Murky Waters

The Urgent Need for Health and Environmental Regulations of the Bottled Water Industry

A Polaris Institute Report

Table of Contents

Polaris Institute

Acknowledgements

Murky Waters: The Urgent Need for Health and Environmental Regulations of the Bottled Water Industry was prepared for the Polaris Institute. A collaborative effort, the report was researched and written by Catherine Trottier, Undergraduate Environmental Science Program (University of Ottawa), Paul Ferguson, Ph.D. Candidate at the Department of Earth Sciences (University of Ottawa), Verda Cook, Zoë Maggio and Joe Cressy of the Polaris Institute. *Inside the Bottle: Exposing the Bottled Water Industry* by Tony Clarke, Director of the Polaris Institute, served as an important background text.

Executive Summary

Public access to affordable, reliable, and safe drinking water distinguishes industrialized countries, such as Canada, the United States, Australia, and those of the European Union, from much of the rest of the world. Despite this, the bottled water industry has grown to a multi-million dollar industry in Canada, outpacing the consumption of tea, coffee, apple juice and milk. Yet bottled water is estimated to be between 240-10,000 times more expensive than tap water.

Among the numerous impacts of the bottled water industry, are those that relate to health and environmental concerns. Independent scientific studies have found toxic contaminants in bottled water products, including antimony leaching from PET plastic. The Canadian Food Inspection Agency (CFIA) has issued 29 separate recalls of 49 bottled water products since 2000. Environmental impacts encompass the production, transportation and disposal of bottled water: they include water depletion from aquifers due to extraction, massive amounts of energy and resources (including water) that go into the production of plastic bottles, energy and resources used in the transportation of bottled water products from factory to retail outlet, and finally atmospheric, soil and water pollution due to disposal of plastic bottles into landfills or incinerators.

The bottled water industry is largely unregulated in Canada, being monitored on a voluntary basis, overseen by the industry. Bottled water is not required to meet the *Guidelines for Canadian Drinking Water Quality*. Rather, it is considered a food product and is overseen by the CFIA, receiving inspections on average only once every three years. There is also a lack of information regarding the source of the water, the contents of bottled water, plus storage and product expiry date. Regarding environmental issues, bottled water companies extract millions of litres of water per day and pay virtually nothing for the water taken. Non-recycled plastic is used in production, and there is a lack of adequate recycling and recovery policies for plastic bottles.

There is an urgent need for comprehensive health and environmental regulations of the bottle water industry in order to take back democratic control of bottled water in the public interest of all Canadians. Re-building and maintaining public tap water systems and infrastructure across the country must become a major public priority.

1. Introduction

Public access to affordable, reliable, and safe drinking water distinguishes industrialized countries, such as Canada, the United States, Australia, and those of the European Union, from much of the rest of the world [Levin et al., 2002]. Large public investments are made in ensuring the safety of municipal water sources. Annual expenditures for public drinking water in the United States and Canada, for example, are approximately $36 billion (USD) [Levin et al., 2002] and over $4 billion (CD), respectively [Stats Can, 2006], yet tap water in most Canadian cities still costs only a few thousands of a cent per litre. This means that in most Canadian cities, wherein drinking water quality is strictly regulated, one could re-fill their glass over fifty times with tap water for less than $0.01.

Despite this fact, more and more Canadians are turning to bottled water, which is hundreds to thousands of times more expensive than water from the tap [Clarke, 2007]. Twenty years ago in Canada, bottled water was largely unheard of. Today approximately 20% of our population relies exclusively on bottled waters for their daily hydration. Bottled water use outpaces the consumption of coffee, tea, apple juice and milk. The bottled water industry is dominated by four large multinational corporations and its main raw material, water, is drawn from two sources. In the case of Nestlé and Danone, (European packaged food conglomerates), water is taken from "ground sources, springs, rivers, streams and glaciers in rural or outlying communities" [Clarke, 2007]. American soft drink companies PepsiCo and Coca-Cola use "purified or processed water, which is taken directly from municipal tap water systems" [Clarke, 2007].

Why are Canadians willing to pay such high prices for drinking water in plastic bottles? Bottled waters are generally marketed as purer and of higher quality than local sources of drinking water. In some instances, specific types of packaged waters claim to have medicinal properties or at least contain beneficial amounts of certain substances, such as minerals or micro-nutrients. People often associate bottled waters with a health-conscious lifestyle and are generally willing to pay more for the supposed health benefits.

According to Adamowicz et al. [2004], who summarized an Ipsos Reid poll, 71% of Canadians who drink bottled water do so for the sake of convenience, whereas the rest claim to prefer the taste (15%) or have health concerns regarding their tap water (14%). Despite the popular association of many bottled water brands with an unusual level of purity, 25 – 40% of bottled waters in the United States are derived from tap water that are subsequently sold to consumers at a much higher price [Suffet, 2001; Rosenberg, 2003]. The most popular brands of bottled water in Canada, Dasani and Aquafina, are essentially municipal tap water.

The average Canadian household spends about $15 (range, $1 to $60) per month on bottled waters or about $180 annually. Compared to the average cost of water services in Canada, which is between $250 and $400 per year, the consumption of bottled waters as a substitute for municipally-supplied drinking water represents a considerable, yet often unrecognized, expense for Canadian families [Dupont, 2005].

Given the widespread and growing consumption of bottled water by Canadians, two questions arise regarding the regulation of bottled water in Canada. First, is the quality of bottled water adequately regulated? Second, when factors such as the massive energy use and the depletion of finite water resources are considered, how can we manage the environmental impacts of the bottled water?

The bottled water industry is not adequately regulated in Canada. This includes a lack of regulation in terms of labelling, testing and quality standards, and water conservation requirements. At the same time, the bottled water industry is swimming in profits, which could be re-allocated to fund the re-building and maintaining of public tap water systems, thereby ensuring safe, clean and affordable water for all.

2. Bottled Water Quality in Canada

Bottled waters are not impervious to contamination issues. Around the world, this is evident from the large-scale recall of bottled waters in the United Kingdom in 2004 due to bromate contamination [Coca Cola, 2004; Clarke, 2005] and as far back as the 1970s when an outbreak of cholera in Portugal that was attributed to transmission of *Vibrio cholerae* via bottled waters [Blake et al., 1974]. A 1994 outbreak of cholera in Saipan (U.S. territory in the Marianas Islands) was also, according to the U.S. Centers for Disease Control and Prevention (CDC), associated with contaminated bottled waters [Kramer et al., 1996]. In November of 2007, consumers in Micronesia were advised not to purchase or drink bottled water manufactured by Crystal Waters due to bacteria contamination. The company has been shut down by Micronesia's Department of Public Health's Bureau of Environmental Health due to health concerns, until it complies with the Bureau's requirements, [Saipan Tribune, Nov 16th, 2007].

In New York City, news reports cited the case of a school cafeteria worker who decided to launch a multimillion dollar lawsuit against Nestlé, claiming that the bottle of the company's Pure Life brand that she drank from was contaminated with ammonia, causing her severe illness, (New York Daily News, Nov. 14th, 2007). Upon receiving a complaint from a man who said a bottle of water made him sick, the Health Department in Okmulgee County, Oklahoma, conducted an investigation of a Coca-Cola bottling plant located there, due to possible mold contamination. The half-litre bottles of the Dasani brand were not bottled properly – they were not air-tight. The Department found that thousands of the Dasani bottled waters "came off the production line that day with the wrong amount of a chemical called ozone [which is] used to keep the water clean," (Fox23.com, Dec. 6th, 2007).

In Canada, there have been 29 separate recalls of 49 bottled water products since January 2000 due to bacterial or chemical contaminants including *Pseudomonas aeruginosa*, *Bacillus cereus*, and Arsenic [CFIA]. The complete details of the Canadian recalls were listed in information obtained by the Polaris Institute under the *Access to Information Act*.

A study by the Warburton team of microbiologists conducted between 1986 and 1992 found that "on average, 40% of bottled water on the Canadian market between 1981 and 1989 had aerobic colony counts (ACC) that exceeded the standards at the time." A later study on the microbiological quality of bottled water sold in Canada between 1992 and 1997, found that the reduction of ACC had only marginally improved, [Clarke, 2007]. Another study by Eva Pip from the University of Winnipeg, found that, after testing 40 Canadian and International brands of bottled water, "seven brands had levels of total dissolved solids (TDS) that exceeded *Canadian Water Quality Guidelines* (CWQG), one brand exceeded CWQG for chloride, and three brands exceeded national standards for lead," [Clarke, 2007].

2.1 Government Regulation Regarding Bottled Water Quality

Most people assume that if they purchase a bottle of water from their local supermarket or convenience store, the quality of the water inside the bottle is assured through some form of government regulation. Despite the fact that most bottled water manufacturers filter and/or purify waters before bottling [IBWA, 2007], in Canada, these processes are voluntarily-administered by the manufacturers for health and aesthetic reasons. In reality, bottled water regulations in Canada are very lax.

In contrast, tap water is overseen by the *Guidelines for Canadian Drinking Water Quality* (GCDWQ), which set Maximum Allowable Concentrations for a series of "microbiological, chemical and radiological substances found in water that are known to be, or thought to be, harmful to human health" [Health Canada, 2002]. The *Guidelines* also outline characteristics of drinking water on the basis of aesthetic qualities such as taste, odour and appearance. The *Guidelines* are produced by the federal government and established by a federal/provincial/territorial committee. The information is updated by a team of scientists and water specialists. According to Health Canada, tap water safety and quality "is a provincial/territorial or municipal responsibility," however the Canadian Food Inspection Agency is responsible for enforcing the *Guidelines* within federal jurisdiction – these include Crown lands, military bases and Aboriginal reserves [Health Canada, 2002]. Additionally, the *Guidelines* are made available to provincial and territorial governments from which the latter can base their drinking water policies. Health Canada states that most provincial and territorial

governments have adopted the *Guidelines* as a basis for their own water testing [Health Canada, 2002].

This means that in provincial and territorial jurisdictions where the *Guidelines* have been adopted as policy or where governments have exceeded them, municipal public tap water quality is strictly tested and monitored regularly at several stages.

Guidelines for the chemical content of bottled waters are much less stringent than they are for tap water. Bottled waters are not governed by the *GCDWQ*. In Canada, bottled waters are considered food products and fall within the purview of the Canadian Food and Drugs Act (FDA). Yet the Act does not specify the maximum allowable concentration of chemicals nor does it require manufacturers to list the chemical contents on the label [see *Consumer Packaging and Labeling Act*]. Instead, there are regulatory tolerances for lead (0.2 mg L^{-1}) and arsenic (0.1 mg L^{-1}), while other chemicals are regulated under a general safety clause stating `no person shall sell any food . . . which has in or on it any poisonous or harmful substance' [Dabeka et al., 2002]. This gives the federal government authority to ensure the safety and quality of food, covering bottled water under Division 12 of the Act, "Prepackaged Water and Ice" and Division 15, which covers the limits for arsenic and lead in bottled water.

Currently, Health Canada and the Canadian Food Inspection Agency (CFIA) share joint responsibility for the regulations concerning bottled water. Health Canada establishes health and safety standards for bottled water and develops labeling policies, whereas the CFIA develops standards related to packaging, labeling and advertising and performs inspection and enforcement duties. While the federal government sets out minimum standards for bottled water, provinces and territories are free to establish stricter standards. However, there are currently very few regulations imposed on bottled water. The FDA prohibits the manufacture or sale of any article of food containing poisonous or harmful substances, or food that has been prepared, preserved, packaged or stored in unsanitary conditions. The importation and transportation across provinces of any food product that does not meet these standards is prohibited. Section 5(1) of Part 1 of the FDA also prohibits against false or misleading labeling and advertising, yet most of the regulations in Division 12 date back to 1973 with some changes made in the 1980s.

In 2002, the federal government called for input on a discussion paper called *Making It Clear: Renewing the Federal Regulations on Bottled Water* [Canadian Food Inspection Agency and Health Canada, 2002], wherein the need to update regulations concerning bottled water was acknowledged. The stated goals of this paper are summarized below:

1. *Incorporate new scientific knowledge.* Most of the Regulations in Division 12 of the FDA date back to 1973 with some minor changes made in the 1980s. The Government wants to update the Regulations to take into account the latest scientific information, including the adoption of new sampling and testing methodologies, and the addition of standards for *Pseudomonas aeruginosa* (a microbial pathogen) and bromate (a by-product of ozonation).

2. *Harmonize regulations with the U.S., Québec, and international standards.* The Government wants to harmonize Canadian standards for bottled water with those used by Québec and the U.S. and seeks to reconcile them with international standards recently established by the Codex Alimentarius Commission[1] and the World Health Organization Guidelines for Drinking Water. It should be acknowledged, however, that these internationally set standards have their own limitations.

3. *Bring regulations for bottled water in line Guidelines for Canadian Drinking Water Quality.* Apart from setting limits on arsenic and lead, the current regulations do not contain specific, detailed parameters for chemical and radiological contaminants in bottled water and packaged ice. Nothing in the regulations obliges manufacturers to observe the *Guidelines* during the production of bottled water and packaged ice and therefore, the CWQG should be specifically referenced in the regulations, making these guidelines law for bottled water.

4. *To make the Regulations clearer and more precise.* Pertaining to bottled water, the Government seeks to clarify rules and policies that are established under both the Food and Drugs Act and the Consumer Packaging and Labelling Act and administered by the Canadian Food Inspection Agency.

5. *Improve consumer protection and reduce confusion.* The Government is considering stricter limits on some microbiological and chemical contaminants and other proposed changes that will give consumers more useful information on which to base buying decisions, such as limiting the variety of common names that can be used to describe bottled water products.

6. *Accommodate new products.* Many new products have appeared in recent years, some of which were not anticipated when Regulations were written, so the Government intends to introduce a new classification scheme that would recognize these new products and allow them to be regulated for the benefit of consumers.

The process of Regulation renewal outlined in the *Making It Clear* discussion paper became stalled in 2003, and as of 2009, no new or modified federal regulations on bottled waters have occurred. In the following sections, we review the literature pertaining to bottled water quality, provide a brief summary of current regulations on bottled water quality, and assess how these regulations compare to drinking water guidelines in Canada.

However, it should be noted that despite the relative strength of the *Guidelines*, the role of the federal government in their development and implementation remain problematic in several critical ways. There are three important related areas that need to be considered: issues pertaining to jurisdiction; questions of enforcement; and matters concerning First Nations access to safe drinking water. These areas have been clearly outlined by David R. Boyd in the report entitled *The Water We Drink: An International Comparison of Drinking Water Standards and Guidelines*, prepared for the David Suzuki Foundation.

Although the federal government plays an essential role in the creation of the *Guidelines*, most of the responsibility for water management lies with the provinces. Further, the *Guidelines for Canadian Drinking Water Quality* were originally termed as standards, but were purposely redefined as guidelines in the 1970's to make this distinction clear. In terms of enforcement, Boyd notes that from a legal perspective, standards are "legally binding and enforceable". *Guidelines*, on the other hand, are voluntary benchmarks that can be pursued. Essentially, the *Guidelines* are legally binding in some provinces and municipalities because they have been incorporated into the laws and regulations, or water treatment facility operating permits. As Boyd states, "these approaches mitigate some of the concern about the relative weakness of relying on national guidelines and provide additional flexibility and efficiency. However, these approaches raise concerns about consistency, transparency, and enforcement" [Boyd, 2006]. In addition to Maximum Allowable Concentrations (MACs), provincial legislation and "operator permits also prescribe legally binding requirements for operator certification and training, public reporting, and other aspects of drinking water management" [Boyd, 2006].

Among the report's recommendations is the replacement of the *Guidelines* with "a set of health-based long-term objectives for drinking water quality, and legally binding national standards for drinking water quality that are equal to or better than the highest standards provided in any other industrialized nation" [Boyd, 2006].

In addition to the issues of jurisdiction and enforcement, is the federal government's catastrophic failure to ensure safe and clean water for indigenous peoples in Canada. This failure has been documented and raised in numerous reports and studies including the 2005 Commissioner of Environment Sustainable Development (CESD) report entitled *Drinking Water in First Nations Communities*, *The Water We Drink* and Polaris Institute's report, *Boiling Point! Six Community Profiles of the Water Crisis facing First Nations within Canada*. The federal government is violating its fiduciary responsibility to ensure the health and safety of First Nations, which is carried out through agencies including Indian and Northern Affairs Canada (INAC) and Health Canada. Part of this failure has to do with the lack of a regulatory regime that would make the provision of safe and clean drinking water to indigenous peoples legally binding. Many First Nations communities have to rely on expensive bottled water on a long term basis as their only source of potable water [Harden and Levalliant, 2008].

2.2 Microbiological Contaminants

Even in carefully controlled waters, an indigenous population of micro-organisms exists at the source and once bottled, bacteria within these waters can multiply rapidly and reach high numbers over a relatively short period of time [Tamagnini and Gonzalez, 1997; Loy et al., 2005]. More quantitatively, the number of viable bacteria counts within bottled waters often increases rapidly after bottling and can attain 10^4 - 10^5 colony-forming units (CFU) per mL within 3 – 7 days [Buttiaux and Boudier, 1960; *Loy et al.*, 2005]. During the following weeks, the bacterial counts may decrease slowly or remain fairly constant [Bischofberger et al., 1990], yet according to a study of bacteria in bottled mineral waters [Legnani et al., 1999], the highest bacterial counts often occur from 7 – 70 days after initial packaging (i.e. the period in which bottled water is most likely to be purchased).

Bacteria that are capable of growing in water supply networks include *Legionella* spp., *Aeromonas* spp., *Mycobacterium* spp., and *Pseudomonas aeruginosa* [*Leclerc and Moreau,* 2002]. Bacteria species belonging to the genus *Pseudomonas*, such as *Pseudomonas aeruginosa,* are of particular concern as they have the ability to thrive in waters that contain very low levels of nutrients [Morita et al., 1997]. These bacteria have even been observed in the ultra-pure, distilled waters that are used to dilute drugs administered by intravenous injection in hospitals [Favero et al., 1971]. As bacteria such as *P. aeruginosa* are opportunistic, they are often responsible for serious episodes of infection, particularly amongst vulnerable portions of the population, such as infants, the elderly, and immuno-suppressed individuals [Warburton et al., 1994; Legnani et al., 1999].

According to a study of commercially-available bottled waters in Canada from 1992 – 1997, 23.3% and 5.5% of the 3460 water samples exceeded 10^2 CFU mL^{-1} and 10^4 CFU mL^{-1}, respectively [Warburton et al., 1998]. Of these samples, 1.2% were contaminated with *P. aeruginosa,* 0.6% were contaminated with *A. hydrophiliai,* and 3.7% were non-compliant with coliforms and 2.1% were non-compliant for fecal coliforms. According to the authors, this indicates the need for an improved surveillance system for the bottled water industry, as *P. aeruginosa*, *A. hydrophiliai*, and coliforms are indicative of poor water quality. According to Warburton and Austin [1997], the process of ozonation, which is commonly used by North American bottled water manufacturers, should destroy any bacteria or biofilms that are present in new or recycled bottles. However, there is no guarantee regarding bottles that are opened and subsequently stored in particularly warm environments, such as vehicles.

In a study published in the Archives of Family Medicine [Lalumandier and Ayers, 2000], researchers at Case Western Reserve University and Ohio State University compared 57 samples of bottled water to the city of Cleveland's tap water. Results indicated that 15, or about one-quarter of the bottles had significantly higher levels of bacteria. The scientists involved in this study concluded that although all of the water they tested was safe to drink, "the use of bottled water on the assumption of purity can be misguided." This conclusion is also supported by a similar study of bottled water quality conducted by the American Society of Microbiology [Klont, 2004], wherein about 40% of all samples analyzed showed evidence of contamination by either bacteria (37%) or fungi (4%). According to the author, "these

findings indicate that the general perception that bottled water is safe and clean is not true" [Klont, 2004].

In Canada, current FDA regulations state that bottled mineral waters and spring waters cannot contain any coliform bacteria, such as *Escherichia coli (E. coli)*, and all other waters in sealed containers cannot contain coliform bacteria in excess of 100 total aerobic bacteria per mL. Furthermore, although it is not explicitly stated in the regulations, according to Health Canada documents, bottled water products in Canada cannot contain any *P. aeruginosa*. Despite this, most recalls of bottled water products since 2000 have been due to *Pseudomonas aeruginosa* contamination, (see 2.6 Monitoring and Recalls).

2.3 Chemical and Radiological Contaminants

In a comprehensive study of more than 1000 bottles of 103 different brands of water conducted by a U.S. environmental group, most bottled waters tested were of high quality, yet approximately one-third of the bottled waters tested were found to contain elevated levels of bacterial contaminants, synthetic organic chemicals, and/or inorganic contaminants, such as arsenic and mercury [NRDC, 1999]. An earlier NRDC-commissioned study tested for hundreds of different chemicals in 38 brands of bottled waters available in California and found that two samples were contaminated with arsenic, six had chemical by-products of chlorination, and six had measurable levels of toluene, a chemical used in paint thinners and other solvents that yields carcinogenic metabolites [NRDC, 1999].

In Canada, Eva Pip at the University of Winnipeg [2000] conducted an independent survey of domestic and imported brands of bottled water available in Manitoba (Canada) during which a variety of water quality indicators were examined, including total dissolved solids (TDS), chloride, sulfate, nitrate, cadmium, lead, copper, and radioactivity. Analyses by Pip [2000] indicated that the chemistry of bottled water was highly-variable amongst the different brands and that some samples of bottled water exceeded the CWQG for TDS, chloride, and lead in drinking water. Concerns regarding TDS and chloride are mainly aesthetic, as they can affect the appearance and taste of water. The concentrations of the other chemical indices in bottled water, such as calcium, magnesium, sulfate, and nitrate, are

generally within drinking water guidelines and health concerns regarding these parameters are unlikely. Trace elements, such as lead, arsenic, cadmium, and antimony could be of more concern as lead, for example, is a neurotoxin that is responsible for the most common type of human metal toxicosis and even at low-levels of exposure may affect the mental development of children [Yule and Rutter, 1985; Needleman, 1993].

In addition to potential contamination during the process of packaging and filtration, synthetic organic compounds [Page et al., 1993; Fayad et al., 1997; Mutsuga et al., 2006] and trace metals [Shotyk et al., 2005; Shotyk et al., 2006] may be leached into bottled water from plastic packaging, polystyrene cap liners, and polyethylene terephthalate (PET) bottles. The leaching of chemicals from plastics to the bottled waters themselves during storage can lead to the deterioration of bottled water quality [Pip, 2000]. In particular, the storage of bottled waters at room temperature over extended periods of time is thought to be a factor in the degree of leaching that occurs, although the potential health consequences of this aspect of bottled water quality remained poorly understood.

There is, however, ample evidence that chemicals do leach from plastics and that these chemicals are found in commercially-available bottled waters, albeit at very low concentrations [Al-Saleh and Al-Doush, 1998; Dabeka et al., 2002]. For example, using clean lab methods and protocols developed for measuring antimony, a potentially toxic trace metal with no known physiologic function, Shotyk et al. [2006] report abundances of antimony in fifteen brands of bottled water from Canada and forty-eight from Europe. In contrast to samples of groundwater collected from southern Ontario (Canada), which contained 2.2 ± 1.2 ppb of antimony, twelve of the brands sold in Canada contained 112 – 375 ppb of antimony, with a mean concentration of 156 ± 86 ppb [Shotyk et al., 2006].

In a similar study of bottled waters in Canada, Dabeka et al. [2002] reported that mineral waters averaged 320 ppb of Sb (Antimony) and spring-waters averaged 300 ppb Sb, both of which are more than 100 times higher the natural abundance in groundwater of southern Ontario. Shotyk et al. [2006] assert that leaching from plastic bottles made of polyethylene terephthalate (PET) is the principal source of antimony, as geological and mineralogical

diversity in the source water region cannot account for these elevated concentrations of Sb in bottled waters.

PET is particularly relevant to the bottled water industry as 150 billion bottles are produced each year using PET and 90% of PET manufacturing worldwide employs antimony trioxide (Sb_2O_3) as a catalyst. Sb_2O_3 is a suspected carcinogen and listed as a priority pollutant by the U.S. Environmental Protection Agency, the European Union, and the German Research Foundation. With respect to leaching from plastic bottles, other chemicals of concern include phthalates, [Page et al., 1993; Fayad et al., 1997] and bisphenol-A [vom Saal and Hughes, 2003], both of which are thought to behave as hormone disruptors in the human body. Bisphenol A (BPA) is also found in hard, clear polycarbonate plastic containers, often identified with the code number 7, and in the liner of some metal food cans. It is also used in the production of home and office delivery jugs, commonly referred to as water coolers. In November of 2007, Health Canada launched an evaluation of BPA, focusing on the effects the chemical in infants up to 18 months of age, and in April 2008, the agency announced that it would ban polycarbonate baby bottles containing BPA. Many major retailers including Mountain Equipment Co-op decided to stop selling polycarbonate containers [CBC News, 2008].

Current Regulations do not set any chemical or radiological standards for bottled water. Regulations for water represented by its origin (i.e. spring water) require it to be potable at the source, implying that it must meet the standards for man-made chemical contaminants laid out in the *CWQG*. Naturally-occurring chemical and radiological substances are not however limited by the Regulations. Division 15 of the Regulations does limit levels of arsenic and lead, two particularly toxic trace elements.

2.4 Labeling Issues Related to Contents

Results from Pip [2000], who studied the chemistry of bottled water available in Canada, and a similar study conducted in Japan by Suzuki et al. [2000] identify the lack of consistent, international guidelines for the chemical contents of bottled water compared to drinking water guidelines established by municipal or federal authorities in different countries.

According to Pip [2000], a number of deficiencies concerning product labeling were observed and consequently, she recommended more stringent standardization of the bottled water market, particularly in regard to quality control, labeling, and water quality monitoring at the source and the potential effects of packaging and storage conditions on the chemical content of water consumed by individuals.

Currently, as required with other packaged food products, labels for all types of bottled water must include basic labelling information such as "common name, list of ingredients if it consists of more than one ingredient, net quantity, name and address of the company responsible," and the fluoride ion content [CFIA 2002]. However, FDA Regulations only require that bottlers of spring and mineral water declare the actual quantity of total dissolved mineral salts in the water in parts per million (ppm). Unlike in the United States, other types of bottled waters, such as those derived from municipal sources, are exempt from this requirement and there are no standards regarding the chemical content of these waters.

Spring and mineral water products are, in addition, obligated to print a "statement relating the geographic location of the underground source of the water" and a "statement indicating whether ozone or fluoride had been added." Bottled water products other than spring and mineral water are required to indicate the "description of any treatment the water has undergone" [CFIA 2002].

2.5 Labeling Issues Required for Production and Product Expiry

One of the most highly-criticized aspects of the bottled water industry is the ambiguity regarding the source of bottled waters, as current regulations do not require that manufactures drawing water from a public or municipal distribution system reveal this fact on their product labels. In the United States, for example, popular brands of bottled water are often advertised as being derived from remote, pristine locales, yet these advertisements are misleading, even deceptive. For example, a brand known as Alaska Premium Glacier was marketed as "Pure Glacier Water from the Last Unpolluted Frontier" whereas in reality, the water used for this brand was derived from the municipal water system of Juneau, Alaska, or more specifically, pipe #111241 [Clarke, 2005]. Similarly, Nestlé's Poland Springs was advertised as being drawn from a pristine, protected source "deep in the woods of Maine", despite being derived

mainly from boreholes near Nestlé bottled centers scattered across the U.S. [Clarke, 2005]. In July 2007 in the U.S., PepsiCo was forced to admit after increasing pressure, that its bottled water product Aquafina is derived from public tap water sources, and this fact would be stated directly on the product's label, [CBC News, 2007].

For these reasons, consumers are often unaware that the water that they are purchasing is taken from a municipal source. Misleading marketing ploys have also lead to several class-action law-suits against bottled water manufacturers in the U.S. Canadians may be unaware that popular brands such as Coca-Cola's Dasani, and PepsiCo's Aquafina are derived from municipal sources. These two brands consist of tap water that is treated via reverse osmosis before being sold. Dasani bottled water, for instance, is derived from the Brampton municipal tap system, which comes from Lake Ontario.

In relation to product expiry dates, according to the CFIA *Guide to Food Labelling and Advertising*, with a few exceptions, "a durable life date ("best-before" date) is required on prepackaged foods with a durable life of 90 days or less." Although bottled water products may print a manufacturing date and/or expiry date on labels, bottled water companies are not required to do so, nor is there any information that must appear on the label as to how bottled water should be stored (for example a 'refrigerate after opening' statement). Information on bottled water product expiry, as well as storage conditions, is indeed unclear: Health Canada indicates that bottled water can be stored in cases of emergency: "The water should be disinfected in well-sealed containers, kept in cool, dark storage areas and changed every year," [Health Canada, 2007]. Despite this recommendation the department also notes that bottled water manufacturers claim that their products have a "two-year shelf-life," [Health Canada, 2007]. Consequently, consumers do not have clear information on how long bottled water is safe to keep and under what conditions.

2.6 Monitoring and Recalls

The bottled water industry conducts its own monitoring of microbiologicals, but the results of these tests are considered confidential and not made public. The monitoring and testing of bottled water quality is essentially voluntary and internally regulated by the bottled water industry. Information including the analytical results of these tests are not available to

the public and are considered confidential. Moreover, bottled water plants receive infrequent government inspections. In 2002 and 2003, 125 bottling plants were inspected per year which represents two-thirds of bottling plants across Canada. This implies that bottled water plants are only inspected approximately once every three years. However, with cutbacks in the Canadian Food Inspection Agency, inspections may have even been reduced even further [Clarke, 2007].

CFIA receives information on contaminations from several possible sources: consumer complaints, outbreaks, internal monitoring and inspection, or foreign country information. Once the Agency has received notice of a problem, it may perform its own testing on the product, followed by a risk assessment carried out by Health Canada, and then, if necessary a recall within 24 hours of risk assessment. [Kevin Marcynuk, Inspections Officers, 2007].

Inquires with CFIA uncovered that in Canada 29 separate recalls of 49 bottled water products occurred between January 1, 2000 and March 1, 2008. The complete details of the 29 recalls were listed in documents obtained by Polaris Institute under the *Access to Information Act*. These bottled water products were recalled for several different areas of concern which included microbiological contaminants such as *Pseudomonas aeruginosa* and *Bacillus cereus* pathogens, molds and coliform bacteria, chemical contaminants such as arsenic, and 'extraneous material,' including glass.

According to CFIA documents, 17 products, including Perrier's Montclair brand 'Mineral Spring Water' product (recalled March 8th 2002), were recalled due to *Pseudomonas aeruginosa*, an infection of which can cause gastrointestinal illness or more serious health implications. In October 2000, CFIA recalled Mount Pelion brand, and in April 2001, 8 spring water products produced and distributed at Canadian Water Superstore in Langley, British Columbia. All were recalled due to *Pseudomonas aeruginosa* contamination. After a recall of Metromint Flavor Water issued in the United States by the Food and Drug Administration, the CFIA advised consumers on December 6th 2007 not to drink the product due to *Bacillus cereus* contamination. *Bacillus cereus* food poisoning symptoms "can include vomiting or diarrhea, abdominal cramps and pain and may occur between 30 minutes and 15 hours after consuming the contaminated product. Infants, children and pregnant women are susceptible to dehydration resulting from diarrhea". Cott Beverages' 'Canadian Glacial Water' and 'Natural

Spring Water' products were the subject of a recall on December 23rd 2004 because of concerns over quality due to molds. In March of 2007 two recalls were issued for bottled water brands due to excessive levels of Arsenic, which is "a toxic substance and is a known cause of cancer in humans": Jermuk Classic on March 9th and for Ark Land bottled water on March 14th. Both brands originated in Armenia [CFIA].

Internationally there have also been a series of deeply concerning incidents of bottled water recalls. In March 2004, Coca-Cola voluntarily recalled 500,000 of its Dasani bottled water products when it discovered bromate levels that were twice the allowable limits set by the Food Standards Agency (FSA). Britain's FSA released a statement on Coke's decision a day later [Food Standards Agency, 2004]. In 2006, a New York lawyer named Ross Getman commissioned an independent test of bottled waters in the U.S. and discovered bromate levels at 27 and 28 ppb, more than 2.5 higher than the U.S.'s Food and Drug Agency's limit of 10 ppb. When US retailers of contaminated products were notified, only Wegmans, a supermarket chain, issued a recall on August 14, 2006. It took the FDA another 10 days to issue a recall notice to the public.

What is clear from these examples is that government agencies inspecting bottled water are often not the trigger in bottled water contamination alerts. Instead, these agencies are often slower than consumers, retailers and producers in detecting contamination and concerns regarding quality.

In contrast to bottled water inspections, the City of Ottawa's municipal drinking water has 35 continuous analyzers for pH, turbidity, C12, F-. City of Ottawa employees also perform over 125,000 tests per year, [City of Ottawa]. The City of Toronto tests treated drinking water every four to six hours to detect bacteria. Over 50,000 bacteriological tests are conducted per year at filtration plants, and around 20,000 bacteriological tests are taken from of samples taken from the distribution system. Water is tested for over 300 chemical substances. These test results are also publicly available [City of Toronto].

3. The Environmental Impacts of Bottled Water Consumption in Canada

There are two principal concerns regarding the packaging of bottled waters, and these are addressed in the following sections. The first concern is the environmental sustainability of large-scale removal of water from local aquifers for purposes of bottling. The second concerns the type of pollution, environmental degradation and energy costs associated with the manufacturing, transport, and disposal of plastic bottles.

3.1 Depletion of Finite Water Resources

Over the last decade, international sales of bottled water have increased dramatically. The bottled water industry is now a $100 billion dollar industry, packaging 40 billion litres of water per year for consumption worldwide [Clarke, 2007]. In Canada alone, approximately 1.9 billion litres of water are packaged and Canadians spent $652.7 million on bottled water in 2005, according to numbers from the Beverage Marketing Corporation [CBC News, 2008], which begs the question, where does this water come from and what is the environmental impact of large-scale water removal on water resources in Canada?

In general, Canada is often regarded to have abundance of water resources and to a degree, this is true. According to the World Resources Institute, Canada is ranked third in the world in terms of renewable water supply with 6.5 percent (behind Brazil, at 12.4 percent and Russia at 10 percent). Actually, Canada is in a tie with three other countries – Indonesia, China and the US – each with 6.4 percent of renewable water supplies. However, Canada's 6.5 percent of renewable water is also misleading. Approximately 60 percent of this country's rivers flow northward into the Arctic and Northwest Territories, away from where the vast majority of Canadians live and work. As a result, it is estimated that Canada's real portion of the world's renewable freshwater supplies is 2.6 percent rather than 6.5 percent [Clarke, 2008]. Moreover, around one third of the total population of Canada and about 80 percent of people in rural areas use groundwater for their drinking water [Nowlan, 2005]. Groundwater resides in sub-surface aquifers, which from a regional context, are defined as

hydrostratigraphic units with a given volume of fluid flowing through its rock matrix and having a considerable lateral extent (i.e. hundreds of square kilometers) [Rivera et al/./, 2003]. Unfortunately, groundwater is often hundreds to thousands of years old and replenishments or 'recharge' by new water often occurs on similar time-scales. For this reason, many hydrologists consider groundwater to be a finite or non-renewable resource on most time-scales that are relevant to humans (i.e. years to decades) [Howard, 2003].

Unlike regional aquifers, which are often vast and inter-connected systems, local aquifers are generally less than one hundred square kilometers and are much more susceptible to the effects of water removal. Consequently, these local aquifers are often an area of particular concern with respect to the expanding bottled water industry, as large-scale water removal for purposes of bottling may threaten the viability of local wells, streams, and wetlands.

Bottling companies often pump hundreds of gallons per minute from local wells in which extractions often occur 24 hours a day, 365 days a year. These operations have drawn intense opposition in many American States, where bottling companies have set up operations and there is increased concern in many communities across Canada. Nestlé Waters North America, for example, which draws water from around 75 different U.S. spring sites and is one of the largest bottled water companies in the world, met with strong community resistance to its proposed bottling operations in the Midwest region of the U.S. "Eventually Nestlé built a $100 million (USD) bottling plant capable of packaging 260 million gallons of water a year from an aquifer in Michigan's rural Mecosta County" [Howard, 2003]. In order to acquire the right to remove water from this community's aquifers, Nestlé paid approximately $150 for permits and the company benefited from significant tax breaks [Howard, 2003].

3.2 Government Regulation Regarding Water Takings

A critical question is how and to what extent water takings are regulated in Canada. Important issues that need to be considered include ownership of and rights to water being used for bottling purposes, and exactly who is benefiting from and who is paying for the water being extracted. In Canada, there are more laws that cover surface waters than exist for

groundwater, and where the latter apply, laws vary between provinces. This is also the case in the United States where legislation differs from state to state. Where permits to take water exist, two important considerations are the volume of water being taken and how much bottled water companies pay for that water – their main ingredient in producing their product.

British Columbia, which is the only province that does not have permitting requirements for groundwater [Nowlan, 2005], has few restrictions: "For water takings of less than 1,710,000 litres per day, no permit is required unless the water comes from a spring source, where it falls under the province's surface water laws and regulations" [Clarke, 2007].

The cost to extract water in Canada is inherently advantageous for any bottled water manufacturer. B.C. has a complicated rent structure for water that identifies specific uses of water and prices them accordingly. For purposes of bottling water, however, the annual rental rates are so low ($0.85 per 1,000 cubic metres) as to be almost meaningless and there is no rate increase in B.C. at least until 2009 [Thompson, 2006]. The water license application fees for bottling of fresh water for sale of 200 cubic metres (approximately 43, 993 gallons) or greater per day is $2,000.00 [B.C. Ministry of Environment, 2008].

In Québec, groundwater takings of over 20,000 gallons per day require a 10 year permit from the government's environment ministry that costs between $1,500 and $4,000, depending on the amount of daily water takings, which is nothing compared to the revenues and profits collected by the companies from the sale of bottled water which is derived from these groundwater sources.

Alberta and Québec are contemplating water pricing, and until recently in Ontario, water was provided without any cost to large corporations. Provincial regulations relating to water in Ontario have changed in recent years with the passing of the *Safeguarding and Sustaining Ontario's Water Act (2007)* and the announcement of a new water charge on commercial and industrial water users, intended to encourage water conservation, of $3.71 per million litres which came into effect on January 1st 2009. Aside from being an ineffective charge (amounting to less than 0.000004 cents on each litre of bottled water produced in Ontario) that would not deter the growth of the bottled water industry, the fee actually contributes to and

facilitates the privatization of water services and management in several ways. Among these is the explicit definition of the fee as a 'charge' (and 'not a tax'), thus putting a price directly on water, which fundamentally contradicts the principle of water as a human right and an ecological commons [Cook et al., 2007]. Further, revenues from the fee will be going directly to the Source Water Protection Committees (SPCs), created with the adoption of the *Clean Water Act (2006)*, on which industry and commercial representatives with a direct interest in exploiting water resources, are allowed to sit as "stakeholders" [Ontario Ministry of Environment, 2006].

Ontario has seen several examples of grassroots community resistance to water bottling operations. Most recently, community groups including the Wellington Water Watchers in the Guelph region have been mobilizing against Nestlé bottling operations and the renewal application of the company's permit to take water. In April 2008, the Ministry of the Environment granted Nestlé a two-year permit (instead of a five-year permit) and requires the corporation to monitor the effects of its operations on the environment, but continues to allow Nestlé to withdraw 3.6 million litres of water per day at its Aberfoyle bottling plant. For processing this permit application, a $3000.00 fee is assessed to Nestlé while the $3.71 per million litres water charge came into effect in January 2009 [Campbell, 2008].

Ice River Springs, also known as Aquafarms and Aquafarms 93, is another bottled water company extracting water from groundwater sources in Ontario and British Columbia and is currently expanding its operations in the United States. Ice River Springs is the largest private label bottled water company in Canada, a multi-million-dollar business that is among the top four bottled water companies in Canada. Its clients include major corporations like Wal-Mart, Loblaws, and Shoppers Drug Mart. In Ontario, Ice River Springs was only required to pay $3,000 for a 5 year permit granted by the Ontario Ministry of the Environment to extract 3,273,120 litres per day from wells located in the village of Feversham. Ice River Springs was taken to the Environmental Review Tribunal by local residents concerned about the environmental impacts of the company's water takings, on the aquifer and neighboring wells [Girard, 2007].

3.3 Energy Costs Derived from Bottle Manufacturing, Transport, and Disposal

In terms of manufacturing costs, the Earth Policy Institute estimates that around 1.5 million tons of plastic are used globally each year in water bottles, or about enough to fuel 100,000 cars [EPI, 2006]. The Berkeley Ecology Center found that manufacturing PET generates more than 100 times the toxic emissions—in the form of nickel, ethylbenzene, ethylene oxide and benzene—compared to making the same amount of glass. Consequently, the Climate Action Network concludes, "making plastic bottles requires almost the same energy input as making glass bottles, despite transport savings that stem from plastic's light weight." Moreover, because more than 22 million tons of bottled waters are transferred each year from country to country, the distribution of bottled water requires substantially more fuel than delivering tap water. Instead of relying on a mostly pre-existing infrastructure of underground pipes and plumbing, delivering bottled water to North America from far-off places such as Italy, France, Iceland, and the islands of southern Pacific burns fossil fuels and results in the release of thousands of tons of harmful emissions and pollutants. As the Pacific Institute puts it, a simple way to visualize the average energy cost required to manufacture plastic bottles -- fill them with water, transport them to market, and then deal with the bottles as refuse -- is to imagine filling a quarter of each bottle with oil. In addition, Pacific Institute estimates that it takes twice as much water to produce a bottled water product than the amount of water in the bottle itself [Pacific Institute, 2005]. Moreover, in a recent study conducted by the Pacific Institute, it was estimated that producing bottled water requires as much as 2000 times the energy cost of producing tap water [Pacific Institute, 2009].

According to the Container Recycling Institute, a U.S.-based non-profit organization, 60 million bottles per day end up as landfill or become litter in the U.S. [CRI, 2006]. In the State of California alone, with a population of 33,871,648, (2000 U.S. Census figures), more than one billion water bottles end up in the State's trash every year [California Department of Conservation, 2003]. Hence, billions of plastic bottles are permanently stored in landfill sites in North America or, as is the practice in many municipalities, are incinerated along with other refuse. According to the Climate Action Network, incineration of plastic bottles causes toxic chlorine (and potentially *dioxin*) to be released into the air while heavy metals are often deposited in the residual ash. Moreover, if plastics are buried in landfills instead of burned,

these containers take up valuable landfill space. During the process of plastic degradation, which can take thousands of years, they can release potentially toxic additives, such as phthalates, that subsequently leak into nearby groundwater. The case in Canada is very much the same. The Province of Ontario alone, according to an *Environment and Plastics Industry Council* (EPIC) study entitled *An Overview of Plastic Bottle Recycling in Canada*, in 2002, had a 35% recycling rate for plastic beverage bottles, one of the lowest rates in the country. As a result, over 33,000 tonnes of plastic was burned or buried that year alone, releasing toxins into the ground, water and atmosphere, [EPIC, 2004].

The bottled water industry portrays itself as a 'green' industry by claiming that they are "committed to actively participating in recycling and educating the public about the importance of recycling bottled water containers and all recyclable materials" [IBWA, 2006]. In response to increasing criticism on the the environmental impacts of plastic bottles, bottled water corporations have further attempted to greenwash their products by introducing 'new packaging' with less plastic. Nestlé, for instance, is now promoting a new 'eco-shape' plastic bottle that consists of 30% less plastic, in addition to other packaging reductions [Arbel, 2008]. However, the truth is fact is that the bottled water and plastics industries are closely connected: "bottled water manufacturers are the end point of a supply chain that contains some of the biggest polluters on the planet" [Girard, 2008]. The plastic industry includes big oil giants such as Royal Dutch Shell, ExxonMobile and British Petroleum. Terephthalic acid and monoethylene glycol (MEG) are derived from crude oil, are the two primary raw materials used to produce polyethylene terphtalate (PET) plastic. "80% of the PET produced in the United States ends up in a Coca-Cola, Pepsi or Nestle beverage or container" [Girard, 2008]. Through NAPCOR (National Association for PET Container Resources) an association which joins the bottled water and plastic industry and operates in North America, and similar trade associations, "bottled water companies and the plastic resource companies have spent millions of dollars to weaken and /or defeat bottle bills and recycled-content legislation, often outspending their opponents as much as 30 to 1," [Clarke, 2007]. Moreover, manufacturers of recycled plastic are unable to compete with producers of virgin plastic products due to the relatively low cost of petroleum used in manufacturing them, [Clarke, 2007].

While recycling plastic bottles is often a viable option in order to reduce the stress on landfill sites, not all plastic water bottles are recycled. One problem is that different types of plastic bottles are often difficult to sort at recycling depots, as different bottles often cannot be recycled together and must be separated. In some instances, this separation is meant to reduce the ratio of coloured bottles (such as Dasani's blue plastic bottles) to clear bottles before processing [CRI, 2007]. In Canada, according to the study by EPIC, "recovery of plastic bottles in Canadian provinces varies dramatically based on the bottle type. In 2002, 235,086 tons of plastic bottles were generated and about 84,744 tones were recovered and recycled based on available data. This amounts to a recovery rate of 36% (for all types)." Also, common plastic additives, such as phthalates or metal salts, can thwart recycling efforts. Due to the many challenges, recycling depots in the U.S. often refuse to accept plastics and in fact, a fair amount of America's plastic recycling is done in China and other countries, where there are lower labour standards and costs, fuel is spent in international transport, [CRI, 2007], and where environmental laws that govern polluting factories are less regulated, [The Economist, 2007; Howard, 2003]

The simple fact is that bottled water can never be an environmentally friendly product. When the entire lifecycle of a bottle of water is considered – production, transportation, disposal – the full energy and environmental implications of the bottled water industry are proven to be extremely harmful. No amount of recycling can dispute the fact that the most environmentally friendly way to drink water is from the tap.

4. Recommendations

The following comprehensive health and environmental initiatives are urgently needed.

Public Health

Bottled water public health regulations, the implementation of which fall under the mandates of Health Canada and the Canadian Food Inspection Agency (CFIA), are needed in order to deal with microbiological, chemical and radiological contaminants, as well as the current lack of strict labelling rules for bottled waters.

1. Bottled water must conform to the same strict standards as municipal tap water. Accordingly, bottled waters should be regulated by the same guidelines as municipal water and the *Guidelines for Canadian Drinking Water Quality* should be referenced as the main criteria for bottled water testing and approval in the Food and Drugs Act (FDA). These guidelines should be considered law for bottled waters and regulations should be rigorously enforced.

2. Bottled water manufacturers should be required by law to disclose and print on bottled water product labels: the water source, the quantity and contents of any added ingredients for all types of bottled water, the date upon which the waters were packaged, an expiry date (mandated by the government), the sentence “refrigerate after opening”, and a toll-free telephone number and other contact information at which the manufacturer can be reached. Furthermore, bottled water manufacturers should be required to disclose the treatment processes that were conducted for their products.

3. a) Similar to test results for municipal waters, analytical results of water quality tests performed by bottled water manufacturers should be publicly-available and easily accessible.

b) Laboratories that conduct water quality tests for bottled water manufacturers should be licensed by governments to carry out these tests. Only government approved labs should be commissioned by companies for any testing done and these tests should be required on a specified regular basis with public reporting. This would provide the grounds for issuing publicly "certified safe" labels on bottled water products.

c) All bacteriological, chemical and radiological contaminants tested for in bottled water should be listed by Health Canada and CFIA. The scope of the list of contaminants should be expanded, and there should be mandatory periodic reviews and updates in order to incorporate new additions and/or changes to this list.

Environment

While many of the environmental impacts of bottled water fall under provincial jurisdiction, the Federal Government can and should do more to exercise their constitutional powers to protect water sources and Canada's environment.

1. A special surtax on the profits of the bottled water industry should be levied by the Federal Government. Revenues derived from the surtax should be targeted towards reinvestments in public drinking water infrastructure through federal transfers to the provinces, territories and municipalities.

2. Since most plastic used by bottled water companies is virgin plastic, the Federal Government should encourage provincial governments to label PET plastic a "problematic material" and require bottled water manufacturers to only use recycled plastics.

3. The Federal Government should demonstrate its commitment to public water by phasing out the sale and distribution of bottled water in government buildings where appropriate and where potable tap water is already available.

4. The Federal Government should significantly re-invest in federal, provincial and municipal water infrastructure and include such re-investments in any new economic stimulus package(s).

3. References

Adamowicz, W., D.P. Dupont and A. Krupnick (2004), The value of good quality drinking water to Canadians and the role of risk perceptions: A preliminary analysis, *Journal of Toxicology and Environmental Health Part A: Current Issues*, 67, 1825-1844.

Al-Saleh, I., and I. Al-Doush (1998), Survey of trace elements in household and bottled drinking water samples collected in Riyadh, Saudi Arabia, *The Science of the Total Environment*, 216, 181-192.

Arbel, Tali. "Bottled Water Sales are Sinking: The lousy economy seems to be weening people off Dasani and Evian in favor of good ol' tap water." The Associated Press, July 8th 2008.

BBC News. "Coke Recalls Controversial Water," http://news.bbc.co.uk/2/hi/business/3550063.stm

Bischofberger, T., Cha, S.K., Schmitt, R., König, B. and W. Schmidt-Lorenz (1990), The bacterial flora of non-carbonated, natural mineral water from the springs to reservoir and glass and plastic bottles, *International Journal of Food Microbiology*, 11, 51-72.

Blake, P.A., Rosenberg, M.L., Florencia, J., Bandeiro Costa, J., do Prado Quintino, L.D., and J. Gangarosa (1977), Cholera in Portugal: II Transmission by bottled mineral water, *American Journal of Epidemiology*, 105, 344-348.

Buttiaux, R. and A. Boudier (1960), Comportement des bactéries autotrophes dans les eaux mineérales conservées en récipients herme-tiquement clos, *Ann. Inst. Pasteur Lille*, 11, 43-52.

Campbell, Murray, "Law on Groundwater Murky." *The Globe and Mail*, April 24th 2008.
CBC News, (May 30th, 2008), *In Depth: Health*, "Bisphenol A: FAQs."
http://www.cbc.ca/news/background/health/bisphenol-a.html

CBC News, (June 25th, 2008), "Bottle or tap? Incom, education influence choices: StatCan." http://www.cbc.ca/consumer/story/2008/06/25/consumer-bottledwater.html

CBC News, (July 27th, 2007), "Aquafina labels to spell out tap water source." http://www.cbc.ca/consumer/story/2007/07/27/aquafina.html

California Department of Conservation (2003), Report: Surge in bottled water popularity threatens environment, NR 2003-13, http://www.consrv.ca.gov/DOR/index.htm

Canadian Food Inspection Agency (2003), *Guide to Food Labelling and Advertising*, Chapter 2. http://www.inspection.gc.ca/english/fssa/labeti/guide/ch2ae.shtml

CFIA (March 2002), "Food Safety Facts on Bottled Water." http://www.inspection.gc.ca/english/fssa/concen/specif/bottwate.shtml

CFIA (2002), *Making It Clear: Renewing the Federal Regulations on Bottled Water*, http://www.hc-sc.gc.ca/fn-an/consultation/init/bottle_water-eau_embouteillee_tc-tm_e.html.

CFIA Food Recalls and Allergy Alerts, Bottled Water:

http://www.inspection.gc.ca/english/corpaffr/recarapp/2007/20071206be.shtml
http://www.inspection.gc.ca/english/corpaffr/recarapp/2007/20070314ce.shtml
http://www.inspection.gc.ca/english/corpaffr/recarapp/2007/20070309be.shtml
http://www.inspection.gc.ca/english/corpaffr/recarapp/2001/20010428e.shtml
http://www.inspection.gc.ca/english/corpaffr/recarapp/2000/20001020e.shtml

City of Toronto. *Toronto Water: Protecting water quality – Water Quality Assurance Program*. http://www.toronto.ca/water/protecting_quality/quality_assurance.htm

City of Ottawa. *Water*. http://ottawa.ca/city_services/water/27_0_en.shtml.

Clarke, T. "Bottled Water Industry Just Swimming in Profits." Toronto Star, November 29th, 2007.

Clarke, T. (2005), *Inside the Bottle: An Expose of the Bottled Water Industry*. Ottawa: *Polaris Institute*.

Clarke, T. (2007), *Inside the Bottle: Exposing the Bottled water Industry. (Revised & Updated Edition)* Ottawa: *Canadian Centre for Policy Alternatives and the Polaris Institute*.

Clarke, T. (2008), *Turning On Canada's Tap? Why We Need a Pan-Canadian Policy and Strategy Now on Bulk Water Exports to the U.S.* Polaris Institute.

Coca Cola Company Official Web-Site (2004), Voluntary Withdrawal of Dasani in UK, http://www.thecoca-colacompany.com/presscenter/viewpoints_dasani.html

Coleman, Chrisena. "Cafeteria Worker says Pure Life bottle was Contaminated." *New York Daily News*, November 14th, 2007.

Container Recycling Institute (2007), http://container-recycling.org

Cook, V., Thompson, L., (May 30th, 2007), *Open Letter on Proposed Ontario Water Conservation Charge*. Polaris Institute. http://www.insidethebottle.org/legislative-action-open-letter-proposed-ontario-water-conservation-charge

Dabeka, R.W., Conacher, H. B. S., Lawrence, J. F., Newsome, W. H., McKenzie, A., Wagner, H. P., Chadha, R. K. H. and K. Pepper (2002), Survey of bottled drinking waters sold in Canada for chlorate, bromide, bromate, lead, cadmium and other trace elements, *Food Additives and Contaminants*, 19, 721-732.

Donato, Agnes E. *Saipan Tribune*. "Crystal Waters Remains Closed." Nov 16th, 2007.

Dupont, D.P. (2005), Tapping into Consumers' Perceptions of Drinking Water Quality in Canada: Capturing Customer Demand to Assist in Better Management of Water Resources, *Canadian Water Resources Journal*, 30, 11-20.

Earth Policy Institute (2006), Bottled Water: Pouring Resources Down the Drain, http://www.earth-policy.org/Updates/2006/Update51_printable.htm

Environment and Plastics Industry Council (2004), *An Overview of Plastic Bottle Recycling in Canada*. Prepared for EPIC and submitted by CM Consulting. http://www.cpia.ca/files/files/files_plastic_bottle_recovery.pdf

Environment Canada (2006), Freshwater Website. http://www.ec.gc.ca/water/en/info/facts/e_quantity.htm

Fayad, N.M., Sheikheldin, S.Y., Al-Malack, M.H., El-Mubaruk, A.H., and N. Khaja (1997), Migration of vinyl chloride monomer (VCM) and additive into PVC bottled drinking water, *Journal of Environmental Science and Health*, A32, 1065 – 1083.

Food Standards Agency. 'Dasani: FSA Statement'. http://www.food.gov.uk/news/newsarchive/2004/mar/dasanistatement; 'Product Withdrawal of Dasani bottled still water.' Friday, March 19th 2004. http://www.food.gov.uk/enforcement/alerts/2004/mar/dasani

Girard, Richard (2008), *January NewsBytes: Oil in My Water?* Polaris Institute.

Girard, Richard (2007), *Aquafarms 93 Exposed: The private company behind the bottled water at Wal-Mart, Shoppers Drug Mart and Loblaws*. Polaris Institute.

Gleick, P.H., and Cooley, H.S (2009), Energy Implications of Bottled Water, *IOP Publishing* 4 (2009).

Harden, Andrea, Levalliant, H. (2008), *Boiling Point! Six Community Profiles of the Water Crisis facing First Nations within Canada*. Polaris Institute.

Health Canada. “Making It Clear - Renewing the Federal Regulations on Bottled Water: A Discussion Paper, http://www.hc-sc.gc.ca/fn-an/consultation/init/bottle_water-eau_embouteillee_tc-tm_e.html

Howard, Brian (2003), “Despite the Hype, Bottled Water is Neither Cleaner nor Greener than Tap Water.” *E/The Environmental Magazine*, Volume XIV, 5. http://www.emagazine.com/view/?1125

Hrudey, S.E., Huck, P.M., Payment, P., Gillham, R.W. and E.J. Hrudey (2002), Walkerton: Lessons learned in comparison with waterborne outbreaks in the developed world, *Journal of Environmental Engineering Science*, 1, 397-407.

International Bottled Water Association (2007), www.bottledwater.org.

Klont, R. (2004), Bacterial and Fungal Contamination of Commercial Bottled Mineral Water from 16 Countries, 44th ICAAC, A meeting of the American Society for Microbiology, October 30 – November 2, 2004, Washington, D.C., U.S.

Kramer, M.H., Herwaldt, B.L., Calderon, R.L., and D.D. Juranek (1996), Surveillance for Waterborne-Disease Outbreaks -- United States, 1993-1994, *Centre for Disease Control, Surveillance Report*, April 12, 1996/45(SS-1);1-33.

Krewski, D., Balbus, J., Butler-Jones, D., Haas, C., Isaac-Renton, J., Roberts, K.J., and M. Sinclair (2002), Managing Health Risks from Drinking Water: A Report to the Walkerton Inquiry, *Journal of Toxicology and Environmental Health Part A*, 65, 1635-1823.

Laing, R.D. (2002), Report of the commission of inquiry into matters relating to the safety of the public drinking water in the City of North Battleford, Saskatchewan, Department of Justice, Government of Saskatchewan.

Lalumandier, J.A. and L.W. Ayers (2000), Fluoride and bacterial content of bottled water versus tap water, *Archives of Family Medicine, 9*, 246-250.

Legnani, P., Leoni, E., Rapuano, S., Turin, D., and C. Valenti (1999), Survival and growth of Pseudomonas aeruginosa in natural mineral water: a 5-year study, *International Journal of Food Microbiology*, 53, 153–158.

Levin, R.B., Epstein, P.R., Ford, T.E., Harrington, W., Olson, E. and E.G. Reichard (2002), U.S. Drinking Water Challenges in the Twenty-First Century, *Environmental Health Perspectives*, *110*, 43 – 52.

Loy, A., Beisker, W., and H. Meier (2005), Diversity of Bacteria Growing in Natural Mineral Water after Bottling, *Applied and Environmental Microbiology*, 71(7), 3624-3632.

Morita, R.Y. (1997), *Bacteria in Oligotrophic Environments: Starvation-Survival Lifestyle*, Chapman and Hall, New York 529 pp.

Mutsuga, M., Kawamura, Y., Sugita-Konishi, Y., Haro-Kudo, Y., Takatori, K., and K. Tanamoto (2006), Migration of formaldehyde and acetaldehyde into mineral water in polyethylene terephthalate (PET) bottles, *Food Additives and Contaminants*, 23, 212 – 218.

Needleman, H.L. (1993), The current status of childhood low-level lead toxicity, *Neurotoxicology*, 14, 161 – 166.

Natural Resources Defense Council (1999), Bottled Water: Pure Drink or Pure Hype, http://www.nrdc.org/water/drinking/bw/bwinx.asp

Nowlan, Linda (2005), *Buried Treasure: Groundwater Permitting and Pricing in Canada*, for The Walter and Duncan Gordon Foundation, with case studies by Geological Survey of Canada, West Coast Environmental Law and Sierra Legal Defence Fund.

O'Connor, D.R. (2002), *Report of the Walkerton Inquiry*, Toronto: Queen's Printer.

Ontario Ministry of Environment (2006), *Clean Water Act Information*. http://www.ontario.ca/ONT/portal51/drinkingwater/Combo?view=Expanded&docId=159631&lang=en

Pacific Institute (2005), http://www.worldwater.org/

Page, B.D., Conacher, H.B., Salminen, J., Nixon, G.R., Riedel, G., Mori, B., Gagnon, J., and R. Brousseau (1993), Survey of bottled drinking water sold in Canada. Part 2. Selected volatile organic compounds, *Journal of the Association of Official Analytical Chemists International*, 76, 26 – 31.

Rivera, A., A. Crowe, A. Kohut, D. Rudolph, C. Baker, D. Pupek, N. Shaheen, M. Lewis, and K. Parks (2003), *Canadian Framework For Collaboration on Groundwater*, Government of Canada, Ottawa, 60 pp. http://www.cgqqgc.ca/cgsi

Rosenberg, F.A. (2003), The microbiology of bottled water, *Clinical Microbiology Newsletter*, 25(6), 41-45.

Shotyk, W., Krachler, M., and B. Chen (2006), Contamination of Canadian and European bottled waters with antimony from PET containers, *Journal of Environmental Monitoring*, 8, 288 – 292.

Sinovic, Emily. "Moldy Bottled Water." *Fox23.com*, December 6th, 2007.

Shotyk, W., Krachler, M., Chen, B., and Zheng, J. (2005), Natural abundance of Sb and Sc in pristine groundwaters, Springwater Township, Ontario, Canada, and implications for tracing contamination from landfill leachates, *Journal of Environmental Monitoring*, 7, 1238 – 1244.

Statistics Canada, (2006), Table 385-0003[3,4] Local government revenue and expenditures for fiscal year ending closest to December 31, annual (dollars x 1,000).

Suffet, M. (2001), http://www.ioe.ucla.edu/publications/report01/BottledWater.htm

Suzuki, J., Katsuki, Y., Ogawa, H., Suzuki, K., Matsumoto, H. and K. Yasuda (2000), Concentration of trace elements in bottled drinking water, *Journal of the Food Hygienic Society of Japan*, 41, 387 – 396.

The Economist (June 7th, 2007), "The Truth About Recycling".

Tamagnini, L.M., and R.D. Gonzalez (1997) Bacteriological stability and growth kinetics of Pseudomonas aeruginosa in bottled water, *Journal of Applied Microbiology*, 83, 91-94.

Thompson, D. (2006), Water for Sale? A Look at the Complex Issue of Bulk Water Export, *Horizons-Policy Research Initiative*, 9(1), 28-32, Government of Canada.

United Nations (2006), The Millennium Development Goals Report, http://unstats.un.org/unsd/mdg/Resources/Static/Products/Progress2006/MDGReport2006.pdf

Vom Saal, F.S., and C. Hughes (2003), An extensive new literature concerning low-dose effects of bisphenol-A shows the need for a new risk assessment, *Environmental Health Perspectives*, 113, 926-933.

Warburton, D.W., Bowen, B., Konkle, A., 1994. The survival and recovery of Pseudomonas aeruginosa and its effect upon salmonellae in water: methodology to test bottled water in Canada, *Canadian Journal of Microbiology*, 40, 987-992.

Warburton, D.W., and J.W. Austin (1997), Bottled water, In: *Microbiology of Food*, Chapman and Hall, London.

Warburton, D., Harrison, B., Crawford, C., Foster, R., Fox, C., Gour, L. and P. Krol (1998), A further review of the microbiological quality of bottled water sold in Canada: 1992–1997 survey results, *International Journal of Food Microbiology*, 39, 221-226.

World Health Organization (2004), Water, sanitation and hygiene links to health, http://www.who.int/water_sanitation_health/publications/facts2004/en/index.html

Yule, W. and M. Rutter (1985), Effect on children's behavior and cognitive performance: a critical review, In: *Dietary and Environmental Lead: Human Health Effects* (Ed., R. Mahaffey), New York, Elsevier, 211 – 251.