HACCP and water safety plans in Icelandic water supply: Preliminary evaluation of experience

María J. Gunnarsdóttir and Loftur R. Gissurarson

ABSTRACT

Icelandic waterworks first began implementing hazard analysis and critical control points (HACCP) as a preventive approach for water safety management in 1997. Since then implementation has been ongoing and currently about 68% of the Icelandic population enjoy drinking water from waterworks with a water safety plan based on HACCP. Preliminary evaluation of the success of HACCP implementation was undertaken in association with some of the waterworks that had implemented HACCP. The evaluation revealed that compliance with drinking water quality standards improved considerably following the implementation of HACCP. In response to their findings, waterworks implemented a large number of corrective actions to improve water safety. The study revealed some limitations for some, but not all, waterworks in relation to inadequate external and internal auditing and a lack of oversight by health authorities. Future studies should entail a more comprehensive study of the experience with the use of HACCP with the purpose of developing tools to promote continuing success.

Key words | drinking water quality, five-step mini-HACCP, HACCP, water safety management, water safety plans

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INTRODUCTION

Safe drinking water is a very important contributor to good public health. Drinking water can be polluted at the source, during treatment, en route to consumers or in the household. Safe drinking water means water that will not jeopardize health and is reliable and available at all times. The World Heath Organisation (WHO) has been promoting a systematic preventive approach – water safety plans (WSP) – as a means of promoting safe drinking water provision. Guidance on WSPs is given in the latest version of WHO's *Guidelines for Drinking Water Quality* (WHO 2006) and further in the publication *Water safety plans: Managing drinking-water quality from catchment to consumer* (Davison *et al.* 2005).

Since 1995 drinking water in Iceland has been classified in legislation as a food, and waterworks as food processing plants. Subsequently the waterworks have had to implement a safety plan to secure the safety of the food (i.e. drinking water) that they produce. Icelandic waterworks have been at the forefront of applying this approach to water safety by implementing hazard analysis and critical control points (HACCP) since 1997, ahead of other countries (Gunnarsdóttir 2005).

Samorka, the Association of Icelandic Waterworks, has promoted the implementation of WSPs and a working group created guidelines both for HACCP in 1996 and later for a simpler WSP, mini-HACCP, for smaller waterworks in 2004. The first utility water supply to implement HACCP was the capital city Reykjavik, in May 1997. Later that same year Reykjavik was followed by two towns: Sauðárkrókur and Vestmannaeyjar. By May 2007, 22 towns, representing 68% of the Icelandic population, had or were in the process of implementing HACCP or the simpler WSP (Gunnarsdóttir & Gissurarson 2006) as shown in Table 1.

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Table 1 | Icelandic waterworks with HACCP and mini HACCP in May 2007

	Name of town	Date of approval	Number of inhabitants (Dec 2004)	Accumulated population with WSP	Proportion of Icelandic population (%)	Type of town
1	Reykjavík	HACCP/May 1997	113,730	113,730	38	Capital town
2	Sauðárkrókur	HACCP/Nov 1997	2,796	116,526	39	Fishing town
3	Vestmannaeyjar	HACCP/Nov 1997	4,522	121,048	41	Fishing town
4	Garðabær	HACCP/March 1998	10,471	131,519	44	Sub town
5	Þorlákshöfn	HACCP/Oct 1998	1,372	132,891	45	Fishing town
6	Hveragerði	HACCP/June 1999	1,766	134,657	45	Greenhouse and agriculture
7	Akureyri	HACCP/Dec 1999	16,800	151,457	51	Town – centre of the northern area
8	Dalvík	HACCP/Jan 2000	2,040	153,494	52	Fishing town
9	Hafnarfjörður	HACCP/June 2000	20,672	174,169	59	Industry, fishing and sub town
10	Mosfellsbær	HACCP/Oct 2002	6,496	180,665	61	Sub town to Reykjavik
11	Seltjarnarnes	HACCP/Oct 2002	4,654	185,319	63	Sub town to Reykjavik
12	Akranes	HACCP/April 2003	5,342	190,661	65	Industry, fishing
13	Borgarnes	HACCP/2004	1,730	192,391	65	Service town for west area
14	Siglufjördur	Mini HACCP/2005	1,561	193,952	66	Fishing town
15	Hvammstangi	Mini HACCP/2005	698	194,650	66	Fishing town
16	Stöðvarfjörður	Mini HACCP/2005	276	194,926	66	Fishing village
17	Berglind, Ölfusi	Mini HACCP/2005	144	195,070	66	Farms and tourist area. Many more temporary residents
18	Hlíðarveita í Biskupstungum	Mini HACCP/2006	200	195,270	66	Farms and summerhouses (mostly temporary residents)
19	Bifröst	Mini HACCP/2006	300	195,570	66	Bifrost-University, farms and tourist area. Many more temporary residents, mostly students
20	Hvanneyri	Mini HACCP/2006	300	195,870	66	Agricultural University. Many more temporary residents mostly students
21	Flúðir	Mini HACCP/2007	536	196,406	67	Greenhouse, farming, tourist centre and summerhouses. 600 more temporary residents
22	Egilsstaðir and Fellabær	Mini HACCP/2007	2,364	198,770	67	Town – service centre for the eastern area
	Total		198,770		68	

Note: Total population of Iceland in December 2004 was 293,291.

The waterborne diseases that have been reported in Iceland in the last 20 years have all been in small waterworks in fishing towns or in recreational areas (Gunnarsdóttir 2005). It is, therefore, important to implement the concept of water safety and the preventive approach in smaller communities. From the early stages of HACCP implementation it became evident that a full HACCP system was too complex and time consuming for the smaller waterworks because of their lack of resources. Therefore, Samorka, in cooperation with four small waterworks, developed a simpler WSP in 2004, called the five-step plan, or mini-HACCP. There are now eight small waterworks with this simpler WSP. The simpler WSP is now being actively promoted for small waterworks and guidelines have been placed on Samorka's website for all waterworks to use.

WHO has recognized the need for attention to the special challenges of supplying safe water to small or remote communities and has initiated international cooperation on small community water supply management. Icelandic waterworks are participating in this work internationally and have been promoting this concept among the Nordic countries.

EVALUATION

The ten years of Icelandic experience with the application of HACCP to water provides a body of experience that should be evaluated. A preliminary study of the improvements resulting from the implementation of HACCP indicates that overall the programme has been a success for Icelandic waterworks (Gunnarsdóttir & Gissurarson 2006).

HACCP has raised awareness of the importance of protecting water resources and many corrective actions and improvements have been implemented. However in some places the implementation revealed a lack of external audit, and inadequate internal self-regulation and control, by health authorities. Audit and back up from the health authorities has been limited because these authorities lack the resources to carry out what would logically be required of them. The lack of support could over time result in a decreased interest in good performance and improvement would fade out with time. External support and recognition is considered important to maintain support from management and staff motivation.

Reykjavik

The preliminary study showed that implementing HACCP improved compliance with regulated drinking water quality standards in the town of Reykjavik as illustrated in Figure 1. The mean compliance value for bacterial count for 22°C improved from 94% for the years 1991 to 1997 to 99% for the years 1998 to 2006. Drinking water in Reykjavik is mostly derived from boreholes.

A number of projects were started when implementing the HACCP system and completed as a result of the hazard analysis. In addition, when implementing HACCP in Reykjavik, some corrective actions were undertaken and additional control measures were applied at critical control points. A number of additional control measures introduced were as follows:

1. Thawing plan: during periods when snow is melting, shallow wells are closed down.
2. A programme was introduced for cleaning out fire hydrants and dead ends twice per year.
3. Sanitary plan: cleaning of tanks 1–2 times per year and cleaning of pumping stations thoroughly once a year with a checklist for on site quality and safety procedures.
4. Other control measures: regular preventive checking of well zones, fencing, status of gates and inspection of vehicles to verify that they are not leaking oil or other fluids.

Waterworks management identified the following as representing the benefits of implementing HACCP:

- More thorough control resulting in higher product quality.
- Greater system understanding and follow up so that if something goes wrong it is easier to trace and fix the problem.

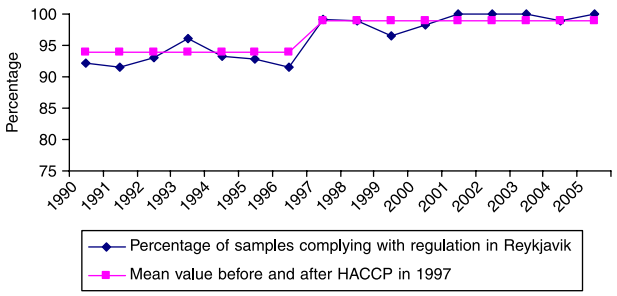

Figure 1 | Percentage of samples complying with regulated drinking water quality standards in Reykjavik from 1990 to 2006 and mean value before and after HACCP in 1997.

- All deviations are documented and reported as incidents.
- More disciplined working methods.
- Continuous improvement.
- Stronger market position.
- Good for business.

The main water quality improvement in Reykjavík was thought to have arisen from closing down shallow wells during periods of snow melt. Regular cleaning of fire hydrants and dead ends is also considered to have led to significant improvements in water quality.

Akureyri

In Akureyri HACCP was implemented in December 1999. Following implementation the proportion of samples complying with the regulated water quality standard increased, as in Reykjavik. The mean compliance value for bacterial counts for 22°C increased from 88% for the years 1992 to 1999 to 99% for the years 2000 to 2004 after implementing HACCP (A. Árnason, unpublished information from Norðurorka, Iceland, in November 2005 and February 2007; see Figure 2). Approximately 86% of water for Akureyri is spring water and 14% is from boreholes.

The improvements detected did not emerge immediately, but arose over time, following corrective actions being taken as a result of implementing HACCP. The corrective actions taken were as follows:

- Improved water intakes for spring water. These improvements were made in stages as there were 22 water intakes in total.
- Old distribution and connection pipes were renewed over a period of time in an area where water samples often had elevated bacterial counts.

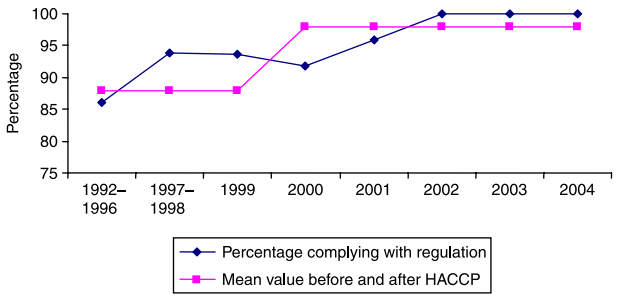

Figure 2 | Percentage of samples complying with regulation in Akureyri 1992–2004, HACCP in December 1999.

- The pipeline to the airport was cleaned as the pipe was oversized which resulted in sedimentation. The pipe is now regularly cleaned twice per year.
- Fencing around the well protection zones was renewed.
- Signs for the catchment area, including a map showing prohibited areas for vehicles, were installed.

The main detected improvements in water quality arose after the pipeline to the airport was cleaned. Control measures around the well zones included a sanitary plan, regular monitoring and a working procedure for protecting well zones. The procedure on well zones included strict rules for snowcats as one of the three well zones is in a ski area. There were 23 critical control points identified that needed regular monitoring based around three well zone areas, each of which had many springs and boreholes.

Not many deviation incidents were recorded, very few in recent years. Most of the deviations recorded were related to the need to repair fences to keep out sheep, the need to repair lids on water tanks and the need to repair cracks in concrete tanks. At the beginning of 2007 there was a deviation incident on one of the well zones (A. Árnason, unpublished information, 2007). Snow scooters went into the well zone and one of them had an accident that resulted in injuries to the driver and an oil spill from the scooter. The spill was quickly cleaned up and measures were taken to promote the importance of protection of the water resource both by advertisements in local newspapers and in cooperation with the local snow scooter club.

RESULTS AND FUTURE STUDIES

The results of this study are consistent with HACCP implementation leading to improved compliance with regulation for drinking water quality. Mean values for compliance for samples from all spring water supplies in Iceland is 89%. In contrast, samples from Akureyri, which is mostly supplied by spring water, had 99% compliance with regulated drinking water standards after implementing HACCP. Most of the water intake in Reykjavik is from boreholes. For the country as a whole, borehole water samples showed 96% compliance with regulated water quality standards compared with Reykjavik which has 99% compliance (Gunnarsdóttir & Gissurarson 2006). The main

improvement in Reykjavík was observed after closing down shallow wells during periods of snow melt.

A study performed by the Environment and Food Agency showed that 90% of drinking water samples in Iceland for the period 1989–2001 complied with regulatory requirements for water quality (Georgsson 2002). The same study showed that 96% of borehole water, 92% of treated surface water, 89% of spring water and 50% of untreated surface water samples complied.

An analysis of regular surveillance results undertaken by health authorities in south Iceland for the year 2004 showed that 85% of the drinking water samples in that area complied with regulatory requirements for quality (Guðmundsdóttir 2006). This part of Iceland is a farming area with some eight towns and also some greenhouses and school centres, with a population of around 20,000. In this area there are three towns where HACCP has been implemented (Vestmannaeyjar, Þorlákshöfn & Hveragerði) and in each case 100% compliance was achieved. Non-compliance occurs mostly at small waterworks serving the farming areas. It has also been shown that there is a significantly higher content of nitrate in drinking water from catchment areas in Iceland with agriculture, albeit at levels well below safety limits (Gunnarsdóttir *et al*. 2005).

This preliminary study indicates that the implementation of HACCP by Icelandic waterworks has been a success, as can be seen in Figure 3. The implementation of HACCP led to many corrective actions and improvements being made. The programme appears to have improved drinking water quality and it is probable that these improvements in water quality have resulted in health benefits in the relevant towns. In addition, the use of HACCP has raised awareness of the importance of protecting water resources.

Our study revealed an inadequate auditing process as well as poor oversight by the health authorities in some areas. Scrutiny from audit and back up from the health authorities has been inadequate due to a lack of resources to carry out these functions. Over time, the lack of support from health authorities could result in decreased interest in good performance and a loss of the continuous improvement benefits of applying a rigorous HACCP approach. Support and recognition from health authorities is important to trigger support from management and for motivating staff.

There were some important exceptions to this problem. At Orkuveita Reykjavikur (OR) internal and external auditing is carried out regularly and was a fundamental component of the HACCP system. Reykjavik is an order of magnitude bigger than other waterworks in Iceland and therefore has relatively more resources to organize audits. OR has an integrated management system approach and has implemented ISO 9001, ISO 14001 and OHSAS 18001 and HACCP, all in place since 1997, for all its functions – drinking water, sanitation, district heating and electricity supply. Nordurorka, which is the waterworks in Akureyri, the town centre for the northern area, also supplies district heating and electricity, and has a good auditing process for its HACCP system and makes great efforts to maintain the process. Nordurorka has implemented HACCP as part of its ISO 9001 system.

HACCP is a relatively new instrument in the water sector and, therefore, there has not been much evaluation of its value, the gains, the lessons learned and what is required

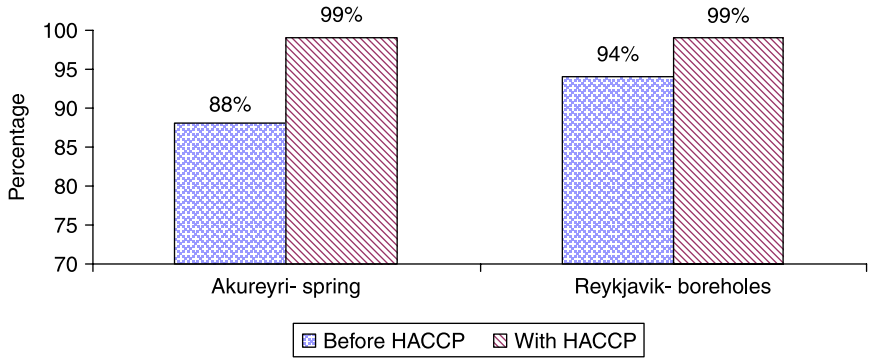

Figure 3 | Improvement in compliance with regulated water quality standards after HACCP implementation in Akureyri and Reykjavík. Compliance is with bacterial count for 22°C (source: Gunnarsdóttir & Gissurarson 2006).

for continual success. Critical review of the Icelandic experience has value for other countries as well as locally. The European Union is preparing a directive where a preventive approach is required and many waterworks in Europe are in the early stages of implementing systematic preventive approach. Iceland now has ten years of experience in this area and it is of value to share this experience.

In future there are plans to undertaken a comprehensive study of the implementation and operation of HACCP and WSP by Icelandic waterworks and an evaluation of the benefits compared with the cost and effort. The smaller waterworks five-step mini-HACCP approach will also be evaluated with a view to identifying what support has to be in place to realize implementation of the system in order to achieve safer drinking water in smaller communities. The long-term aim is to develop tools to keep the water safety process active so that the approach of preventive control and quality awareness will be firmly established in the water sector in Iceland. The major challenge in Iceland, as elsewhere, is to secure the safety of water from waterworks serving smaller communities with simpler systems and also to secure continuing success and quality awareness in waterworks that have already implemented HACCP and WSPs.

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