Microbiological Quality of Bottled Water, International Perspective

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Abstract

Bottled water is drinking water that meets all relevant standards, is sealed in a container and sold for human consumption. Drinking water can be sourced from surface water and from ground water. Surface water includes rivers, lakes, springs and reservoirs. Water is one of the most important and sensitive issues in the Middle East, where increasing water deficiency and deterioration of the available water resources are imminent. Potable or drinking water is defined as having acceptable quality in terms of its physical, chemical, and bacteriological characteristics so that it can be safely used for drinking and cooking. Since, the water provide essential and suitable environment for the pathogens, water borne disease, its needs repetitive treatment to minimize the water risks.

Keywords: Bolted water, drinking water, microbiological water quality

Introduction

Water is essential for the majority of the body functions, to maintain a healthy lifestyle and is especially important for thermoregulation (EFSA, 2010). In addition to thermoregulation, water also protects and cushions our vital organs and is required for breathing and transporting nutrients and oxygen throughout the body. Water is the main constituent of the human body, comprising around 60% of body weight in adult males, 50 to 55% in females and 75% in newborn infants is water. However this varies depending on body constitution (EFSA, 2010). Our bodies obtain water from a variety of sources, such as drinking water (tap and bottled water), beverages, moisture content of foods and water produced by oxidative processes in the body (EFSA, 2010).

It is estimated that approximately two litres of water per day should be consumed by a 60 kg person and one litre per day for a 10 kg child (WHO, 2000). However, it is dependent upon climate, physical activity and culture. Good health is dependent upon clean, potable (drinkable) water. This means that water must be free of pathogens, dissolved toxins, and disagreeable turbidity, odour, colour and taste (Talaro, 1999). If this is not ensured, then outbreaks can occur. Two examples of waterborne outbreaks were an epidemic of cholera, where thousands of people were killed due to the consumption of water contaminated with Vonibrio cholerae bacteria in South America.
(Blake et al., 1974) and an outbreak of *Cryptosporidium spp.* in Wisconsin, USA, which affected 370,000 people (Talaro, 1999). The latter outbreak was traced to a contaminated community drinking water supply.

United Nations Conference on Environment and Development (UNCED) in 1992 recommended nominating an international day to celebrate freshwater. Since 1993 the International World Water Day is held every year on 22 March. The purpose of this day is to raise the awareness of freshwater and to advocate the sustainable management of freshwater resources. Every year the World Water Day raises awareness of a specific aspect of freshwater. ([http://www.unwater.org/worldwaterday/about.html](http://www.unwater.org/worldwaterday/about.html)).

Ground water is pumped from wells or bores that are drilled into aquifers ([www.excelwater.com](http://www.excelwater.com)). Drinking Water Standards for New Zealand 2005 (DWSNZ) state that a fundamental requirement for public health is safe drinking water available to everyone. Confidence in the public health safety of water is increased if multiple barriers to contamination are in place. These barriers include protection of source waters to minimise the number of pollutants of public health significance entering the water source. Any pollutants of the source water must then be dealt with by the complex staged treatment processes, for example filtration to remove particulate matter, disinfection to inactivate any pathogenic organisms present and protection of treated water from subsequent contamination. Concerns about pollution and presence of pathogenic bacteria in drinking water have prompted many people to turn to bottled water as a substitute for ordinary tap water ([http://www.articlesbase.com](http://www.articlesbase.com)). What first started as a trend is now a profit making worldwide industry.

**Bottled Water Quality**

The quality of bottled and packaged waters may vary considerably since bottled waters are not subjected to extensive quality standards, unlike municipal water supplies. A variety of organisms have been recovered from bottled water. Recovery of *Staphylococcus aureus* and *Aeromonas hydrophila* from bottled water has caused concerns about its safety over the last thirty years (Guo-Jane Tsai & Shou-Chin Yu, 1997). Beuret et al. (2002) described the detection of Ribonucleic acid (RNA) with nucleotide sequences specific for —Norwalk-like viruses in European bottled mineral water.

Bottled water is consumed by people of all age groups and various occupations. Generally bottled water consumers may be perceived as being more health conscious, contemporary and socially aware. Some people choose to drink bottled water, because they want to avoid chemicals used in the treatment of public water supplies, others do it purely for convenience and some people choose to buy bottled water because of its taste. Bottled water may be distributed in emergency relief operations, such as Asian Tsunami, cyclones in Queensland and other emergencies that have interrupted the delivery of safe drinking water. Bottled water is supplied to communities that lack safe and clean potable water around the world, such as in the events of earthquakes, flooding or military missions and operations. Grant (1997) stated that consumption of bottled water was steadily increasing as a result of public concerns about palatability and microbial and chemical contaminants in tap water. European consumption of bottled water has increased by 200% between 1987 and 1997. Developing nations, such as China and Indonesia were projected to increase bottled water demand by 30% in the next 5 years following the research published in 1997 (Grant, 1997). Even though bottled water is often perceived as a sterile product, water obtained even from a deep aquifer (a water bearing underground layer of rock or sand) may contain microorganisms at levels as high as 107 CFU/ml (Grant, 1997). The microflora in source water may also increase after bottling, typically reaching maximum levels after one week. Personnel hygiene practices in bottling plants have also been shown to contribute to contamination of bottled water (Grant, 1997). Grant (1997) stated, that out of 104 brands of retail bottled water from 10 countries (container sizes ranged from 296 ml to 3,785 ml; 101 containers were plastic and 3 glass) tested, 36 different brands contained presumptive coliforms.
According to the most recently available International Bottled Water Association statistical data that had been obtained from the Beverage Marketing Corporation, the consumption of bottled water worldwide in 2002-2007 had increased by 7.6% (www.bottledwater.org). A number of studies have shown that bacteria isolated from waterfowl droppings, such as Campylobacter, Salmonella, Escherichia and Aeromonas, have the potential for human pathogenicity which can lead to infection and disease, such as diarrhoea or gastroenteritis (Clarke et al., 1998). With regard to protozoal pathogens, studies by Graczky et al. (1996; 1998) provided clear evidence that waterfowl can distribute Giardia cysts and Cryptosporidium oocysts in the environment and that these protozoa in water may have epidemiological implications. Outbreaks due to the consumption of contaminated water containing E.coli 0157:H7 have occurred in USA (Keene et al., 1994), South Africa, Swaziland (Isaacson et al., 1993) and Scotland (Dev et al., 1991). While many of these outbreaks were related to the consumption of contaminated surface waters, currently there is an increasing concern that the entry of this microorganism into groundwater supplies may pose risks in relation to the consumption of bottled waters (Kerr et al., 1999).

Bottled water has been known to be a source of Vibrio cholerae (Blake et al., 1974), Salmonella spp(Palmera-Suárez et al., 2007) and Norovirus (Beuret et al., 2002). Blake et al. (1974) described transmission of Vibrio cholerae by bottled mineral water, where the organism was isolated from two springs which supplied mineral water to a spa and to a commercial water bottling plant. Palmera-Suárez et al. (2007) described the first published outbreak of Salmonella Kottbus that was associated with commercial bottled water in Spain and Europe. The latter study found out that pigeons frequently visited the water reservoirs that supplied the local factory. Salmonella Kottbus was detected in bottles randomly selected from markets and in the local bottling factory in the island of Gran Canaria. Salmonella spp. was detected in the pigeons. Both studies were case-control studies that studied non-carbonated waters. Blake et al. (1974) demonstrated that bacteriologically confirmed cholera cases had a history of consuming bottled non-carbonated water. The results of the second study (Palmera-Suárez et al., 2007), led to the inspections by the Public Health authorities, which then resulted in the closure of the bottling factory and recall of bottled water. In another study 11 brands of European mineral waters were found to contain nucleotide sequences specific for —Norwalk-like viruses‖ (currently called Norovirus) that causes more than 90% cases of acute viral gastroenteritis worldwide (Beuret et al., 2002) each year. Warburton et al. (1986) examined 114 samples that represented five lots of domestic and imported mineral water brands. Although they did not detect any faecal coliforms or E.coli, it was observed that if mineral water was governed by the aerobic colony count standards for bottled water, five lots domestic and imported mineral water examined in this study (a total of 114 samples) would have been found to be unsatisfactory.

Bottled natural mineral waters are not as microbiologically pure as some suppliers seem to claim (Hunter et al., 1987). The study carried out by Hunter et al. (1987) demonstrated, that carbonated waters were found to be of food quality, and surmised that this was most likely due to carbon dioxide’s antibacterial activities. On the other hand, the research in Taiwan (Guo-Jane Tsai & Shou-Chin Yu, 1997) was carried out on uncarbonated mineral waters. In this study 88 domestic and 48 imported samples were tested. While coliforms and faecal streptococci were not detected in any of the samples tested, two of domestic samples were found to be contaminated with Aeromonas hydrophila and four with Pseudomonas aeruginosa. The legally permitted level of Heterotrophic Plate Count (HPC) in Taiwan is 200 CFU/ml. The study found that 51.1% of domestic samples and 60.4% of imported samples failed to comply with this limit. There is no information available whether any changes to the legislation were implemented after this finding. The other species of bacteria isolated in the bottled water samples in this study were Pseudomonas, Aeromonas, Flavobacterium, Pasteurella, Xanthomonas, and Staphylococcus.

In this study moulds were also detected in both, domestic (38.6 %) and imported (18.8%) samples. Sefcová H. (1998) found that limits of psychrophilic microorganisms were higher in still table water compared with carbonated water. During 1995-2003 Venieri et al. (2006) studied the microbiological quality of 1,527 samples of bottled non-carbonated (‘still’) mineral water that represented 10 manufacturing companies in Greece. The samples were tested
for coliforms, *Escherichia coli*, *Enterococcus spp.*, *Pseudomonas aeruginosa* and HPC (at 22ºC and 37ºC). Venieri et al. (2006) study found that 13.95% of tested bottled water samples did not comply with the Greek bottled water regulations. In addition to *P. aeruginosa*, other bacteria, such as *Pseudomonas spp.*, *Aeromonas spp.*, *Pasteurella spp.*, *Citrobacter spp.*, *Flavobacterium spp.*, *Providencia spp.* and *Enterococcus spp.* were isolated.

A number of studies had demonstrated that many factors, such as material of bottles, colour of bottles and the length of storage influence the microbiological quality of bottled water. Fewtrell et al. (1997) reported lower colony counts from glass bottles compared to plastic bottles. They also noted that the colour of containers affected the total colony counts. *Pseudomonas aeruginosa* was the most frequently detected microorganism in samples tested by Fewtrell et al. (1997). Mavridou (1992) findings were consistent with Fewtrell et al. (1997) and her study demonstrated that during storage larger numbers of bacteria grew in PVC rather than glass bottles. The largest number of bacteria grew in PVC bottles filled by hand. Massa et al. (1997) examined heterotrophic plate counts in 31 glass and 40 plastic (PVC) bottled mineral waters. Several researchers studied the effects of storage in plastic and glass bottles on the microbiological quality of bottled waters. A quantitative study of bacterial populations in mineral water was carried out by Gonzalez et al. (1987). This study demonstrated that bacterial counts in samples collected from the spring source in sterile glass flasks and from the bottling factory in conventional plastic and glass containers storage were much higher than those found in water obtained directly from the spring source.

Bischofberger et al. (1990) found that after 1 week of storage at 20ºC highernumbers of colony counts were found in plastic bottles than glass bottles. Raj(2005) also examined the effects of time and storage temperature on bacterialgrowth in bottled waters. His study found that the bacterial counts in bottled waters increased dramatically if bottles were stored for more than 48 hours at37ºC. Bischofberger et al. (1990) thought that the growth promotion bydissolved organic substances in the plastic bottles played only a minor role. Their study concluded that the difference of bacterial proliferation between the two types of bottles was caused by an inhibition of growth due to residues of cleaning detergents in the glass bottles. Raj (2005) found that bacterial growth was reduced under refrigeration compared with room temperature. While Bischofberger et al. (1990) and Raj (2005) did not describe the genera of bacteria isolated in their studies, the most frequently isolated genus in Gonzalez et al. (1987) study was *Caulobacter*, followed by *Sphaerotilus-Leptothrix, Acinetobacter calcoaceticus* and *Pseudomonas fluorescens, Pseudomonas putida, Arthrobacter spp., Aeromonas hydrophilia,* and *Corynebacterium spp.* were isolated less frequently.

*E.coli* (Lal & Kaur, 2006; Bharath et al., 2003), coliforms (Olayemi, 1999;Zamberlan da Silva et al., 2008; Kassenga, 2007; Lal & Kaur, 2006; Bharath et al., 2003; Jeena et al., 2006), *P. aeruginosa* (Ogan 1992; Venieri et al., 2006), *Enterococcus* (Venieri et al., 2006), HPC (Kassenga, 2007; Venieri et al., 2006; Bharath et al., 2003; Croci et al., 2001; Jeena et al., 2006; Saleh et al., 2008) and fungi (Ribeiro et al., 2006; Criado et al., 2004; Cabral 2002; Papapetropoulou et al., 1997; Lal and Kaur, 2006) have been detected in bottled waters in many countries around the world. Bottled water has been found to contain bacteria that are resistant to antibiotics (Jeena et al., 2006) and toxin producing fungi (Criado et al., 2004).

Olayemi (1999) examined spring waters packaged and hawked in cellophane in Nigeria. The study found that the majority of brands tested positive for the presence of coliform bacteria and concluded that 40% of the hawked water did not meet drinking water quality standards. The Trinidad study (Bharath et al., 2003) found that 5% of bottled water sold in Trinidad was unfit for human consumption. Those brands, all domestic, were found to contain coliforms and 1.5% of samples contained *E.coli*. Bottled waters sold in India were tested by Lal and Kaur (2006). They demonstrated that out of the 23 brands examined one brand of bottled water contained the presumptive coliforms and one brand was positive for *E.coli* and therefore was unfit for human consumption due to the presence of *E.coli*. Kassenga (2007) detected total coliforms in 4.6% of brands and faecal coliform bacteria in 3.6% of brands.
tested in Tanzania. Grant (1998) analyses 104 brands of bottled water originating from 10 countries and detected presumptive coliform colonies in 5.8% of the bottled water sample tested. The presumptive coliforms had not been confirmed as true coliforms in subsequent analysis.

Another Indian study (Jeena et al., 2006) demonstrated a linear relationship between HPC and coliform bacteria. In this study out of 150 samples that represented 30 brands Jeena et al. (2006) found that 44% of the samples that displayed HPC counts between 100 and 1000 CFU/ml also tested positive for coliforms. 14% of samples examined in this study were positive for coliforms. Some researchers compared bottled water quality with tap water quality. Breuer et al. (1990) concluded that bottled waters sold in Iowa were of the same microbiological quality standard as the typical drinking water from public drinking water supplies in the state. Zamberlan da Silva et al. (2008) compared bacteriological quality of municipal tap water with that of 20-L bottles of mineral water collected from water dispensers. This study found that 36.4% of the tap water samples from municipal water systems and 76.6% of the 20-L bottles of mineral water from water dispensers in Brazil were contaminated by at least one coliform per milliliter. While Breuer et al. (1990) cautioned that bottled waters may not be tested as frequently and for as many contaminants as public water supplies, the results of the Brazilian study are alarming. _Pseudomonas spp._ were isolated in bottled water brands sold in several countries, such as Spain (Rivilla & Gonzalez, 1988), Nigeria (Olayemi, 1999), Trinidad (Bharath et al., 2003), India (Lal and Kaur, 2006) and Greece (Venieri et al., 2006). 7.6% of samples tested in Trinidad by Bharath et al. (2003) contained _Pseudomonas spp._ and 13% of samples tested in the Indian study (Lal and Kaur, 2006) also tested positive for _Pseudomonas spp._ _Pseudomonas aeruginosa_, some of which are antibiotic resistant, have been isolated in bottled waters. _P. aeruginosa_ was isolated in Nigeria (Ogan, 1992), Greece (Venieri et al., 2006) and Spain (Rivilla & Gonzalez, 1988). Venieri et al. (2006) found that _P. aeruginosa_ was the most frequently isolated microorganism in bottled noncarbonated (‘still’) mineral waters tested and the Nigerian study isolated antibiotic resistant _P. aeruginosa_ from two brands of bottled water. Rivilla & Gonzalez (1988) found that all samples tested in their study did not comply with the European Economic Community (EEC), Food and Agriculture Organization of the United Nations (FAO), World Health Organization (WHO) or the Spanish normative requirements. Therefore they recommended using testing for _Pseudomonas aeruginosa_ as one of the parameters for determining bottled water quality.

The growth of heterotrophic bacteria has also been observed in bottled water brands. The difficulty with heterotrophic plate count (HPC) in bottled water is that this microbiological criterion is not regulated in some countries, such as USA. Contrary to USA, HPC values in bottled waters are governed in India. The study by Jeena et al. (2006) found that approximately 40% of the samples tested in her study exceeded the limit of 100 CFU/ml set by the Department of Health and by the Bureau of Indian Standards (BIS), Government of India. Saleh et al. (2008) found that four out of the 35 brands of the bottled water samples analysed in Texas were found to be contaminated with heterotrophic bacteria. Massa et al. (1997) detected HPC in 31 glass and 40 plastic (PVC) Italian bottled mineral waters. Breuer et al. (1990) stressed that the presence of HPC of 100-500 CFU/ml in 5 out of the 31 samples they tested, indicated a problem with the bacterial cleanliness of the samples. Breuer et al. (1990) thought that the lack of microbiological information about the source water, the treatment methods and the containers being used could have affected the interpretation of HPC results. This is one of the reasons why in my study I have chosen to look in more detail at the source water quality, treatment, transportation, materials of bottles, the status of Food Safety Programmes, policies, procedures and training. Several studies recommended that bottled water should not be consumed by immunocompromised individuals. Croci et al. (2001) stated that the presence of high densities of _Aeromonas hydrophila_ in bottled mineral water can constitute a risk. While _A. hydrophila_ naturally occurs in mineral waters, the level of mineral content, temperature, length of storage, and, in some cases, the type of container used may favor the growth of _A. hydrophila_, which is not desirable for immunocompromised individuals. Jeena et al. (2006) concluded that high levels of HPC bacteria with multiple drug resistance (to ampicillin, nalidixic acid, novobiocin and oxytetracycline) posed a significant health hazard to the consumers, especially to immunocompromised individuals. Papapetropoulou at al. (1997) also stressed...
that when bottled water is going to be consumed by immunocompromised patients, the environmental mycobacteria counts in bottled water was a useful guide of the hygienic quality. Olayemi (1999) recovered *Staphylococcus aureus* in spring waters packaged and hawked in cellophane in Nigeria. Bharath et al. (2003) isolated aerobic bacteria in 33.6% of domestic brands and in 14.8% of imported brands in Trinidad. Kassenga (2007) detected heterotrophic bacteria in 92% of the 13 bottled water brands tested in Tanzania. Venieri et al. (2006) tested still mineral waters in Greece and isolated *Pseudomonas spp*, *Aeromonasspp*, *Pasteurellasp*, *Citrobacterssp*, *Flavobacteriumssp*, *Providenciasp* and *Enterococcuspp*. In bottled waters sold in Puerto Rico *P. fluorescens*, *Corynebacterium sp.* J-K, *S. paucimobilis*, *P. versicoloris*, *A. baumannii*, *P. chlororaphis*, *F. indologenes*, *A. faecalis* and *P. cepacia* were isolated by Reyes et al. (2008). Breuer et al. (1990) recommended using HPC as a quality control check or as an auxiliary check of the source water quality immediately after the bottling process. They recommended using a control value in line with the order of the European standard of approximately 100 CFU/mL. The study also concluded that additional quality control checks for containers to prevent bacterial growth during storage and transit should be carried out.

Inspecting water bottling plants adds a new dimension to the multifaceted approach of ongoing research of bottled water in general. As research has no legal powers to enter the bottled water plants, it is very difficult for them to gain entry into those plants and to achieve the cooperation of the manufacturer. The to date available research that involves the inspections of bottled water plants has been described by Mavridou et al. (1994) and Defives et al. (1999). Defives et al. (1999) found that while the initial levels of bacteria in some French mineral waters were low, the counts were higher after the bottling process. This indicated that contamination could have occurred during the bottling process. Mavridou et al. (1994) collected microbiological data by inspecting thirty eight bottling water plants in Greece between 1987 and 1992. The data was collected using two methods: 26 factories were monitored monthly according to the legislation and 12 factories were inspected after complaints from consumers were received or within the routine work of health officers. The researcher tested the collected bottled water brands for total coliforms, faecal coliforms, *E. coli*, total streptococci, *Pseudomonas aeruginosasa* and Clostridium perfringens in accordance with the International Standards Organization (ISO) techniques (ISO 1993). Mavridou et al. (1994) found that 31.3% of samples tested were unsuitable for consumption according to the corresponding Greek legislation. In 1997, Papapetropoulou and colleagues, isolated environmental mycobacteria in 15.3% of the bottled water samples tested that were bottled by the Greek factories. Following the studies by Mavridou et al. (1994), Defives et al. (1999) and Papapetropoulou et al. (1997), the researchers made recommendations.

As the researchers do not have legal powers, from their respective articles I was unable to ascertain whether the recommendations, for example not to consume certain brands or batches of bottled water or withdraw it from sales, had been followed or implemented. To date there have been four studies (Cabral, 2002; Criado et al., 2004; Riberio et al., 2006; Papapetropoulou et al., 1997) that have investigated the presence of fungi in bottled water. While there is no legal requirement under the government regulations for testing for fungi with respect to bottled water quality, the presence of fungi in water may indicate poor process control. Papapetropoulou et al. (1997) isolated environmental mycobacteria in 23 of the 150 tested bottled water samples bottled by Greek factories. The environmental mycobacteria detected were *Mycobacterium chelonae*, *Mycobacterium phlei*, *Mycobacterium gordonae* and *Mycobacterium flavescens*. In 2002 Cabral reported detecting 5 different fungal isolates, namely *Penicillium* (46%), *Cladosporium* (32%), *Rhizopus* (8%), *Aspergillus* (3%) and *Phoma* (3%), from samples of eight commercial mineral water brands in Argentina. Riberio and colleagues (2006) performed an one-year long fungal survey located at one bottling plant. The purpose of the survey was to evaluate the incidence and fluctuations of the mycobiota (Riberio et al., 2006). The dominant fungal genera in order of highest numbers isolated were found to be *Penicillium*, *Cladosporium* and *Trichoderma*. The samples were collected during the warmer months, particularly during May and June. Fungal strains were isolated from the water filter and were also detected elsewhere in the factory. This highlighted the need to change filters more often. As a result of this survey a HACCP programme was implemented and Best Practice Guidelines introduced in this factory.
Although the perceived public health risk posed by filamentous fungi in water is thought to be negligible, some fungi, such as *Penicillium citrinum*, that have been isolated from mineral water may be toxigenic. Criado et al. (2004) studied the influence of different storage conditions, such as temperature, illumination, brand of mineral water and storage time on growth of mould spores. Mineral and mineralised waters packaged in polyethylene terephthalate (PET) bottles were inoculated with *Alternaria alternata, Penicillium citrinum* and *Cladosporium cladosporioides*. Storage time was the parameter that had the most important influence on mould growth. Spores grew into visible colonies after 5 months of incubation in bottles just filled, and in one month in bottles that had been stored for 5 months. *A. alternata* and *P. citrinum* strains were toxicologically characterised and both strains produced mycotoxins in vitro. *P. citrinum* also produced citrinin, a toxigenic substance, in mineral water.

Several researchers (Defives et al., 1999; Ribeiro et al., 2006; Kokkinakis et al., Zamberlan da Silva et al., 2008) have highlighted the importance of Good Manufacturing Practice (GMP). Defives et al. (1999) also recommended Best Practice Guidelines. Kokkinakis et al. (2007) recommended improvement of Hazard Analysis of Critical Control Points (HACCP) based systems. Zamberlan da Silva et al. (2008) highlighted the need for an improved surveillance system for the bottled water industry. Ribeiro et al. (2006) highlighted the need to change filters in the factories more often during periods of high fungal contamination, such as warmer months of the year. As a result of Ribeiro et al. (2006) study HACCP programme was implemented and Best Practice Guidelines were introduced in one water bottling factory. Defives et al. (1999) also pointed towards the need of more stringent legal requirements to be introduced. Kokkinakis et al. (2007) highlighted the importance of continuous monitoring of the source water quality, implementing the correct storage conditions, hygiene procedures and customer training at supermarkets.

According to the European Community Directive (1980), natural mineral water in Europe cannot be treated. The safety is maintained by strict controls at the source. In Spain and France legislation does not permit the treatment of mineral water, because the water is considered to have ‘therapeutic’ properties. The presence of naturally occurring bacteria is seen as unavoidable, even indicative that the mineral water has not been sterilized and therefore its therapeutic characteristics have been conserved (Gonzalez et al., 1987). In the European Union (EU) natural mineral waters are subject to an authorisation procedure, which is carried out by the competent authorities of the EU member states or by European Economic Area (EEA) countries (http://ec.europa.eu).

**Bottled Water Quality Monitoring- Legislative Responsibilities**

There have been several guidelines published by the World Health Organization (WHO) and the most recent edition is dated 2008. Many countries use the WHO Guidelines for Drinking-water Quality as the basis to establish their own national standards. In these Guidelines a scientific assessment of the risks to health from biological and chemical determinants of drinking-water and of the effectiveness of control measures is described. When adapting the Guideline values to national standards WHO recommend using a risk-benefit approach and to take into account social, economic and environmental factors. As the WHO Guidelines for the Drinking Water Quality are meant to be the base for the development of standards, including bottled water, the actual standards will sometimes vary from the Guidelines. WHO also raised the importance of microbiological quality of ice designated for human consumption. What they meant was that the ice should be of drinking water standard. The equipment where the ice is made and stored must be of satisfactory standard of cleanliness. The same principles should apply for water in large glass bottles that are protected by basketwork or wooden boxes. WHO, one of the cosponsors of the Codex Alimentarius Commission (CAC), has advocated the use of the Guidelines for Drinking Water Quality as the basis for derivation of standards for all bottled waters (www.who.int). In many European countries consumers believe that natural mineral waters have medicinal properties or offer some health benefits. These waters generally
are high in mineral content and, in some cases, notably above the concentrations that are generally accepted in drinking water. Such waters have a long tradition of use and are often accepted on the basis that they are considered foods rather than drinking water. In some countries bottled waters with very low mineral content, such as distilled or demineralised waters, are available for sale. CAC is the intergovernmental body for the development of internationally recognized standards for food. The CAC has developed a Codex Standard for Natural Mineral Waters and an associated code of practice. The Codex Standard describes the product and its labeling, compositional and quality factors, including limits for certain chemicals, hygiene, packaging and labeling. The Codex Code of Practice for Collecting, Processing and Marketing of Natural Mineral Waters provides guidance to the industry on a range of matters of good manufacturing practices. While CAC standards and recommendations are not strictly mandatory, Codex health and safety requirements are recognized by the World Trade Organization as representing the international consensus for consumer protection. Any deviation from Codex recommendations may require a scientifically based justification. A draft of a Codex Standard for Bottled and Packaged Waters to cover drinking water other than natural mineral waters is being developed. Under the existing Codex Standard and Code of Practice, natural mineral waters must comply with strict requirements regarding, for example, the direct collection and bottling of water without any further treatment from a natural source, such as a spring or a well. The draft Codex Standard for Bottled and Packaged Waters has been proposed to include waters from other sources in addition to springs and wells.

It also proposed to include the treatment to improve the safety and quality of bottled water. The distinctions between these standards are especially relevant in regions where natural mineral waters have a long cultural history. Within the CAC, the Codex Committee for Natural Mineral Waters, which is hosted by Switzerland, is responsible for the development of draft Codex Standards and Codes of Practice in consultation with other relevant Codex Committees, especially the Codex Committees on Food Additives and Contaminants and Food Hygiene. CAC and WHO do not certify bottled or mineral water products. Many countries have national standards for bottled waters and some countries have national certification schemes. At present there is no universally accepted international certification scheme for bottled and mineral waters. The European Union European Directive 80/777/EEC, modified by Directive 96/70/EC deals with the marketing and development of natural mineral waters in the European Union. The Australasian Bottled Water Institute Inc. (ABWI) is an Australian bottled water industry lobby group. It is a regional member of the International Council of Bottled Water Associations (ICBWA).

Conclusion

Out of all the literature researched for my research project, Venieri et al. (2006) study design proved to be the closest to my study. In that study Enterococci were detected in Greek bottled waters, which indicated possible faecal contamination. All thirty eight domestic and imported bottled water brands complied with the Food Standards Code (Australia and New Zealand) for Pseudomonas aeruginosa. Seventeen bottled water brands, nine of them New Zealand domestic brands, failed to demonstrate compliance for the TVC with the Packaged Water and Ice Criteria of Australia and New Zealand Food Standards Code (2002). I consider this to be of importance as linear relationship between HPC and coliform bacteria had previously been identified (Jeena et al., 2006). Therefore bottled waters should be routinely and regularly monitored for TVC during or immediately after the bottling process to ensure a satisfactory quality control and adequate plant hygiene. In addition to subjecting the bottled water samples for microbiological testing, a questionnaire to examine the impact of the manufacturing practices on the microbiological quality of bottled waters tested was performed. There was a low response rate and questionnaires from only four manufacturers representing 11 of the bottled water brands tested were received. Even though most manufacturers carried out microbiological monitoring, contaminated bottled water brands were still identified, demonstrating that GMP procedures were not fully effective. These findings support the conclusions made by Zamberlan da Silva et al. (2008) who highlighted the need for an improved surveillance system in the bottled water industry.
References


