very different depending on the source and may include different materials including gases, organic matter, metals, hydrocarbons, etc. PM is generally classified by size, as follows:

- Ultrafine particles (UFPs), with a diameter less than 0.1 micron;
- Fine particles ($PM_{2.5}$), with a diameter less than 2.5 microns;
- Coarse particles ($PM_{10-2.5}$), with a diameter between 2.5 and 10 microns; and
- Inhalable particles (PM_{10}), with a diameter less than 10 microns.

Although all sizes of PM can be inhaled, most studies focus on the health effects of the fine ($PM_{2.5}$) and ultrafine particles because they are more easily inhaled and can penetrate deeply into the lungs.

Apart from PM and ozone, the other major air pollutants managed in Canada are nitrogen oxides, sulphur oxides, carbon monoxide (CO) and VOCs. These pollutants may themselves have health effects and are also important contributors to the formation of ozone and PM. These potential health effects are discussed later in this section.



What are main sources of air pollution?

The major sources of air pollution are transportation (e.g., cars, trucks, marine vessels,

trains, tractors and airplanes), industry (e.g., oil and gas production, pulp and paper, base metal smelting), electric power generation (e.g., coal-fired power plants), agriculture and the manufacture of consumer and commercial products. Figure 1 shows the relative

Main Sources of Outdoor Air Pollutants in Canada

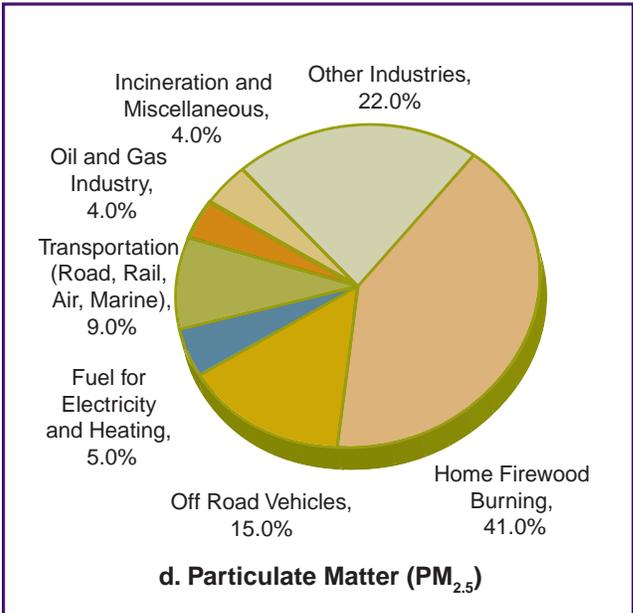
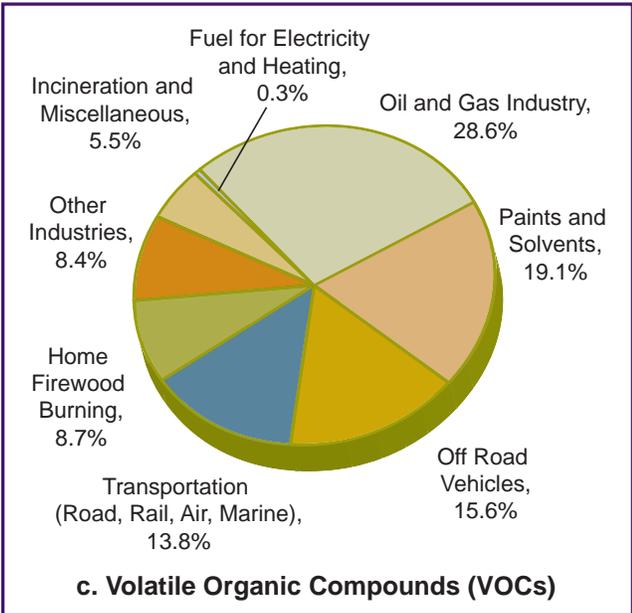
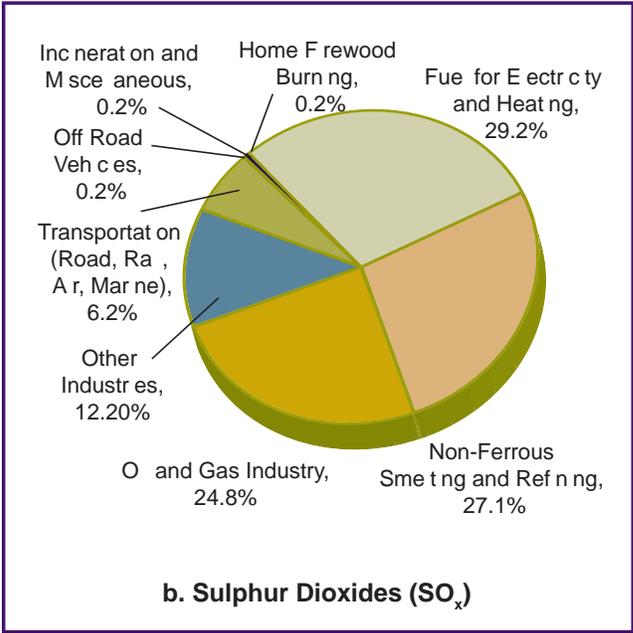
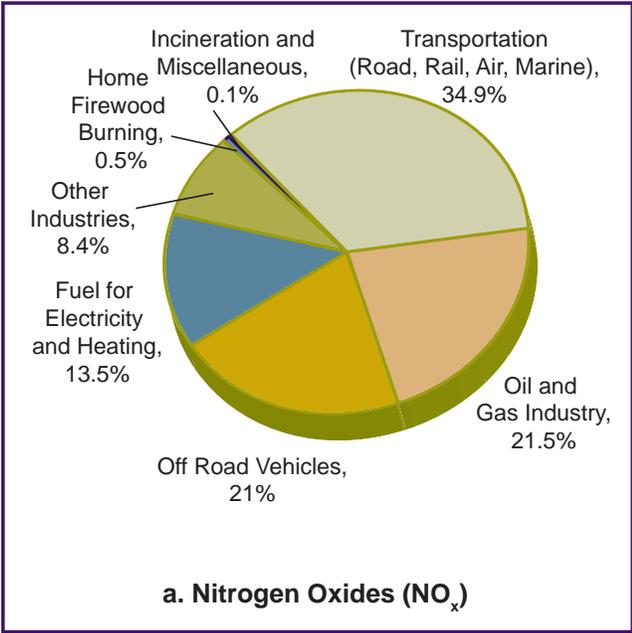


Figure 1: Major sectors contributing to emissions of nitrogen oxides (NO_x), sulphur oxides (SO_x), volatile organic compounds (VOCs) and fine particles (PM_{2.5}) in 2009, excluding natural sources (Environment Canada, 2012).

contribution of different sources in Canada to the levels of nitrogen oxides, sulphur oxides and VOCs (pollutants that can lead to ozone and secondary PM formation) as well as PM. The data show that burning fossil fuels is one of the main sources of air pollution.

Air pollutants produced in other countries can also affect air quality in Canada. While there is some movement of air pollutants from Canada to the United States, air pollutants usually travel in the opposite direction. In southern Ontario and southern Quebec, pollutants from U.S. sources, combined with those from local sources, result in higher ozone and PM_{2.5} levels. The Canadian Maritime provinces, while having air pollution sources of their own, are also under significant influence from the U.S. northeast. Typical weather systems move pollutants from southern Ontario and the eastern U.S. to Quebec and Atlantic Canada, particularly in the spring and summer for ozone, and year-round for PM_{2.5}.

What are the health risks?

Exposure to air pollutants has many health effects, which vary depending on an individual's susceptibility to air pollution, the pollutant types and levels and the length of time an individual is exposed to them. Air pollution can affect the respiratory and cardiovascular systems, which can result in a wide range of health effects and even premature death. Anyone can be affected by smog to some degree, but the elderly, children, pregnant women, diabetics and individuals with heart and lung conditions seem particularly susceptible.

As principal components of smog, PM and ozone are the air pollutants of most concern and studies have shown a number of health effects from both short- and long-term exposure to these pollutants.

Particulate matter

The main health concerns of PM are its effects on the cardiovascular and respiratory systems. Studies have clearly shown that increases in PM levels can result in increased:

- Health symptoms for people with chronic breathing and heart conditions;
- Emergency room visits and hospital admissions for cardiovascular and respiratory conditions (e.g., heart disease, heart attacks, pneumonia, asthma, bronchitis, allergies, and chronic obstructive pulmonary disease);
- Emergency room visits among newborns for bronchiolitis; and
- Premature deaths due to lung and heart disease.

Recent studies have also linked exposure to PM to premature births, low birth weight and certain neurological effects, although more research is needed to confirm these effects.

Some groups of people, such as diabetics and those with respiratory and cardiac disease, are particularly susceptible to the effects of air pollution. Children are also more susceptible because their growing respiratory systems are more sensitive to harmful substances. Children are also generally more active than adults and inhale greater amounts of air pollution.

In 1991, the U.S. and Canada entered into the Air Quality Agreement to address transboundary air pollution. This Agreement led to reductions in acid rain in the 1990s, and expanded in 2000 to include an Ozone Annex to reduce transboundary smog emissions.



Research on PM suggests there is no completely safe level of exposure, and any exposure to PM may have adverse health effects, depending on an individual's sensitivity to PM.

Ozone

Ozone is a respiratory irritant and can interfere with the respiratory and cardiovascular systems. Studies have shown that increased ozone levels can lead to increased:

- Emergency room visits for asthma;
- Hospital admissions for respiratory and cardiovascular diseases (e.g., asthma, heart disease);
- Hospital admissions among the elderly for chronic obstructive pulmonary disease, pneumonia or asthma; and
- Premature deaths due to lung and heart disease.

Research shows that the groups most susceptible to ozone pollution are the elderly, adolescents, children with asthma, and individuals who engage in strenuous outdoor activities (e.g., runners, outdoor workers).

The results of ozone studies suggest that there is no known safe level of exposure. Therefore, any exposure to ozone could have adverse health effects depending on an individual's susceptibility.

Other air pollutants

Nitrogen oxides and sulphur dioxide

Nitrogen oxides, which include both nitric oxide and nitrogen dioxide, are by-products of burning fossil fuels. Nitrogen oxides can irritate the respiratory system, especially the lungs, when they react with VOCs in the presence of sunlight, producing ground-level ozone.

Sulphur dioxide, emitted mainly by fossil fuel combustion and metal smelting, can also irritate the respiratory system and reduce lung function.

Carbon monoxide

Carbon monoxide is a result of the incomplete combustion of fossil fuels. All engine exhaust contains a certain amount of CO, but the amount of CO emitted increases if a vehicle engine is poorly maintained. CO decreases the ability of blood to carry oxygen and is, therefore, a greater concern for individuals with heart and lung conditions. Current levels of CO in outdoor air are not associated with any significant health effects.

Air toxics

Air toxics are other substances in air known to cause or suspected of causing harm with sufficient exposure. The possible effects of exposure include cancer and damage to the immune, respiratory and reproductive systems. VOCs such as benzene and 1,3-butadiene are examples of air toxics, as are polycyclic aromatic hydrocarbons (PAHs) and some metals. While some air toxics are known or suspected carcinogens, the health risk at current levels in the Canadian environment is considered to be low.

Traffic-related pollutants

Pollution from motor vehicles contains a mixture of the air pollutants previously described. Researchers around the world are interested in the combined impact of traffic-related air pollution on human health. Scientific studies in Canada, the United States and Europe show that children living in areas with high road traffic volumes have more respiratory-related illness symptoms than other children. In particular, many studies show that exposure to air pollution from traffic can trigger asthma symptoms in children. Other health issues linked to traffic are heart attacks, coronary artery disease

and increased risk of dying from respiratory and cardiac problems. There is also some evidence that traffic-related pollution can make allergies worse and can alter reproductive outcomes, but further research is required to confirm these links.

Status and trends in Canada

Air quality in Canada has generally improved over the last few decades as regulations have reduced the amount of smog-forming pollutants (e.g., PM, ozone and VOCs) being released into the air. Over the last 20 years, there has been a general decrease in the air pollutants that are measured routinely (PM, ozone, sulphur dioxide, nitrogen dioxide and CO), as shown in Figures 2 and 3. The only exception to this trend is ozone, which has risen slightly over this time period. The increase in ozone levels is likely due to a combination of air pollution coming from industrial growth in other parts of the world and the complex interactions of ozone with other pollutants in our atmosphere. While average levels have increased, there has been a significant decline in peak ozone levels in recent years, due to regulatory measures implemented in Canada and the United States that have reduced local sources of ozone.

In 2000, the federal, provincial and territorial governments developed Canada Wide Standards (CWS) for PM and ozone that provide a measure of air quality in a given area. The CWS were intended to be achievable targets to guide actions that will reduce health and environmental risks. The CWS measurements provide another way to compare pollutant levels across the country and over time. For more information on the CWS and how they are measured, please visit the website of the Canadian Council of Ministers of the Environment (CCME) at www.ccme.ca.

PM_{2.5} and ozone levels across the country from 2004 to 2006, as defined by the CWS

measurements, were highest in southern Ontario and southern Quebec (Figure 4 and 5). This part of Canada is at the northern edge of a large region with high pollutant levels which covers the entire north-eastern United States.

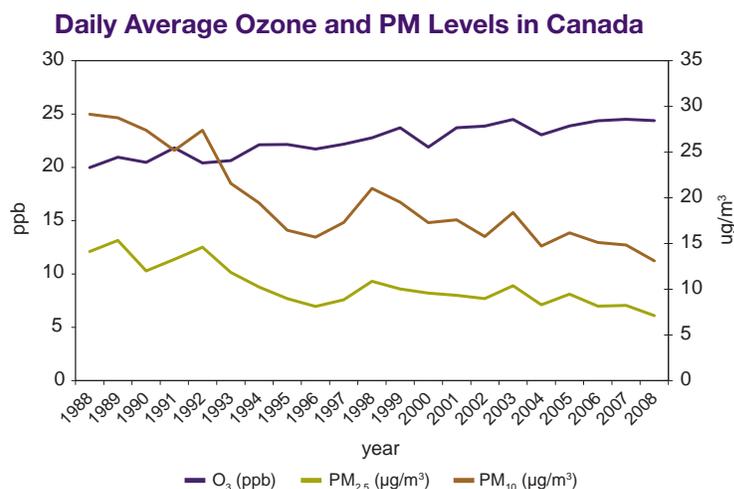


Figure 2: Daily average ozone (O₃) and particulate levels in Canada from 1988–2008 (National Ambient Pollutant Surveillance Network).

Note: ozone is measured in parts per billion (ppb). Particulate matter (PM_{2.5} and PM₁₀) is measured in micrograms per cubic metre (µg/m³).

Daily Average NO₂, SO₂ and CO Levels in Canada

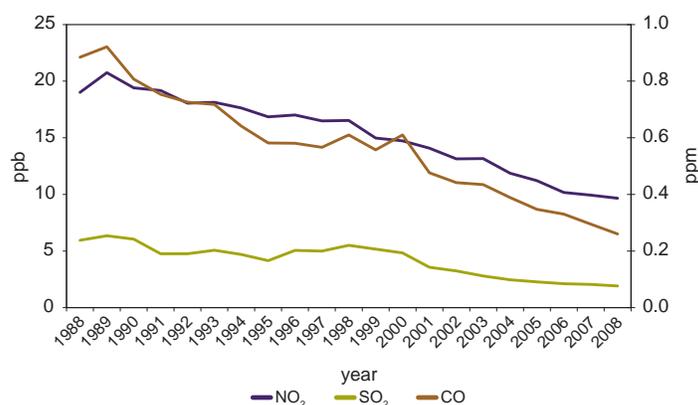


Figure 3: Daily average nitrogen dioxide (NO₂), sulphur dioxide (SO₂) and carbon monoxide (CO) levels in Canada from 1988–2008 (National Ambient Pollutant Surveillance Network).

Note: sulphur dioxide and nitrogen dioxide are measured in parts per billion (ppb). Carbon monoxide is measured in parts per million (ppm).



Particulate Matter Levels in Canada

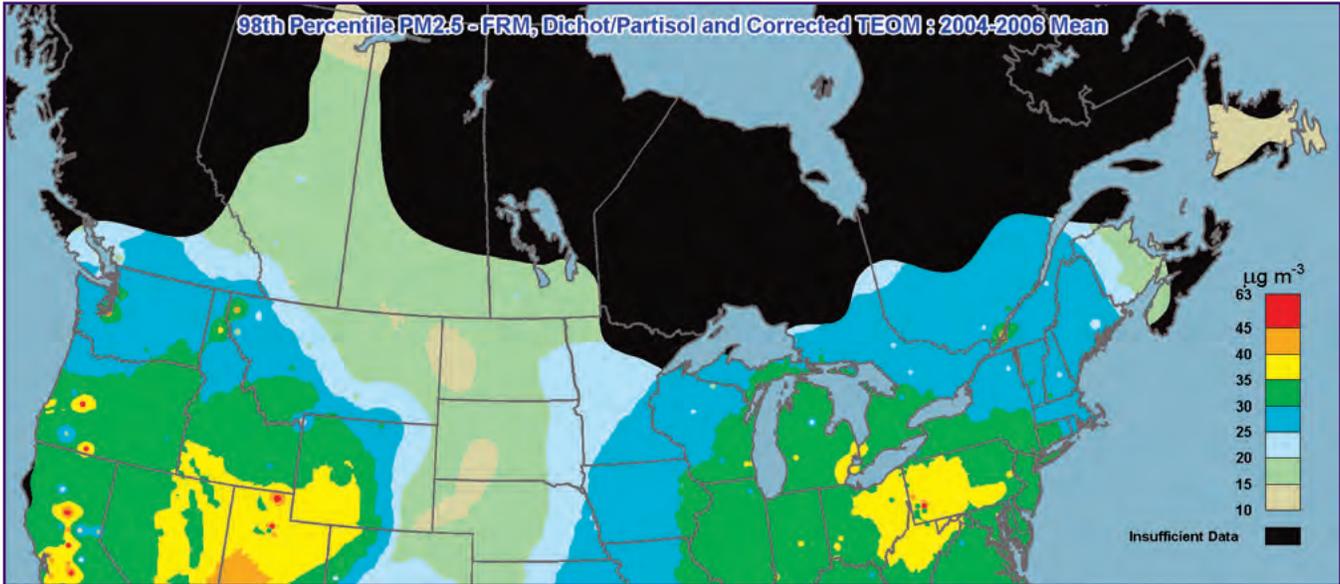


Figure 4: Spatial distribution of the 98th percentile 24-hour PM_{2.5} level (µg/m³) across Canada (2004–2006) (Environment Canada and Health Canada, 2011).

Ozone Levels in Canada

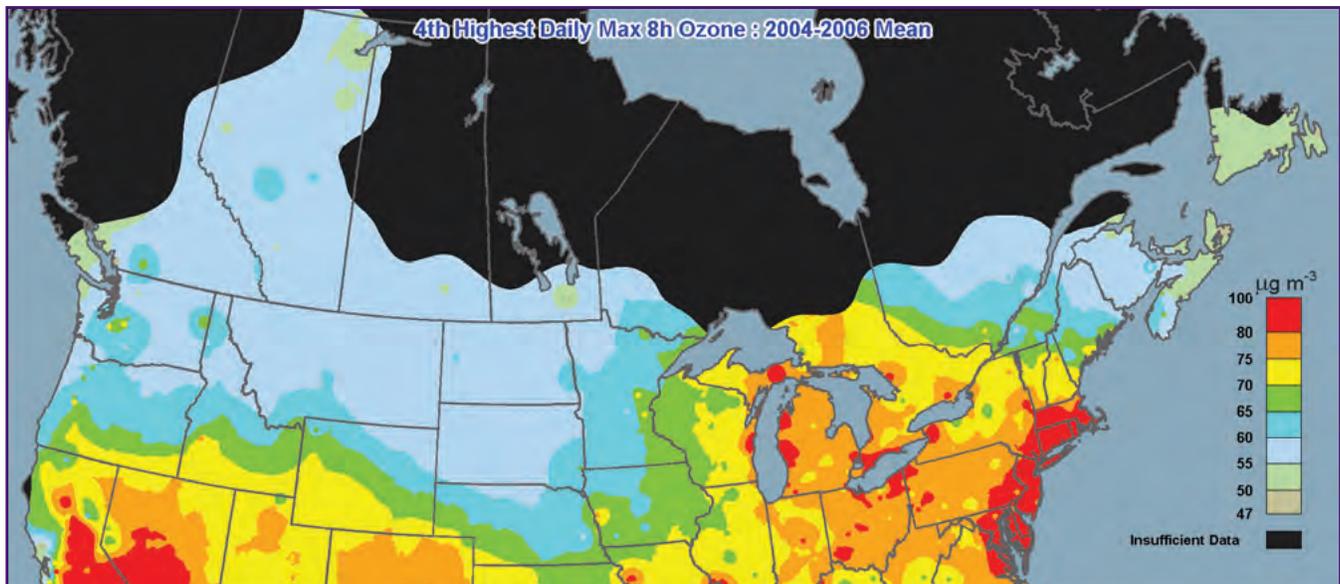


Figure 5: Spatial distribution of the 3-year average (2004–2006) of the 4th highest daily maximum 8-hr ozone average level (parts per billion, ppb) across Canada (Environment Canada and Health Canada, 2011).

The highest pollutant levels are found in the southern Great Lakes area and along the U.S. Eastern Seaboard.

Volatile organic compounds, a key contributor to the formation of smog, have declined significantly and are 50% lower than they were in 1990 (Figure 6). This is the result of regulations which limited the amount of VOCs in fuels and in consumer and industrial products. Benzene, a volatile organic compound with significant health effects, has also been subject to a series of regulations designed to reduce Canadians' exposure from the most important sources. These regulations included reductions in the amount of benzene allowed in gasoline, requirements for emission controls on petroleum pipelines and measures to reduce benzene from industrial sources. The result has been a major

drop (75 percent) in outdoor concentrations of benzene in Canadian cities (Figure 7).

What is being done?

The Government of Canada works closely with the provinces and territories to manage air quality. Health Canada works with Environment Canada, other government departments, provinces and territories as well as stakeholders to address the health issues related to air pollution. Environment Canada is the primary federal agency involved in regulating air pollution and has established a variety of regulations concerning the reduction of hazardous emissions from vehicles and other sources. Provinces and territories may also regulate the pollutant sources within their borders.

Atmospheric VOC Levels in Canada

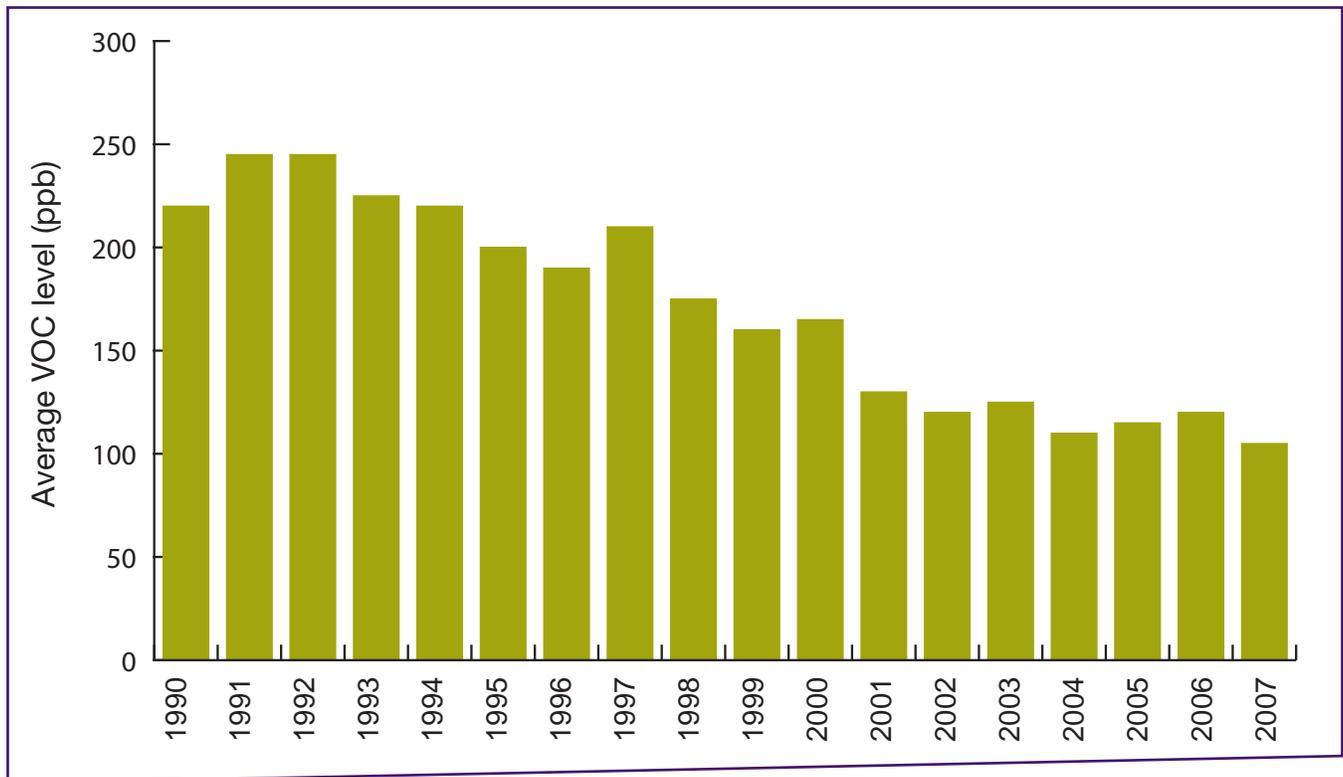


Figure 6: Average volatile organic compounds (VOC) level in air (parts per billion, ppb) in Canada (1990–2007) (National Air Pollution Surveillance Network).



Atmospheric Benzene Levels for Urban and Rural Locations

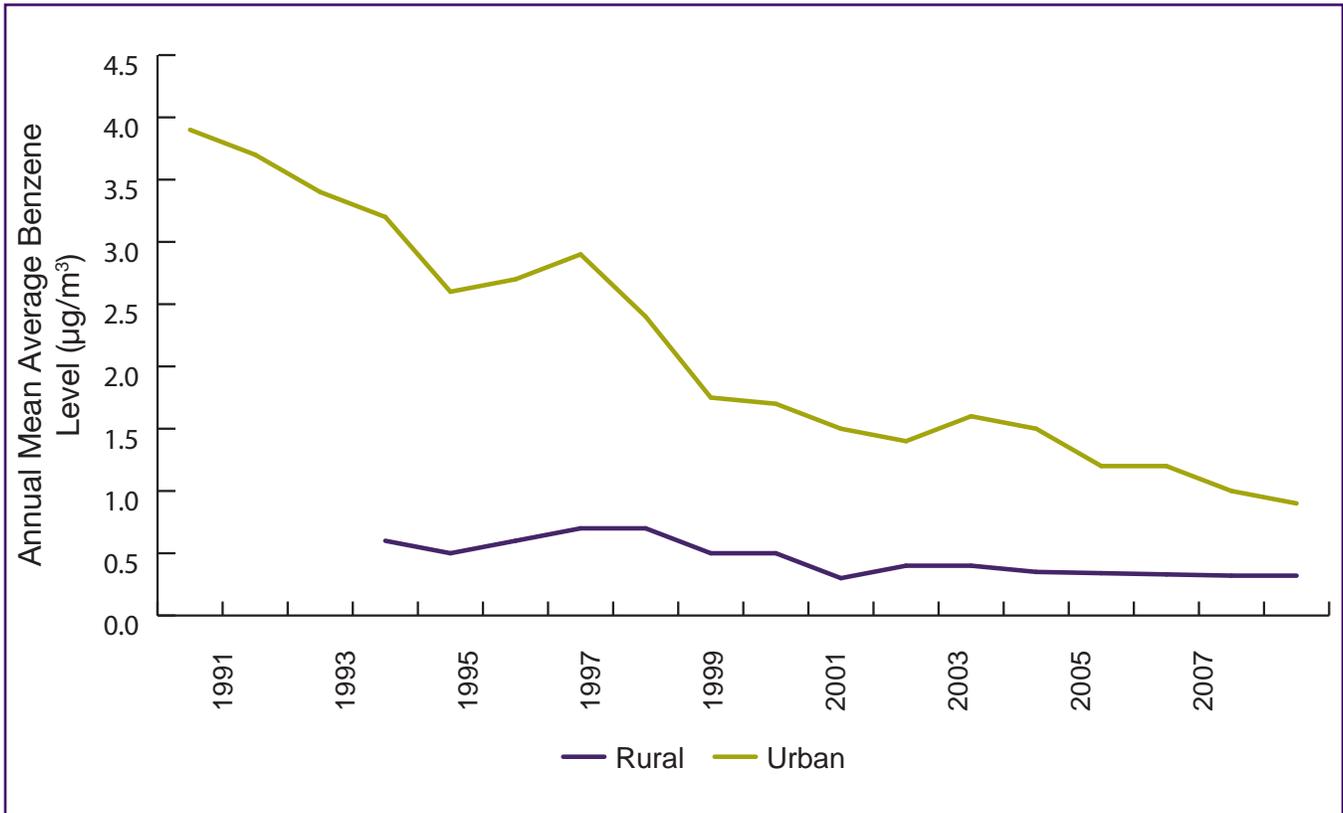


Figure 7: Average benzene level (µg/m³) for urban and rural locations (1991–2008) (National Air Pollution Surveillance Network).

Health Canada is primarily responsible for researching and evaluating the effects of air pollution on health. This work has played an important role in developing national air quality standards and has contributed to the development of regulations, such as those to lower sulphur levels in gasoline and diesel fuel.

The Government of Canada is working with the provinces and territories, in collaboration with industry and health groups, to establish a new national system to manage air quality. This system will include new air quality standards for PM and ozone (the two pollutants which have the greatest impact on public health) and local management to improve air quality where it is under stress and to keep clean areas clean.

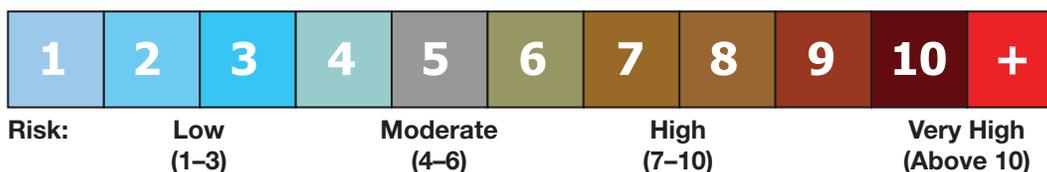
The Government of Canada has already produced a number of publications to assist local communities in regulating sources of air pollutants that are handled at the municipal level (e.g., model anti-idling and woodstove bylaws).

Health Canada and Environment Canada are also working closely with provincial and municipal governments, as well as environment and health advocates from across the country, to implement the Air Quality Health Index (AQHI). The AQHI is a communication tool that helps Canadians to make decisions to reduce the impact that air quality can have on their health in the short-term. The AQHI provides actual and forecasted air quality for a local area, as well as what actions

people can take to reduce their exposure to air pollutants and protect their health. This includes specific messages for people who are at greater risk of health problems due to air pollution (e.g., people with heart or breathing problems or the elderly) (Figure 8). The AQHI is based on

health research undertaken by Health Canada that estimates the short-term health risks posed by a combination of common air pollutants that are known to harm human health. More information on the AQHI is available at www.airhealth.ca.

Air Quality Health Index



Health Risk	Air Quality Health Index	Health Messages	
		At Risk Population*	General Population
Low	1-3	Enjoy your usual outdoor activities.	Ideal air quality for outdoor activities.
Moderate	4-6	Consider reducing or rescheduling strenuous activities outdoors if you are experiencing symptoms.	No need to modify your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High	7-10	Reduce or reschedule strenuous activities outdoors. Children and the elderly should also take it easy.	Consider reducing or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very High	Above 10	Avoid strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion.	Reduce or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation.

Figure 8: The index is an indicator of the short-term health risks associated with air quality based on measuring air pollutants known to harm human health. The index rating is the sum of the health risks from each of the pollutants in the index. It takes into account how even low levels of exposure to multiple pollutants (such as ground-level ozone and other components of smog) can affect the health of Canadians. The calculation of health risk is based on a combined exposure to nitrogen dioxide, PM_{2.5} and ground-level ozone.

*People with heart or breathing problems are at greater risk.



Climate Change and Air Pollution

The linkages between climate change and air quality are becoming more important for public health officials and governments. Scientists have identified that rising temperatures related to climate change will likely increase the levels of air pollution and, accordingly, population health impacts. By developing clean technology, governments and corporations continue to consider, balance and support economic growth and the well-being of Canadians while addressing greenhouse gas emissions and air pollution at the same time.

Some recent studies have indicated that reducing short-lived greenhouse air pollutants with known health impacts (e.g., black carbon, organic carbon, sulphates and ozone) may also play an important role in climate warming.

Scientists from various areas of discipline are working to better understand the atmospheric interactions between various pollutants, the contribution of air pollutants to climate change and the impact of regulatory policies on both climate and air quality.

What can I do?

Everyone has a role to play in improving outdoor air quality. By following the tips below, you can reduce your exposure to air pollution and also help reduce pollution levels in the air.

Reducing your exposure to air pollution

Use these tips to limit your exposure to air pollutants when you are outside.

Check the air quality. Check the AQHI regularly and adjust your activities accordingly. If the AQHI is not yet available in your area, check your provincial Environment Ministry website for information on local air quality.

Stay out of traffic. Avoid or reduce exercising in high-traffic areas, especially during rush hour. Instead, cycle, run or walk along routes with low traffic flow. Be aware of traffic patterns when choosing a school or daycare, or when

purchasing a home since traffic pollution can aggravate asthma as well as heart and lung conditions.

Ask your doctor. If you have a heart or lung condition, talk to a health professional about ways to protect your health when air pollution levels are high.

Reducing pollutant levels in the air

The following tips will help lower pollutant levels:

Park your car. Use public transportation and walk or ride your bicycle to work instead of taking your car whenever possible. If public transit is not available, carpool.

Cut down on gas. Reduce the use of gas-powered vehicles and equipment. For example, for leisure activities, try a rowboat or sailboat instead of a motorboat, or travel by bicycle.

At home, use a battery-operated, electric or push lawn mower instead of a gas mower. Take fuel efficiency into account when buying a vehicle by consulting Natural Resources Canada's Fuel Consumption Guide (to obtain a copy, see Additional Resources). Also remember to turn off your car's engine when stopped for more than ten seconds, unless in traffic or at an intersection.

Get involved. Be part of community action or join a citizens' committee to advocate for cleaner air.

Additional resources

- It's Your Health: Road Traffic and Air Pollution (www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/traf-eng.php)
- It's Your Health: Smog and Your Health (www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/smog-eng.php)
- Health Canada: Health Risks and Benefits Associated with the Use of 10% Ethanol-Blended Gasoline in Canada (www.hc-sc.gc.ca/ewh-semt/pubs/air/ethanol-eng.php)
- Energy-efficient vehicles (<http://oee.nrcan.gc.ca/transportation/personal/15864>)
- Canada–United States Air Quality Agreement (www.ec.gc.ca/Air/default.asp?lang=En&n=83930AC3-1)



DRINKING WATER QUALITY

Introduction

Access to safe, clean water is essential to life, health and well-being. Canada is fortunate to have many sources of clean water. In 2010, the international Environmental Performance Index ranked Canada's water-quality as the second best among selected industrialized countries (Source: Environment Canada).

Water in the environment, or "source water", is never pure. It picks up bits of everything it comes into contact with, including minerals, silt, vegetation, fertilizers, and agricultural run-off. Drinking water quality is dependent on source water quality (surface and ground water) as well as treatment and distribution. Canadian drinking water supplies are generally of excellent quality and among the safest in the world.

The wide geographical diversity in Canada means a large variation in the quality of source water

across the country. While most Canadians obtain their drinking water from municipal treatment plants using surface water sources, approximately 30% of Canadians rely on groundwater as their source of drinking water. Some groundwater may be less vulnerable to microbiological contamination and require little treatment, other groundwaters are under the direct influence of surface water (GUDI) and require the same level of treatment as surface waters.

Drinking water challenges also vary greatly across the country. Whereas large municipalities generally provide high quality drinking water at a reasonable cost, small community water supplies face the same need for treatment but have far fewer resources, both economically and in terms of available expertise. In addition, small northern communities must address distribution challenges in areas affected by permafrost. The prairie provinces often have

Percentage of Population Reliant on Groundwater

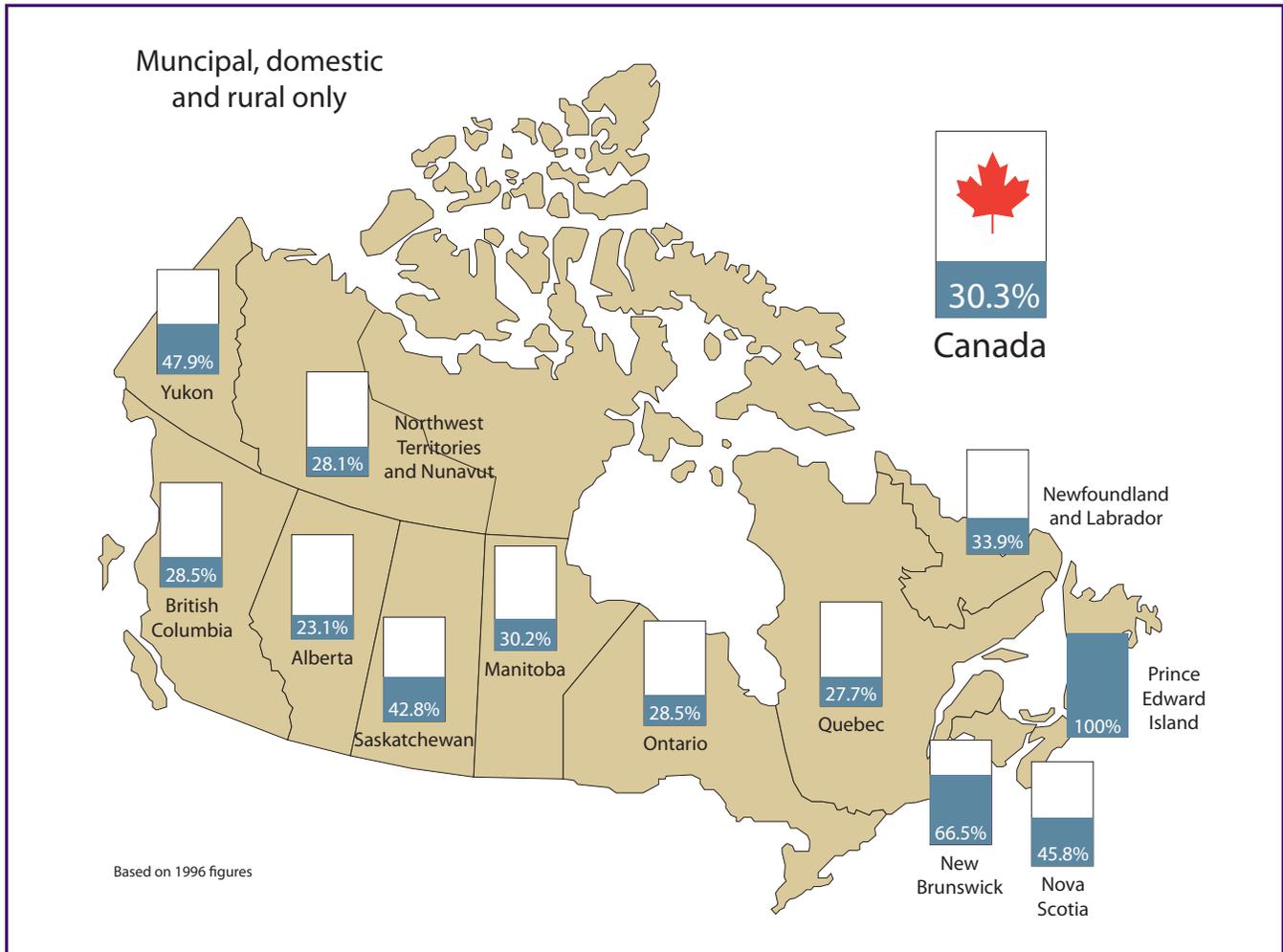


Figure 1: Percentage of the Canadian population reliant on groundwater (Environment Canada, 1996).

to deal with drought conditions, while Prince Edward Island relies entirely on groundwater.

Canada’s drinking water safety record is the result of a longstanding collaborative effort and information-sharing by key players and stakeholders in every jurisdiction in the country.

Drinking water in Canada: who is responsible?

In Canada, all levels of government (federal, provincial and territorial, municipal) and the

public share responsibility for the safety of drinking water. Because of the complexity of water issues, effective collaboration is fundamental to maintaining drinking water quality.

The federal government plays a key role in the area of drinking water by, among other things, leading the development of the *Guidelines for Canadian Drinking Water Quality* and providing scientific and technical expertise to the provincial and territorial governments. These guidelines are used by all jurisdictions in Canada as a basis for establishing regulatory requirements for

drinking water quality, either through legislation and regulations or through water treatment plant licensing. As part of their management responsibilities, the provinces and territories are in charge of managing source waters and regulating treatment plants and distribution systems. Municipalities are usually responsible for the actual treatment and distribution of drinking water to the public, with the exception of private homeowners who draw drinking water from a source on their property.

Other federal departments and agencies also have some responsibilities for drinking water. The Government of Canada is directly responsible for drinking water in areas under its jurisdiction, such as on board passenger

conveyances (e.g., ships, airplanes), in national parks, military facilities, and other federal buildings. The federal government, through Aboriginal Affairs and Northern Development Canada and Health Canada, shares responsibility for drinking water on First Nations lands with those communities and other levels of government. Health Canada works with First Nations communities to identify and address potential drinking water quality problems.

Sources of drinking water contaminants

Water in the environment, or “source water”, is affected by everything it touches. Groundwater

Federal-Provincial-Territorial Committee on Drinking Water

The Federal-Provincial-Territorial Committee on Drinking Water (CDW) is a well-established national committee that has been active for more than 30 years. It is made up of members from the federal, provincial and territorial government departments responsible for drinking water. The main purpose of the CDW is to establish the *Guidelines for Canadian Drinking Water Quality*, published by Health Canada. Health Canada leads the development of the guidelines and provides scientific expertise to this group as its technical secretariat.

The CDW has evolved to ensure the consistency of drinking water quality across Canada and to provide an economy of scale by avoiding duplication. It also takes on additional roles to protect drinking water quality, including working in collaboration with the Canadian Council of Ministers of the Environment to develop the Multi-Barrier Approach to Safe Drinking Water. This is described later in this section (under Multi-Barrier Approach).

Guidelines for Canadian Drinking Water Quality

The objective of the *Guidelines for Canadian Drinking Water Quality* or “Guidelines” is to protect the health of all Canadians, based on protecting the health of the most vulnerable age group. They are established at a level that would be protective of health for exposure at the guideline level over a person’s lifetime. They are set at a level that must be measurable and achievable, taking into consideration the availability of treatment technologies for municipal systems as well as for individual residences. The Guidelines deal with microbiological, chemical and radiological contaminants. They also address concerns with the physical characteristics of water, such as taste and odour.

is affected by geological formations as well as some sources of pollution. Surface water quality is impacted by natural (e.g., wildlife, geological formations) and artificial (e.g., agriculture, mining, municipal wastewater) sources of contaminants. The quality of the source water will affect the types of treatment needed to ensure the safety of drinking water, which means every drinking water treatment plant is uniquely designed to address the specific needs of the community it serves.

The most significant risks to health from drinking water come from microscopic organisms such as disease-causing bacteria, protozoa and viruses. The Guidelines that relate to these microorganisms are stringent because the health effects associated with them can be quite severe in the short-term and can be chronic in individuals with a compromised immune system. This means that the single most important treatment for drinking water is always disinfection.

A wide variety of chemical substances may be present in drinking water from a number of sources. Generally speaking, these chemical substances pose less of a health risk than microbiological pathogens. Chemical substances include metals (e.g., lead, chromium), inorganic substances (e.g., nitrates) and organic chemicals (e.g., pesticides, benzene). Some of these chemical substances are found in nature, while others are generated by human activities like mining, agriculture or manufacturing processes. Substances such as lead and copper may leach from the materials that make up the water distribution system, including household plumbing (such as pipes, tanks, and fittings). In addition, when drinking water is treated to make it microbiologically safe, such as through disinfection, chemical by-products may be left in the water. It is important to remember that by-products from disinfection pose less of a health

risk than the pathogens that the process kills; it is always safer to drink water that has been disinfected than water that has not been treated at all.

Radiological substances can also occur in drinking water supplies. These can be naturally present in the environment or enter the environment as a result of human activities.

The best way to ensure the safety of a drinking water supply is to incorporate a strategy to reduce contamination of the source water. This is described later in this section (under Multi-Barrier Approach).

Small drinking water systems

It is estimated that there are more than 45,000 drinking water systems in Canada, the majority of which are small systems, typically serving fewer than 5,000 people. Small systems may include small, remote supplies both in First Nations and non-First Nations communities; institutions such as rural schools, hospitals or long-term care facilities that manage their own drinking water supplies; seasonal campgrounds or parks; as well as systems run by private, rural businesses serving the public such as restaurants or motels.

Small drinking water systems face a number of significant challenges both in Canada and abroad. In 2006, the World Health Organization identified the management of small community water supplies as a critical issue for sustainable development and health. In the same year, the Office of the Inspector General within the U.S. Environmental Protection Agency recognized that effort and resources are needed to help small drinking water systems overcome their many challenges. In Canada, federal, provincial and territorial governments have long recognized that small systems face numerous challenges. Even though efforts to address these challenges are ongoing, much remains to be done.

While drinking water regulations continue to evolve and become more stringent, small drinking water systems face challenges that make it more difficult for them to keep pace. For instance, they cannot easily finance the renewal of aging infrastructure, treatment plant upgrades, and ongoing operations. Personnel often have less experience and technical expertise than their counterparts at larger utilities. Managers and decision-makers may also lack the resources required to facilitate and administer needed solutions.

Northern communities face additional challenges. For example, in Yukon and Nunavut—as in other areas where small communities with a limited tax base are serviced by local drinking water systems—there are cost-related challenges with respect to operation, maintenance, infrastructure improvements and new construction. These costs may be higher in northern Canada because of high transportation costs for equipment, building materials and supplies, as well as higher costs for labour and professional expertise.

One of the biggest challenges for these communities is to secure and retain certified operators. This is becoming more of a challenge as more sophisticated treatment systems are being installed. Once operators become trained, they tend to move to larger municipalities.

Solutions are being explored to help address challenges faced by small community water systems. These include training and certification programs for operators, remote monitoring of operational and water quality parameters, the use of water safety plans and the adoption of source water protection strategies.

Status and trends in Canada

As drinking water is primarily under provincial and territorial jurisdiction, there is no national database. Instead, Health Canada uses various strategies, including surveys and a drinking water advisory surveillance system, to better understand the status of drinking water quality and trends in Canada. All work is done in collaboration with provincial and territorial partners. This section includes the status and trend information for selected drinking water contaminants, as well as the health risks associated with exposure.

Disinfection by-products

Disinfection by-products (DBPs) form when disinfectants used to treat the water, such as chlorine, react with naturally-occurring organic matter (e.g., decaying leaves and vegetation). The use of disinfectants to treat drinking water has virtually eliminated waterborne diseases because disinfectants such as chlorine can kill or inactivate most microorganisms commonly found in water. Although disinfection by-products vary with the disinfectant and quality of the source water, some can pose a risk to human health, and their formation should be minimized. However, it is clear that the health risks from disinfection by-products are much lower than the risks from consuming water that has not been disinfected. Although all chemical disinfectants can produce DBPs, those formed as a result of chlorination are more common and, consequently, more studied. This is due to the fact that the majority of drinking water treatment plants in Canada use some form of chlorine to disinfect drinking water, by treating water directly in the plant and/or by maintaining chlorine residual in the distribution system to prevent bacterial re-growth in pipes.

Trihalomethanes (THMs) and haloacetic acids (HAAs) are the major DBPs found in drinking water treated with processes that include a chlorine disinfectant. For practical and economic reasons, not all DBPs can be routinely measured in drinking water. Together, the concentrations of THMs and HAAs can be used as indicators of the total amount of all chlorinated DBPs that may be found in drinking water supplies. The best strategy to reduce levels of DBPs in drinking water is to reduce their formation by removing organic matter prior to the addition of the disinfectant.

Chloroform is the THM found in highest concentrations and about which the most health information is available. It is considered to be a possible carcinogen in humans; specifically, it has been linked to liver, kidney and colorectal

cancers. The drinking water guideline for total THMs is a maximum acceptable concentration (MAC) of 0.1 milligrams per litre (equivalent to 100 micrograms per litre [$\mu\text{g/L}$] or 100 parts per billion [ppb]). It is measured as an annual average of quarterly samples to account for seasonal variations in the source water quality.

The health effects associated with exposure to HAAs will vary with the specific compound. Some are probably carcinogenic to humans, and developmental effects are also being suggested. However, further studies are required to confirm these effects as well as their long-term significance to human health. The drinking water guideline for HAAs is 0.08 milligrams per litre (equivalent to 80 micrograms per litre or 80 parts per billion). It is also measured as an annual average of quarterly samples.

Health Canada Tap Water Survey

Health Canada recently undertook a national survey to look at selected drinking water contaminants. The National Survey of Disinfection By-Products and Selected Emerging Contaminants in Canadian Drinking Water was performed as part of a research program designed to give Health Canada more information about the presence of various disinfection by-products and other contaminants in drinking water.

During this two-year study (2009–2010), Health Canada analysed more than 100 different water quality parameters at 65 water treatment facilities across the country that provide drinking water to more than 9 million Canadians. Sites were selected based on source water characteristics, treatment process, geographic area, and the size of the population served. The survey looked at general water quality, and also analysed specific contaminants, including:

- Specific disinfection by-products; and
- New and emerging contaminants (e.g., selected pharmaceuticals and personal care products, perfluorinated compounds, etc.).

Health Canada will use the results of this survey to help determine priorities for drinking water guideline development. The first-year survey results show that levels of by-products and other contaminants in drinking water are very low and do not present any health concerns.

Levels of THMs and HAAs are generally higher in treated surface water than in treated groundwater because of the high organic content in lakes and rivers. They will also be higher in warmer months because of the higher concentrations of precursor organic materials in the raw water and especially because the rate of formation of disinfection by-products increases at higher temperatures.

Health Canada has compared the levels of THMs found during the 2009–2010 National Survey of Disinfection By-Products and Selected Emerging Contaminants in Canadian Drinking Water to similar data from the 1995 National Survey of Chlorinated Disinfectant By-Products in Canadian Drinking Water Supplies. Although the data are not directly comparable, the overall trend is towards an improvement in water treatment plant performance; there are now fewer drinking water systems with concentrations of THMs near or above the MAC. Figure 2 shows the number of facilities broken down by the average levels of THMs measured during winter and summer at the location in the distribution system where THMs occur at the highest levels. It is important

Level of Trihalomethane in Canadian Drinking Water Systems

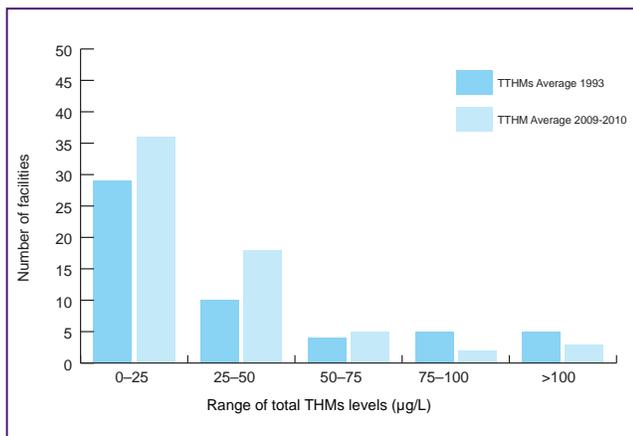


Figure 2: Distribution of water systems based on total trihalomethanes (TTHMs) levels—comparison of average levels measured in summer and winter of 1993 and 2009–2010.

to remember that the MAC for THMs is measured as an annual average of quarterly samples, which is not reflected by the data used in Figure 2.

The 2009–2010 national survey also measured levels of HAAs. The results show that the majority of facilities achieved levels below the Canadian drinking water guideline of 0.08 milligrams per litre (equivalent to 80 micrograms per litre or 80 parts per billion). Figure 3 shows the number of facilities broken down by the average levels of HAAs measured during winter and summer at the location in the distribution system where HAAs occur at the highest levels. As for THMs, it is important to remember that the MAC for HAAs is measured as an annual average of quarterly samples, which is not reflected by the data used in Figure 3.

Level of Halocetic Acids in Canadian Drinking Water Systems

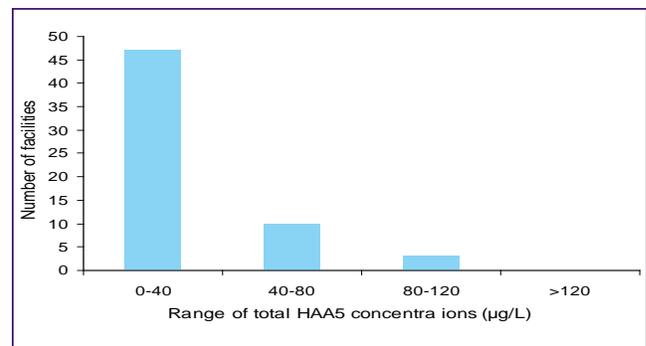


Figure 3: Distribution of water systems based on total halocetic acid (HAA5) levels—average levels measured in summer and winter 2009 and 2010.

Pharmaceuticals and personal care products

Pharmaceuticals and personal care products (PPCPs) are synthetic or natural chemical substances used in medicine, agricultural and veterinary drugs, cleaning agents, skin

care products and cosmetics. These chemical substances can be introduced into drinking water source waters through effluent from sewers, uncontrolled drug disposal (e.g., discarding drugs into toilets), and agricultural runoff.

The presence of PPCPs in the environment is not new. What is new is scientists' ability to detect these compounds at very low levels in drinking water supplies given recent advances in analytical methods. In Canada, concentrations of pharmaceuticals in treated water are very low, if present at all. These compounds have been detected in treated drinking water supplies at levels generally in the low parts per trillion range. This represents amounts more than 1000 times lower than the lowest typically prescribed dose.

Assessments show that current levels of these substances in drinking water are not of concern. The contaminants found most often were carbamazepine (anticonvulsant), diclofenac (non-steroidal anti-inflammatory drug), ibuprofen (non-steroidal anti-inflammatory drug), sulfamethoxazole (antibiotic) and triclosan (preservative and antibacterial agent). The occurrence in raw and treated water and removal rates vary widely among the different treatment plants.

While there are no known adverse human health effects attributed to the very low levels of pharmaceuticals in drinking water, research continues to focus on detection and removal from drinking water. Health Canada continues to work with the scientific community in this area. There is not enough scientific information or exposure data available to date to develop a drinking water guideline for any PPCP; Health Canada continues to monitor new scientific publications in this area.

Perfluorinated compounds (PFCs)

Perfluorinated compounds, such as perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) are manufactured chemical substances that are very good at repelling water and oil because of their chemical structure. They have been used as water, oil, soil, and grease repellents for carpets, fabric, upholstery, and food packaging. PFCs may enter into the environment through treated or untreated municipal/industrial wastewater discharged to surface water. They may leach from landfills into groundwater when products and materials containing these substances are sent for final disposal, or may be released directly to air, land and water when products containing PFCs are used.

For people who are exposed to higher levels of PFCs than are typical in the environment—for example, people who work in manufacturing facilities that produce or use PFCs—exposures to PFCs have been associated with decreases in levels of certain thyroid hormones, slight elevations in cholesterol levels and effects on the immune system.

Health Canada's tap water survey measured levels of PFOS and PFOA. PFOS was not detected in the treated water at any of the 31 locations tested, and PFOA was found in very small amounts in 16 of the 31 locations tested. Exposure to PFOA and PFOS at such low concentrations is not considered to be a health risk.

Other drinking water contaminants

Some chemicals in drinking water bring a higher level of interest for various reasons including their potential health effects and their occurrence across Canada. These include arsenic, lead, cyanobacterial toxins and fluoride.

Arsenic

Arsenic is a naturally occurring substance found within the Earth's crust. The major source of exposure to arsenic for most Canadians is through food, followed by drinking water, soil and air. For areas of Canada where arsenic is present at elevated levels in surface water or groundwater, drinking water will represent the major source of exposure; these elevated levels are mostly reported from private wells drawing on naturally contaminated groundwater.

Health Canada and the International Agency for Research on Cancer consider arsenic to be a human carcinogen. Its effects have been studied in a population in Taiwan where the drinking water contains naturally high levels of arsenic (more than 0.35 parts per million). The results suggest that consuming drinking water with very high levels of arsenic over a lifetime can increase the risk of cancer in internal organs such as the bladder, liver and lungs.

Health Canada and CDW have established a guideline of 0.010 milligrams per litre (0.010 parts per million) for arsenic in drinking water, stressing that levels in drinking water should be kept as low as reasonably achievable (or ALARA). Data collected in Canada indicate that the levels of arsenic in treated drinking water supplies are generally less than 0.005 milligrams per litre (0.005 parts per million), although concentrations may be higher in some areas. In areas where the geology contains elevated levels of arsenic, levels in groundwater have been detected up to 1 milligram per litre (or 1 part per million).

Lead

For the most part, the amount of lead in natural water sources in Canada is very low. However, under the right conditions, lead can be leached into the drinking water from lead service lines (water pipes that link the house to the main

water supply), and from lead solder in plumbing or brass fittings such as faucets.

Lead was a common component of distribution systems for many years, particularly in service lines. Although it is not feasible to replace all lead service lines in the short-term, most municipalities replace lead service lines as they undertake infrastructure renewal or repairs. Where a lead service line supplies the water to the home, it is recommended that the full service line be replaced. It is important to note that the portion from the curb to the house is the responsibility of the homeowner. The portion from the main water supply to the curb is the municipality's responsibility. Some municipalities that are replacing the main service lines have established programs where homeowners can replace their portion of the lead service line at the same time for a reduced cost.

Health Canada and CDW have established a guideline of 0.01 milligrams per litre (0.01 parts per million) for lead in drinking water. More information on lead and on strategies to control leaching in drinking water can be found in the Lead section of this document.

Cyanobacterial toxins

Blue-green algae, also known as cyanobacteria or pond scum, can form in slow moving, shallow waters, where conditions (such as water temperature and presence of nutrients) are favourable. Cyanobacteria are naturally found in surface waters of all types. These blooms can cause problems in water supplies since 50 to 70% can produce harmful toxins, like microcystins.

Cyanobacterial blooms in general occur sporadically over the three to four month summer period. Recent rises in bloom incidences can be linked in part to continued eutrophication (an increase in nutrients such as nitrogen and

phosphorus that increase algal growth) of water supplies as well as increased monitoring and public awareness. Controlling the releases of these nutrients to source waters represents the most effective strategy for preventing bloom formation. For this reason, the Government of Canada has adopted regulations to reduce the concentration of phosphorus in laundry detergents, household dish-washing compounds and household cleaners.

Municipal water quality surveys in Canada indicate that microcystins have rarely been detected in treated drinking water supplies. As blue-green algae are becoming more prevalent in Canada, guidelines have been established for cyanobacteria in drinking water and in recreational water. Levels found in drinking water are generally below the Canadian drinking water quality guideline of 0.0015 milligrams per litre (or 0.0015 parts per million).

Fluoride

Fluoride is a mineral naturally found in the ocean, the Earth's crust and in fresh water. Fluoride may also be added for its dental benefits to drinking water, toothpaste, supplements, and dental products applied by a dentist. Water fluoridation is the process whereby the level of fluoride in a water supply is adjusted to a level that will optimize dental benefits. Health Canada recommends an optimal fluoride concentration of 0.7 milligrams per litre to achieve these benefits (or 0.7 parts per million [ppm]) and a maximum acceptable concentration of 1.5 ppm.

Like many natural substances, fluoride can be harmful in excessive amounts. One of the most noticeable side effects of an overexposure to fluoride is dental fluorosis. Dental fluorosis is a condition characterized by white spots or mottling on dental enamel caused by ingesting too much fluoride in childhood. Most dental fluorosis is mainly a cosmetic condition: mild,

barely visible, and not a threat to health.

Over the years, numerous organizations have studied the effects of fluoride on human health. Currently available, published, credible scientific literature continues to indicate there is no cause to be concerned about adverse health effects from exposure to fluoride in drinking water up to the guideline level of 1.5 milligrams per litre (or 1.5 parts per million).

According to the 2010 Canadian Health Measures Survey, fluorosis is not a significant issue in Canada. Only 12% of the individuals studied had dental fluorosis classified as very mild and 4.4% as mild. So few Canadian children have moderate or severe fluorosis that, even combined, the prevalence is too low to allow reporting.

In 2008, community fluoridated drinking water was provided to about 43% of Canadians at average levels varying from 0.46 to 1.1 milligrams per litre across Canada. Furthermore, more than 75% of the Canadian population on a water system are estimated to receive fluoride in their water at concentrations of less than 0.6 milligrams per litre. Fewer than 2% of the population receive community water with fluoride levels over 1.0 milligrams per litre. Based on levels measured in Canada, fluoride in drinking water is not considered a public health concern.

Drinking water advisories in Canada

Drinking water advisories are issued when a responsible authority deems the safety of a drinking water supply to be threatened. Advisories may require households to boil their drinking water if there is a concern about the microbiological safety of the water. Advisories may also take the form of a 'do not use' or 'do not consume' order if there is a concern about a chemical contaminant in the drinking water from an emergency situation such as a leak or spill.

Through a partnership between the federal, provincial and territorial governments, a surveillance and alerting system designed for drinking water advisories was developed and launched in 2008. The drinking water advisories application is part of the Canadian Network for Public Health Intelligence (CNPHI). It allows health protection agencies to share information and work together in real-time to better protect public health when there is a potential threat to drinking water safety. The application also provides unique analytical and reporting tools to reveal the root causes and key trends underlying drinking water advisories in Canada.

A growing number of drinking water authorities across Canada are either using or preparing to

use the system. The goal is to have pan-Canadian surveillance of drinking water advisories. The World Health Organization and the United States Centre for Disease Control are looking with interest at what is being carried out in Canada and how it might be applied elsewhere.

Emerging trends underlying drinking water advisories in Canada

The majority of drinking water advisories issued in Canada are related to small systems, which face unique challenges in Canada and around the world (see Figure 4). Regulatory oversight of drinking water in Canada is not only becoming more stringent, but is growing to cover a broader array of small drinking water systems which serve the public.

Effects of Water System Size on Drinking Water Advisories in Canada

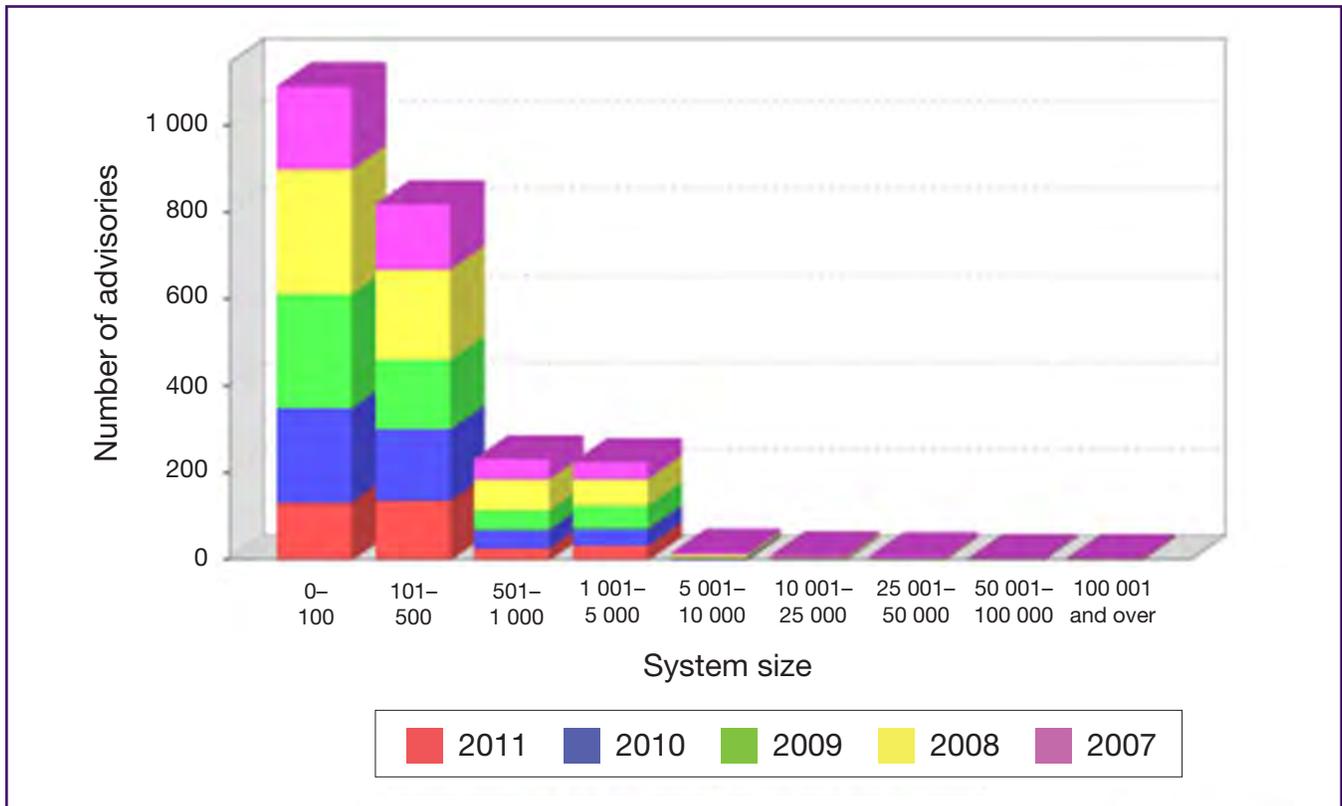


Figure 4: An example of the number of advisories issued by size of the water system.

The drinking water advisories application can identify reasons for drinking water advisories, either because of water quality reasons (e.g., microorganisms detected in water, exceeding the MAC or standard) or for operational reasons (e.g., equipment failure, failure to meet monitoring requirements). Figures 5 and 6 provide examples of specific reasons for issuing drinking water advisories for both of these categories. It is important to note that most drinking water advisories are precautionary. They are issued to prevent possible exposure to contaminants when a system may have failed.

Aging infrastructure has a direct impact on drinking water. Precautionary drinking water

advisories issued because of water main breaks, for example, account for more than 30% of precautionary boil water advisories.

Infrastructure maintenance and upgrades, particularly in small drinking water systems, require capacity, time and investment to keep up to more stringent operational requirements. Trends underlying the operational reasons for drinking water advisories (Figure 6) are helping to illustrate these needs, but also emphasize the highly precautionary nature of the vast majority of drinking water advisories.

The Drinking Water Advisories application is currently available to all Canadian jurisdictions

Water Quality Reasons for Issuing Drinking Water Advisories

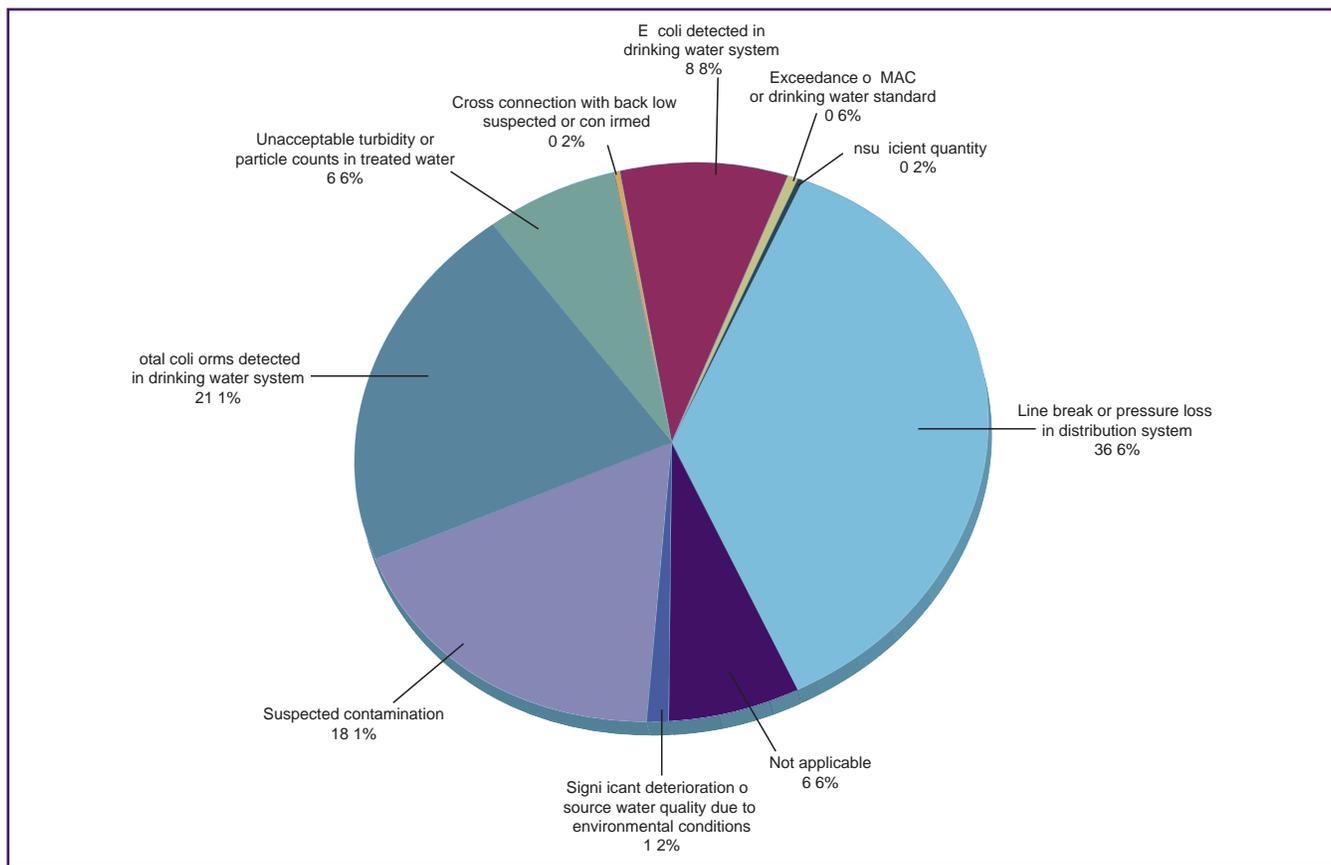


Figure 5: Example—Percentage of drinking water advisories posted by water quality reason.

to keep track of drinking water advisories, although it has not been fully populated yet. As it is used more widely across Canada, it will provide information on national trends and allow jurisdictions to better address the underlying reasons for drinking water advisories.

What is being done?

The Multi-Barrier Approach

One of the key lessons from incidents such as the Walkerton tragedy in 2000 was that testing and reacting to the quality of water that is already reaching consumers is not

enough to protect public health. Scientists and policy makers in many countries began emphasizing the need for broader measures that would actually prevent water from becoming contaminated in the first place.

It is now well documented that the key to ensuring clean, safe and reliable drinking water is to implement a multi-barrier approach. This approach starts with understanding the drinking water supply from the source all the way to the consumer's tap, including:

- The general characteristics of the water and the land surrounding the water source; and

Operational Reasons for Issuing Drinking Water Advisories

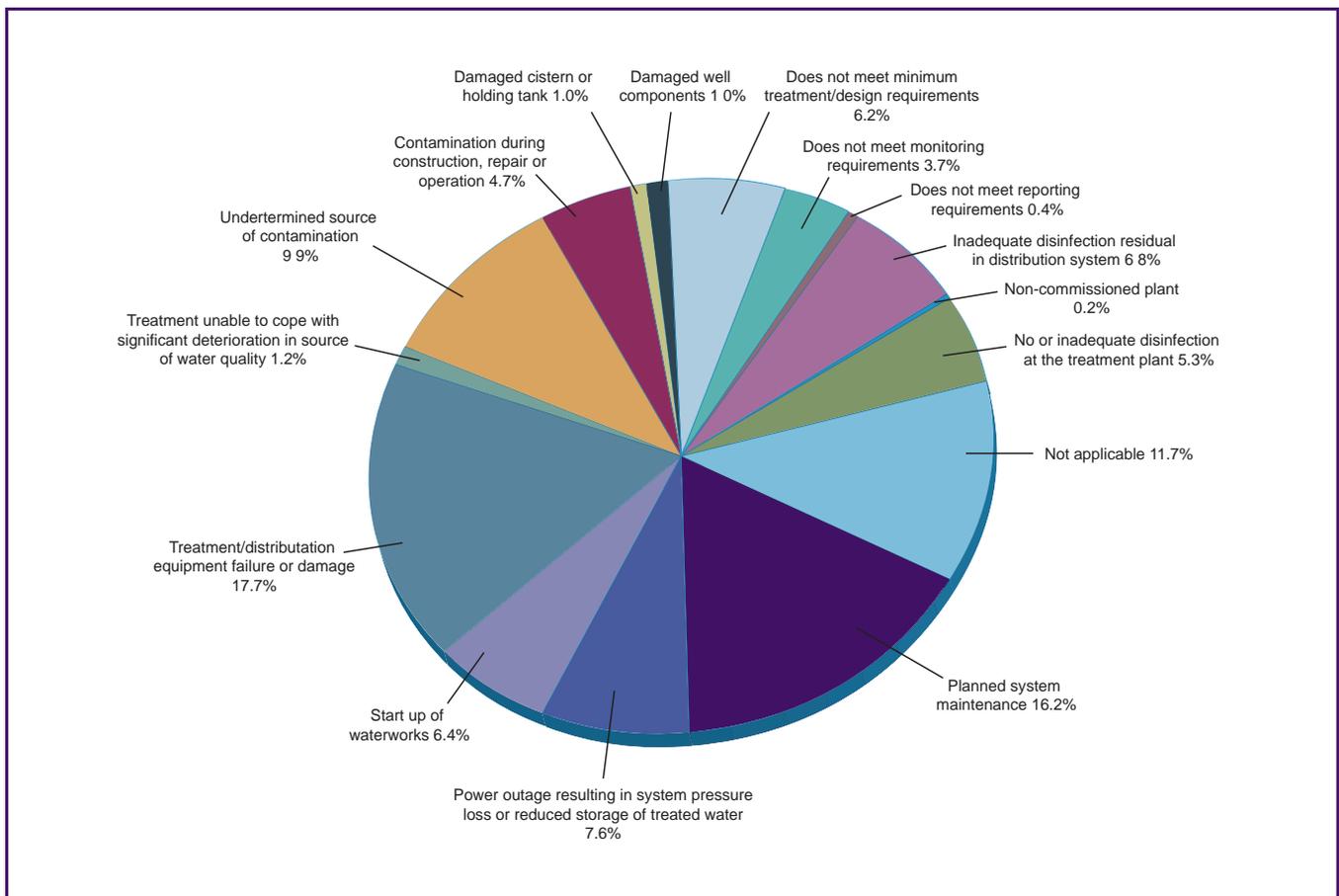


Figure 6: Example—Percentage of drinking water advisories posted by operational reason.

- The real and potential threats to the water quality.

Threats can be natural or created by human activity, including recreational activities in the watershed. Aging infrastructure or operational breakdowns in the treatment plant or distribution system can also threaten drinking water quality.

The multi-barrier approach takes all of these threats into account and puts “barriers” in place to either eliminate the threats or minimize their impact. Barriers include:

- Selecting the best available drinking water source (e.g., lake, river, and aquifer);
- Protecting source water from contamination;
- Using appropriate and effective water treatment; and

- Maintaining water quality in the distribution system.

The multi-barrier approach recognizes that each individual barrier may not completely remove or prevent contamination. Taken together, however, the barriers work to provide greater assurance that the water will be safe to drink over the long-term and, therefore, protect public health.

Initiatives undertaken by provinces and territories

As stated earlier, drinking water quality and source water protection are primarily a responsibility of the provinces and territories. Since the Walkerton tragedy in May 2000, all provinces and territories have taken action; this includes various initiatives to put the multi-barrier approach for safe drinking water into practice. A few examples are provided here.

The Multi-Barrier Approach

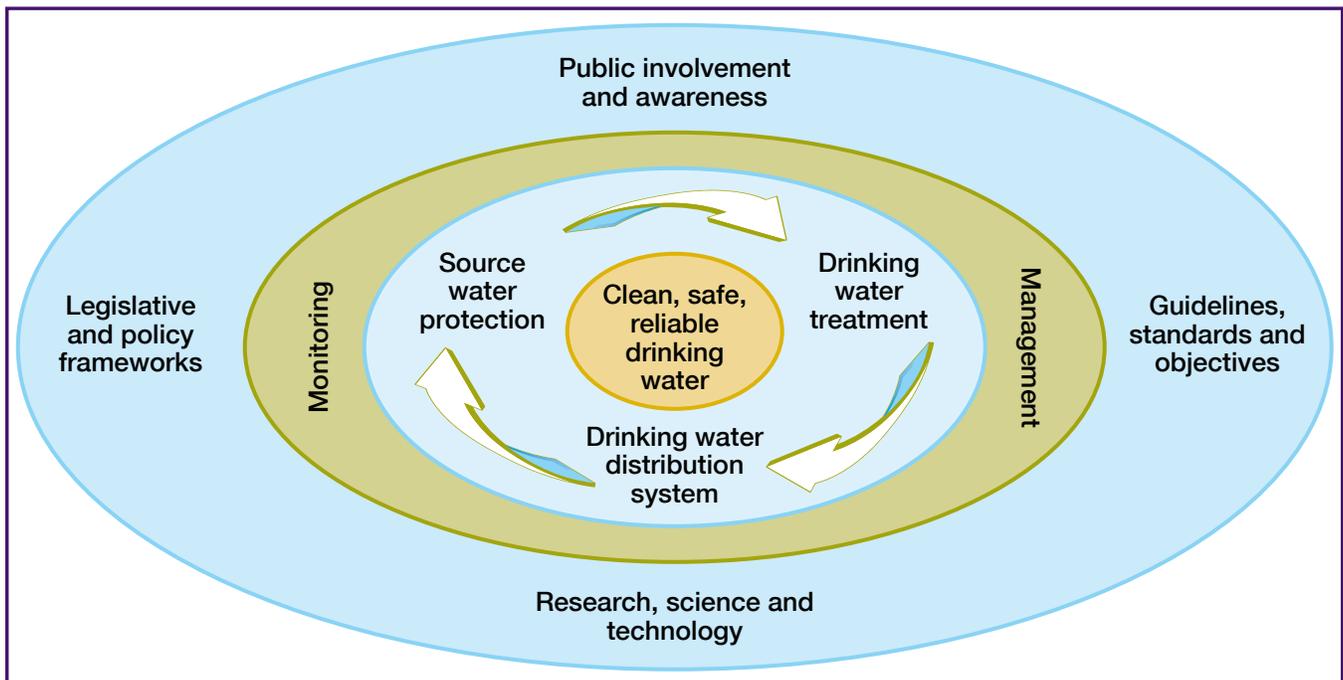


Figure 7: The multi-barrier approach to safe drinking water.

Walkerton's Legacy: Lessons Learned

Although Canada benefits from high quality water, it is important not to become complacent about the safety of our drinking water. The tragedy that occurred in Walkerton, Ontario, in 2000, when the drinking water supply became contaminated with the 0157:H7 strain of *E. coli* bacteria, and 2,300 people became severely ill and seven died, was a powerful reminder of the possible consequences of distributing drinking water that has not been adequately treated. Another contamination event occurred one year later, in North Battleford, Saskatchewan, this time with the protozoa *Cryptosporidium*, which resulted in renewed initiatives to ensure the safety of drinking water supplies across the country.

The Walkerton tragedy was the subject of an inquiry. The reports from the inquiry provided recommendations to the province of Ontario and resulted in changes across Canada to better protect our drinking water. This included adoption of a “source to tap” approach to safe drinking water, also called the multi-barrier approach.

More information can be found on the websites of each of the provinces and territories, provided at the end of this section.

Drinking water quality in First Nations communities

As stated earlier, Aboriginal Affairs and Northern Development Canada and Health Canada share responsibility for drinking water on First Nations lands with those communities. This includes putting the multi-barrier approach into practice to help First Nations communities address water management challenges associated with small water supplies, and ensuring drinking water quality monitoring programs are in place in First Nations communities south of 60 degrees parallel.

Health Canada partners with more than 600 First Nations communities to provide training and funding for drinking water monitoring through the Community-Based Water Monitor program. All interested First Nations communities now have access to portable laboratories, and all communities

have access to an Environmental Health Officer or a Community-Based Water Monitor to monitor the quality of their drinking water. In 2009/2010, 683 out of 720 community sites in all regions reported having access to Community-Based Water Monitors.

Water quality monitoring activities have historically mainly targeted water systems with more than five connections. To address drinking water quality in individual wells and wells with fewer than five connections on reserves, new public awareness materials about well inspection and maintenance have been developed and made available, supported by a program of bacteriological sampling and testing services for well water, provided on request, free of charge.

Health Canada, Aboriginal Affairs and Northern Development Canada and Environment Canada have collaborated to develop and implement a framework and guidelines for reviewing water and wastewater infrastructure project proposals in First Nations communities. These processes are meant to help review project proposals at the

Examples of Provincial/Territorial Initiatives

Quebec: *Drinking water regulations that incorporate a multi-barrier approach (2001)*

Major developments resulting from these regulations include the establishment of a committee charged with analyzing new treatment technologies to ensure consistent compliance with treatment efficiency requirements, and of a training program for treatment plant operator qualifications in the workplace. This program has since issued about 7,000 qualification certificates.

In order to help implement regulatory requirements, the Quebec government provides tools such as a guide for designing small drinking water treatment plant facilities.

Newfoundland and Labrador: *Strategic action plan for implementing a multi-barrier approach to drinking water safety (2001)*

The plan includes source water protection, infrastructure improvement, monitoring and reporting, and operator education, training and certification. As a result, the number of boil water advisories has declined over the last ten years. Community members are also more aware of drinking water safety.

The action plan focuses on small drinking water systems, emphasizing corrective measures, capacity building and infrastructure improvements. Hands-on training for operators through mobile training units has improved the operation and maintenance of many small systems across the province. The province will install a total of 24 potable water dispensing units or small-scale water treatment systems for communities of 500 or fewer people.

Ontario: *Safe Drinking Water Act and Drinking Water Safety Net*

As recommended by the Walkerton Inquiry report, the Ontario *Safe Drinking Water Act* was adopted in 2002. A Drinking Water Safety Net was created to protect drinking water, public health and to increase people's confidence in the quality of their drinking water. It consists of:

- A strong legislative and regulatory network;
- Timely, reliable testing;
- Immediate notification of, and action on, adverse water quality incidents;
- Strong licensing, operator certification and training requirements;
- Inspections;
- Integrated information management;
- Delivery of educational and outreach initiatives; and
- Public access to information.

Nova Scotia: *Drinking water strategy for Nova Scotia (2002)*

The strategy included 24 specific actions which have all been accomplished, including operator training, updating watershed protection plans and developing a compliance monitoring program.

Key accomplishments of the strategy include:

- Consistent approval processes for municipal water utilities, that require them to meet clear standards for water treatment and operator certification;
- The registration of approximately 1,800 small public drinking water supplies; and
- The publication of several educational documents help private well owners understand their roles in protecting and testing their water.

feasibility, pre-design and design stages to make sure adequate measures will be taken to prevent or mitigate any factors that could threaten public health in First Nations communities.

In 2011, 71% of First Nations individuals who participated in a survey said they perceived their drinking water on reserve to be safe, up from 62% in 2007. For additional information, visit www.hc-sc.gc.ca/fniah-spnia/promotion/public-publique/water-eau-eng.php.

What you can do

Municipally-treated and distributed drinking water should not need any more treatment in your home in order to be safe to drink. Most municipal water supplies are regularly tested for certain chemical substances, and many treatment plants are designed to reduce substances of concern to safe levels. You can contact your local drinking water provider for more information about the quality of your municipal water supply.

If you do not like the taste or smell of your water, you can purchase water filters or treatment units that work either at the point where the water enters your home (point-of-entry devices) or where you use it (point-of-use devices). When purchasing a product that will come into contact with your drinking water, it is extremely important to buy the right product for your water needs (e.g., to take away a chlorine taste), ensuring it has been certified for that purpose. The label will indicate whether the product is certified and how to properly maintain and use it.

If your water comes from a private well, you should have it tested regularly to ensure it is safe to drink. Commercial testing laboratories can analyze water samples. If the test results raise concerns, you may need to get professional

advice on how to treat your water or maybe even find another source.

Additional resources

Drinking water quality (www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/index-eng.php)

Health Canada's Tap Water Survey (www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/tap-water-eau_robinet-eng.php)

It's Your Health and Water Talk series (www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/guide/index-eng.php#watertalk)

Water Quality (www.ec.gc.ca/indicateurs-indicators/default.asp?lang=En&n=13307B2E-1)

Provincial and Territorial websites:

- Newfoundland and Labrador (www.env.gov.nl.ca/env/waterres)
- PEI (www.gov.pe.ca/environment/water)
- New Brunswick (www.gnb.ca/health)
- Nova Scotia (www.gov.ns.ca/nse/water)
- Quebec (www.mddep.gouv.qc.ca/eau/potable)
- Ontario (www.ene.gov.on.ca/environment/en/category/water/index.htm)
- Manitoba (www.gov.mb.ca/waterstewardship/drinking_water/index.html)
- Saskatchewan (www.saskh2o.ca)
- Alberta (www.environment.alberta.ca/01157.html)
- British Columbia (www.healthservices.gov.bc.ca)

- Northwest Territories (www.maca.gov.nt.ca/operations/water/homepage.asp)
- Nunavut (www.gov.nu.ca)
- Yukon (www.gov.yk.ca)

LIST OF ACRONYMS

AANDC	Aboriginal Affairs and Northern Development Canada	NCCEH	National Collaborating Centre on Environmental Health
ALARA	As low as reasonably achievable	NCP	Northern Contaminants Program
AQBAT	Air Quality Benefits Assessment Tool	NHANES	National Health and Nutrition Examination Survey (U.S.)
AQHI	Air Quality Health Index	NO ₂	Nitrogen dioxide
ASD	Active sub-slab depressurisation	NRC	National Research Council of Canada
BPA	Bisphenol A	PAHs	Polyaromatic hydrocarbons
Bq	Becquerel	PCBs	Polychlorinated biphenyls
CAEAL	Canadian Association for Environmental Analytical Laboratories	PCPA	<i>Pest Control Products Act</i>
CCME	Canadian Council of Ministers of the Environment	PFCs	Perfluorinated compounds
CCPSA	<i>Canada Consumer Product Safety Act</i>	PFOA	Perfluorooctanoic acid
CDW	The Federal-Provincial-Territorial Committee on Drinking Water	PFOS	Perfluorooctane sulfonate
CEAA	<i>Canadian Environmental Assessment Act</i>	PHAC	Public Health Agency of Canada
CEPA	<i>Canadian Environmental Protection Act</i>	PM	Particulate matter
CHMS	Canadian Health Measures Survey	PM _{2.5}	Fine particles
CMHC	Canada Mortgage and Housing Corporation	PM ₁₀	Inhalable particles
CNPHI	Canadian Network for Public Health Intelligence	PM _{10-2.5}	Coarse particles
CO	Carbon monoxide	PM UFPs	Ultrafine particles
CWS	Canada-wide Standards	POP	Persistent organic pollutants
DDT	Dichlorodiphenyltrichloroethane synthetic pesticide	ppb	Parts per billion
DPBs	Disinfection by-products	PPCPs	Pharmaceuticals and personal care products
FDA	<i>Food and Drugs Act</i>	ppm	Parts per million
FNFNES	First Nations Food, Nutrition, and Environment Study	SCC	Standards Council of Canada
FRM	Federal reference method (particle pollution data)	TDGA	<i>Transportation of Dangerous Goods Act</i>
HAAs	Halocetic acids	TEOM	Tapered Element Oscillating Microbalance instruments
HC	Health Canada	THMs	Trihalomethanes
HEPA	High-efficiency particle accumulation	VOCs	Volatile organic compounds
HPA	<i>Hazardous Products Act</i>	WHO	World Health Organization
HRV	Heat-recovery ventilator	µg	Microgram, unit of mass equal to one millionth of a gram of 1/1000 of a milligram (or mcg, or sometimes ug)
MAC	Maximum acceptable concentration		
MIREC	Maternal-Infant Research on Environmental Chemicals		

