WRc-NSF Ltd

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FURTHER STUDY ON THE POTENTIAL FOR THE RELEASE OF NICKEL FROM KETTLE ELEMENTS – FINAL REPORT

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FURTHER STUDY ON THE POTENTIAL FOR THE RELEASE OF NICKEL FROM KETTLE ELEMENTS – FINAL REPORT

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1. INTRODUCTION

1.1 Background

In 2002 the Drinking Water Inspectorate funded WRc-NSF to undertake a study of the influence of jug filters on the quality of drinking water. This project included an investigation of the corrosion potential of tap water and release of nickel from kettle elements. The report DWI 6049/2 “Assessment of the effect of jug water filters on the quality of public water supplies” (Jackson *et al*. 2003a) was completed in December 2002 and the results were considered by the Food Standard Agency’s Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (CoT).

The results of the study showed a significant release of nickel from kettle elements, with concentrations of up to 150 times greater that the then 50 µg/l standard for nickel in drinking water (the current standard is 20 µg/l with effect from 1 January 2004). The release of nickel was greatest when tap water had been passed through a jug filter that softened the water but the nickel release declined significantly during the four-week period of use of the filter cartridge to levels similar or below that of unfiltered water.

The CoT opinion called for further studies and indicated a specific need for studies in soft and peaty water. The Scottish Executive appointed WRc-NSF to carry out further studies to address some of the questions raised by the CoT. Scottish tap water, deionised water and Medmenham tap water were tested with three models of jug filter and two models of kettle over a five-week period (Jackson *et al*. 2003b). Water boiled in kettles with exposed nickel-plated heating elements contained elevated concentrations of nickel. The results obtained with two different models of kettle were similar throughout the tests. In laboratory tests nickel concentrations in boiled unfiltered water were generally lower than the corresponding results for filtered water using new kettles and filter cartridges. The highest nickel concentrations were found with filtered Scottish water; the lowest nickel concentrations were found with unfiltered Scottish water. There were statistically significant differences in the results for different filters (including unfiltered water), different waters and filter-water combinations. Samples were also taken by a selection of consumers and elevated nickel concentrations were found in about half of these samples. However, the nickel concentrations were generally lower than those found in laboratory tests and filtered water did not consistently produce higher nickel release in these samples.

Following consideration of the results of these studies, CoT concluded that further studies would be beneficial in order to more accurately replicate domestic kettle usage patterns of consumers. It was also felt that the use of jug filters to provide artificially softened water for trial alongside naturally soft tap water introduced further variables into the study, which complicated the interpretation of the results. The Scottish Executive appointed WRc-NSF to conduct further studies that mimic more closely the normal domestic usage of kettles, without the complication introduced by the use of jug water filters.

1.2 Objectives

The objectives, as stated in the invitation to tender were as follows.

The overall objective of this project is to address CoT concerns surrounding the applicability of results obtained from the previous work and provide sufficient robust data to enable them to form an opinion on the potential health risks associated with acute levels of exposure to nickel *via* this route.

Specific objectives are:

1. To repeat boiling trials using two different types of kettle containing nickel elements at intervals, boiling and sampling at intervals more typical of likely domestic usage patterns, including the possibility of re-boiling water;

2. To examine the influence of water standing time in the kettle prior to analysis;

3. To provide a final report which will present data which is sufficiently robust to enable the CoT to determine the likely health risks.

Trials should be undertaken using two models of kettle having elements containing nickel and two water types: de-ionised and naturally soft tap water. A control kettle, which does not contain nickel, should also be used. The presence of nickel in the kettle elements should be verified using a suitable analytical technique. The chemical composition of the waters used in the trials should also be determined by analysis of relevant key parameters.

The boiling and sampling regime used should aim to replicate typical domestic usage patterns as far as possible and over an extended time period of at least 20 weeks[1].

Water taken from the kettles should be analysed for nickel using a recognised method in an accredited laboratory.

The data obtained from these trials should be analysed using an appropriate statistical analysis technique to determine the significance of any trend found.

Information on the reproducibility of the results should be obtained by using replicate kettles.

1.3 Structure of the report

The kettles, test waters and experimental conditions are described in Section 2.

The results, including statistical analysis, are presented in Section 3.

Section 4 discusses the results and the principal conclusions are given in Section 5.

Details of the results and the statistical analysis are given in Appendices A and B respectively.

[1] Following consideration of the initial results, the experiment was terminated after 12 weeks on the advice of the CoT. Experiments on re-boiling were then undertaken.

2. EXPERIMENTAL

2.1 Experimental protocol – extended boiling tests

The protocol, as given in the project proposal, was as follows.

The boiling experiments will be undertaken at WRc-NSF's Oakdale laboratory, which is supplied with naturally soft tap water. Two test waters will be used: deionised water and Oakdale tap water (calcium content ~20 mg/l Ca). At the start of the experiments a 'full' chemical analysis will be undertaken on Oakdale tap water; thereafter pH will be measured daily and calcium and alkalinity weekly.

Two models of kettle with nickel-plated elements will be tested – these will be kettles K and L as used in the previous studies for the Scottish Executive and DWI[2]. Sections of the kettle elements will be dissolved in acid and analysed for metals by ICP-MS to confirm that the elements are nickel-plated[3]. A 'control' kettle, with stainless steel element, will also be tested (kettle Q as used in the DWI study). The kettles will be purchased from retail outlets. Duplicate kettles will be tested with each test water. A total of 12 kettles will be tested (3 Models x 2 Replicates x 2 Waters).

The tests will be conducted over a 20-week period. Four 1-litre portions of test water will be boiled each day, five days per week, similarly to the previous experiments. At intervals (for the first six weeks daily, later weekly) samples for nickel analysis will be taken immediately after boiling. For the first five weeks of the test, water will also be analysed for nickel after standing in the kettles for 5, 15 and 30 minutes. Test water 'blank' samples will also be analysed for nickel.

Nickel analysis will be undertaken using a UKAS accredited Inductively Coupled Plasma – Mass Spectrometry (ICP-MS) method ING 113, which has a limit of detection of 0.5 μg/l for nickel.

2.2 Test waters

Two test waters were used:

W Deionised water

Z Oakdale tap water

A full chemical analysis was run on Oakdale water sampled on Day 1 of the testing. Thereafter, pH was measured daily, and alkalinity, calcium and nickel on each sampling day (the sampling schedule is described in Section 2.1).

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2 The kettle models K and L previously used were found to be no longer available, see 2.3.

3 Should this prove inconclusive, analysis by X-ray diffraction would be conducted.

Alkalinity was determined by titration against standardised hydrochloric acid with potentiometric detection of the end point (SCA 1981). Calcium was determined by flame atomic absorption spectroscopy (SCA 1987) and nickel was determined by inductively coupled plasma – mass spectrometry (SCA 1996).

2.3 Test samples

Kettles K and L, as used in the previous studies, were found to be unavailable. Three models of kettle with exposed elements, together with an example of the control kettle Q, were purchased. A volume of 500 ml of 2.5 mol/l nitric acid was boiled once in each kettle and analysed for metals, including nickel. The results are given in Table 2.1.

Table 2.1 Results of acid boiling experiments

Kettle code	Cd μg/l	Cr μg/l	Cu μg/l	Ni μg/l	Pb μg/l	Zn μg/l
Q	0.72	148	556000	93.1	50.4	941000
U	<0.5	106	451000	182	2.50	802000
S	6.37	10.3	7.23E+07	546000	156	63200
T	551	32.7	2.78E+08	1220000	824	497000
Acid blank	<0.5	<1.5	<2.0	<0.5	<0.5	<1.5

On the basis of these results it was concluded that kettles S and T had nickel-plated elements. The kettles used in the acid boiling test were not used in subsequent testing.

Four each of kettles Q, S and T were purchased from retail outlets by WRc-NSF staff. The kettles were prepared by boiling and discarding water following the manufacturers' instructions for use, using the test water with which each kettle was to be used.

2.4 Re-boiling tests

Tests were undertaken to determine nickel concentrations when boiled water had stood in kettles for 8 or 16 hours[4], and the effect of re-boiling that water. Fresh samples of the same models of kettle as used in the extended boiling tests were purchased for this experiment. Each model of kettle was tested in duplicate with deionised or Oakdale water (a total of 12 kettles). The experimental protocol was as follows:

Day 1	at 09:00	add 1 litre of water, boil, sample, do not empty kettle
	at 17:00	sample, boil, sample, do not empty kettle
Day 2	at 09:00	sample, boil, sample, empty kettle
		add 1 litre of water, boil, sample, do not empty kettle
	at 17:00	sample, boil, sample, do not empty kettle

continue as day 2 on days 3, 4 and 5.

[4] The actual times were staggered for each pair of replicate kettles. The '8 hour' standings varied from 7 hours 25 minutes to 8 hours 0 minutes and the '16 hour' from 15 hours 45 minutes to 16 hours 0 minutes.

3. RESULTS

3.1 Extended boiling tests

The chemical analysis of the initial sample of Oakdale water is given in Table 3.1.

Table 3.1 Chemical analysis of feed water

Parameter	Unit	Concentration
Al	μg/l	12.1
Alkalinity	mg/l $CaCO_3$	57.3
Ca	mg/l	25.4
Cl	mg/l	12.3
Conductivity	μS/cm	191
Cu	μg/l	3.96
Fe	μg/l	<20
K	mg/l	1.48
Mg	mg/l	2.94
Mn	μg/l	<1.5
Na	mg/l	9.44
NH_3	mg/l N	<0.5
Ni	μg/l	<0.5
NO_3	mg/l N	0.51
Pb	μg/l	<0.5
Total P	mg/l	0.94
Si	mg/l	0.57
SO_4	mg/l	22.9
TOC	mg/l	1.22
Zn	μg/l	<1.5

The detailed results of the tests are tabulated in Appendix A.

Figure 3.1 shows the pH values of the test waters before boiling[5]. The concentrations of nickel in boiled Oakdale water were either undetectable or similar to the blank value (see Appendix A). Leaching of nickel did occur in deionised water – the results for the first five weeks of testing are summarised in Figure 3.2 to Figure 3.5.

[5] The reason for the shift in the pH of deionised water around Day 15 is not known.

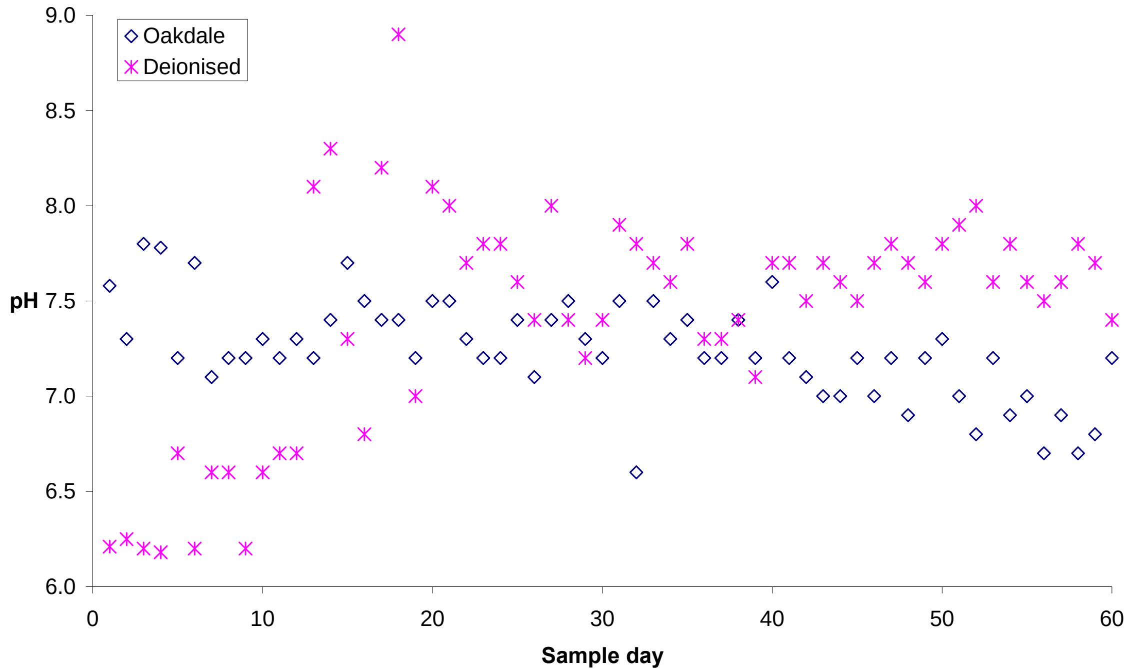

Figure 3.1 pH of test waters before boiling

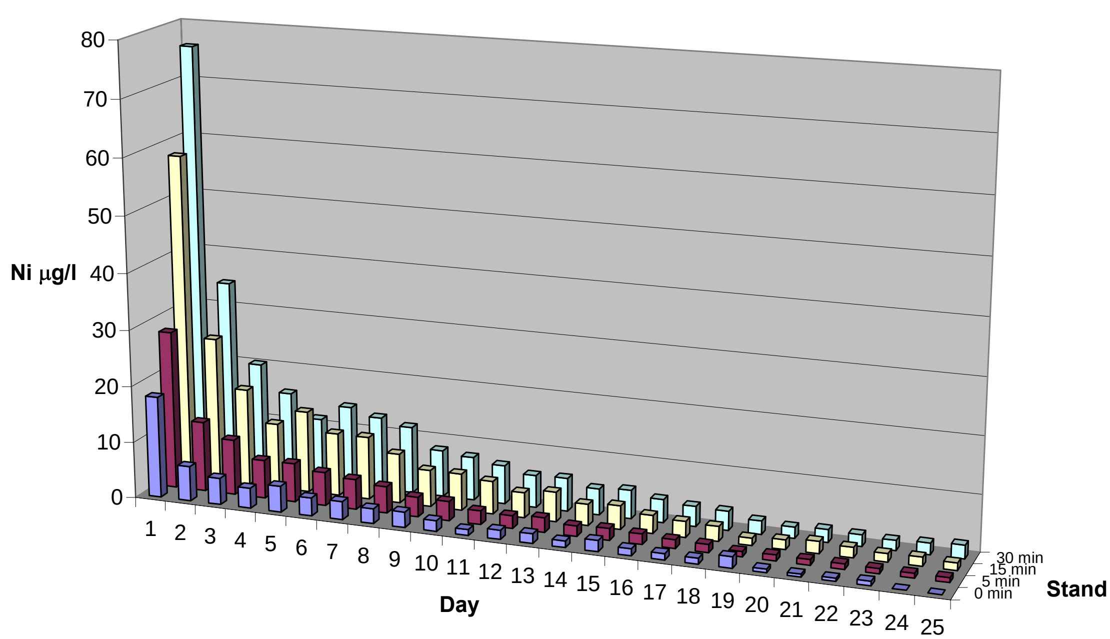

Figure 3.2 Nickel leaching – Deionised water, Kettle S, Replicate 1

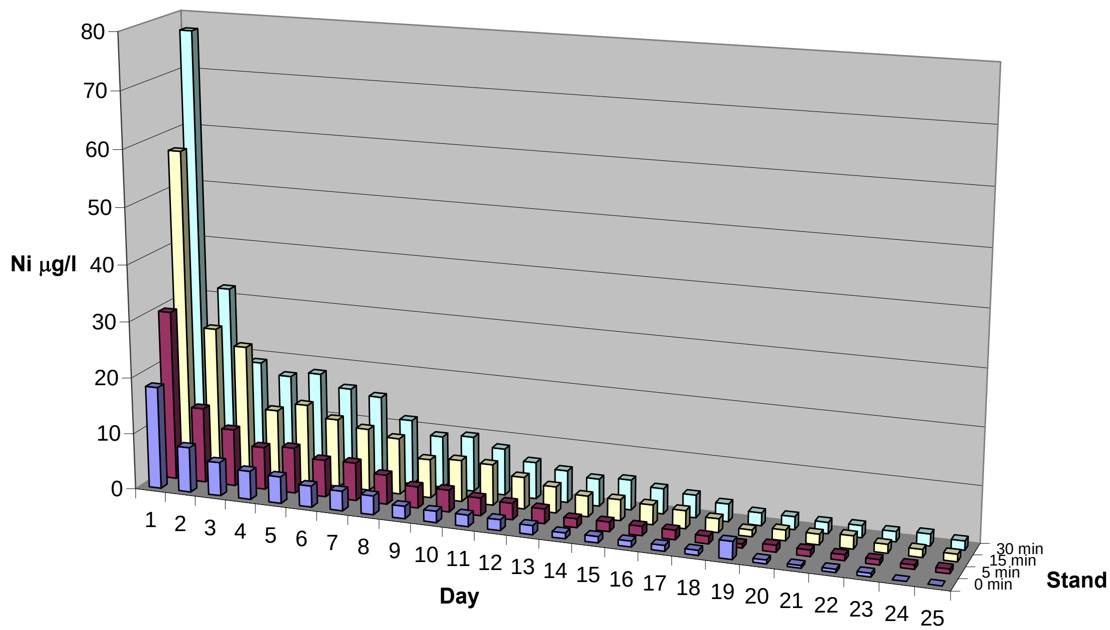

Figure 3.3 Nickel leaching – Deionised water, Kettle S, Replicate 2

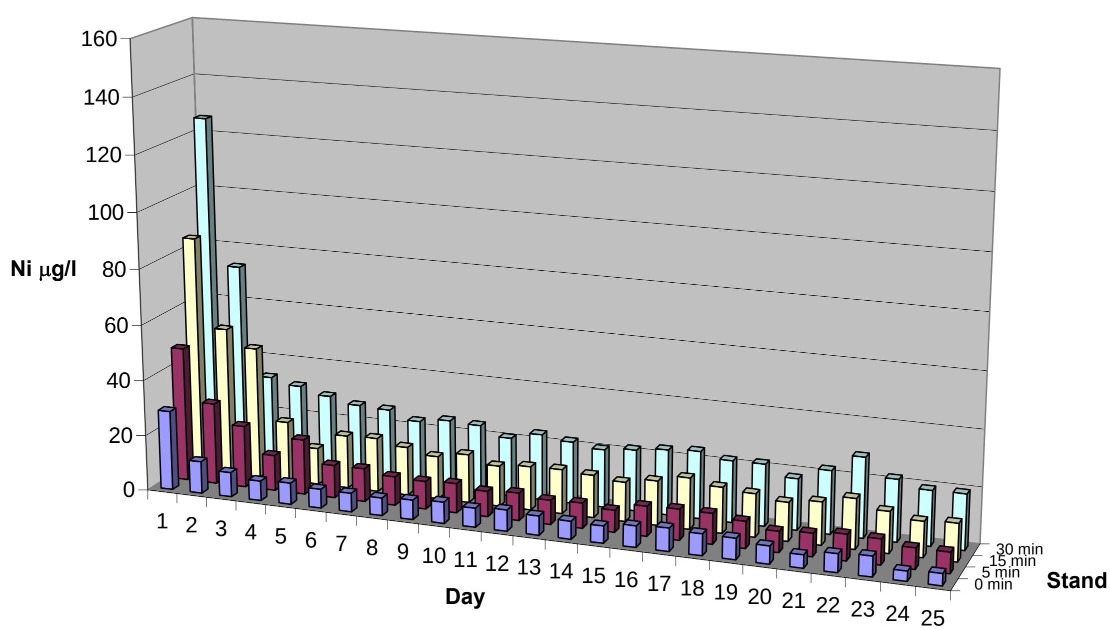

Figure 3.4 Nickel leaching – Deionised water, Kettle T, Replicate 1

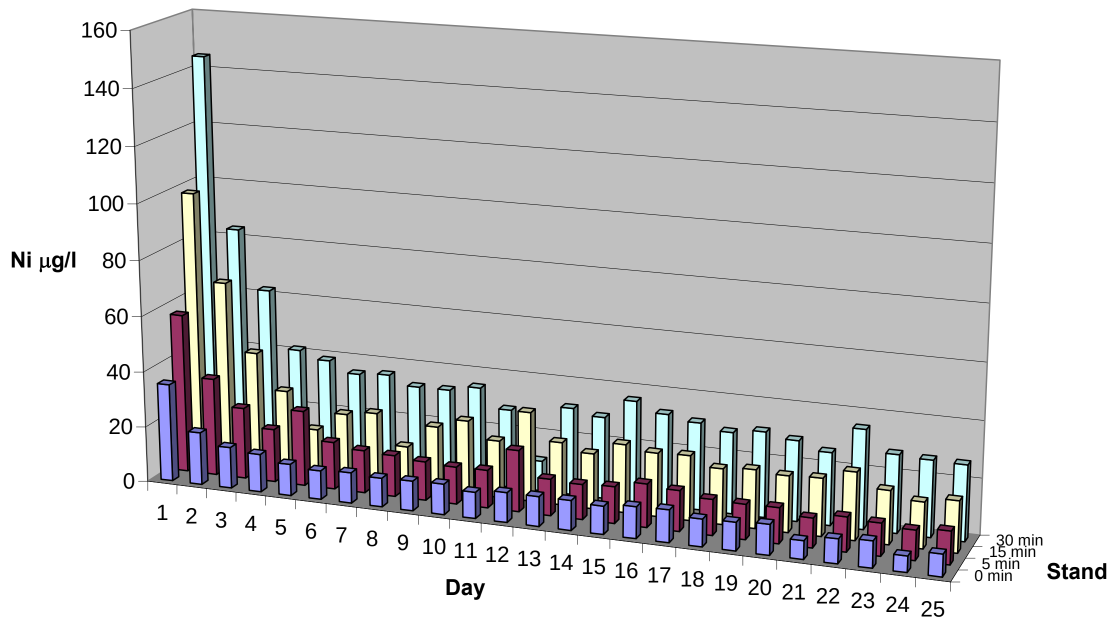

Figure 3.5 Nickel leaching – Deionised water, Kettle T, Replicate 2

The results for all of the samples of deionised water taken after 30 minutes standing for the full 12 weeks of the test are shown in Figure 3.6.

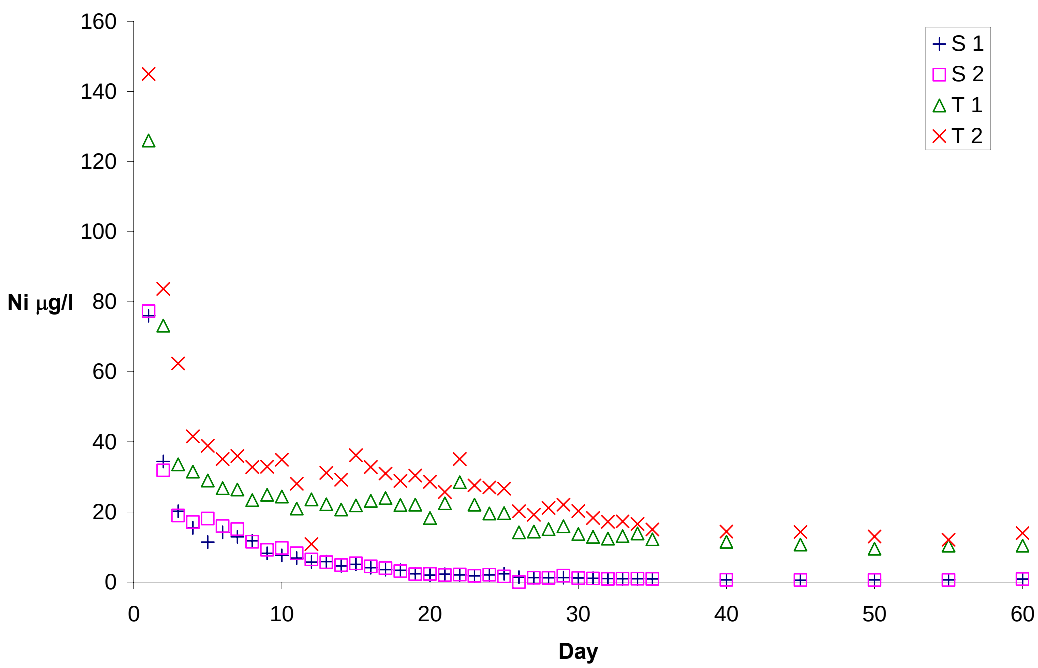

Figure 3.6 Nickel leaching – Deionised water after 30 minutes standing

3.2 Statistical analysis

3.2.1 Data

Nickel concentrations were measured daily between 1 and 25 days:

- In two water types – Oakdale and deionised.
- For each water type, in duplicate kettles of each of 3 types – Q, S and T.
- After four standing times – 0, 5, 15 and 30 minutes.

3.2.2 Regression method

Generalised linear regression was carried out for selected days, using Genstat. The model used was:

Square root [Ni] = Kettle type.Water type + Residence time

The square root of the nickel concentration was used to make the residuals (unexplained variation) approximately normal. Interactions between kettle and water type were allowed, to permit the effect of water type to be different in the different kettles. For each kettle type, water type and standing time there were two replicate kettles.

The selected day numbers were 1, 2, 5, 15 and 25. These were judged to be sufficient to confirm conclusions that were quite evident from examining the data.

3.2.3 Regression results

Effect of standing time

As expected, nickel concentrations tended to increase as standing time increased (Figure 3.7).

For days 1, 2 and 5, there were highly significant differences between all standing times. For days 15 and 25, the differences between 0 and 5 minutes are not statistically significant.

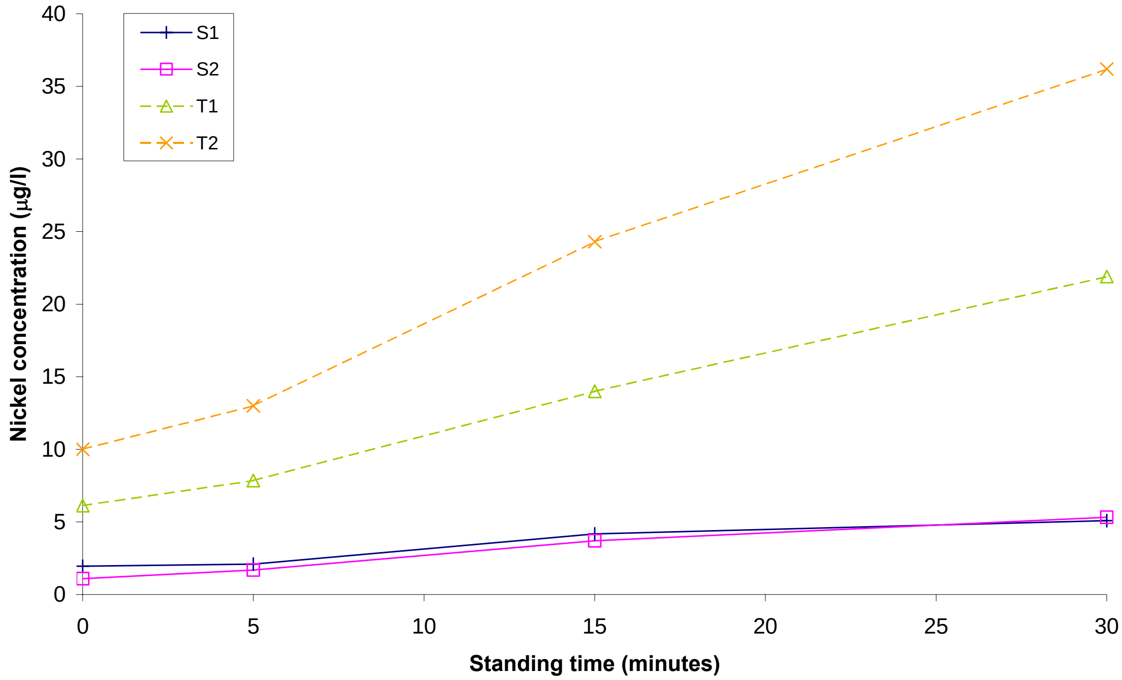

Figure 3.7 Nickel concentrations at day 15

Effect of kettle and water type

A consistent pattern was observed for all the days considered (Table 3.2). The differences between the three kettle types containing deionised water are highly statistically significant (99.9% confidence) for all the days considered.

Nickel concentrations >20 µg/l were found in the kettles S and T containing deionised water on days 1 and 2, which persisted until day 25 and beyond with kettle T (Figure 3.6). Nickel concentrations were consistently low in all kettles containing Oakdale water. Details are given in Appendix B.

Table 3.2 Nickel concentration by kettle and water type

Kettle type	Deionised water	Oakdale water
S	**Second highest**	Low
T	**Highest**	Low
Q	Low	Low

Differences between replicates

Consistently higher nickel concentrations were measured in kettle T2 containing deionised water, compared to kettle T1 (see for example Figure 3.7). No other consistent differences between replicates were observed.

With deionised water, the three kettle types show highly significant differences. With Oakdale water, although there are some statistically significant differences, all nickel concentrations are well below the 20 µg/l limit.

3.3 Re-boiling tests

The following terminology is used for the water samples:

- '0 h' – fresh water, boiled and sampled immediately
- '8 h' – the 0 h water re-sampled after standing for 8 hours
- '8 h boiled' – the 8 h water boiled and sampled immediately
- '16 h' – the 8 h boiled water re-sampled after standing for 16 hours (no sample on day 1)
- '16 h boiled' – the 16 h water boiled and sampled immediately (no sample on day 1)

The replicate kettles are designated as '3' and '4' to distinguish them from the kettles used in the extended boiling tests.

The detailed results are presented in Appendix A. The results for kettles S and T are summarised in Figure 3.8 to Figure 3.15. Table 3.3 gives the average percent increases in nickel concentrations between the various stages of standing and boiling.

Table 3.3 Mean percent increases in nickel concentrations

Water	Kettle	0 h → 8 h	8 h → 8 h boil	8 h boil → 16 h	16 h → 16 h boil
Oakdale	S	70	16	29	0
	T	35	21	71	7
Deionised	S	226	22	56	10
	T	354	21	98	4

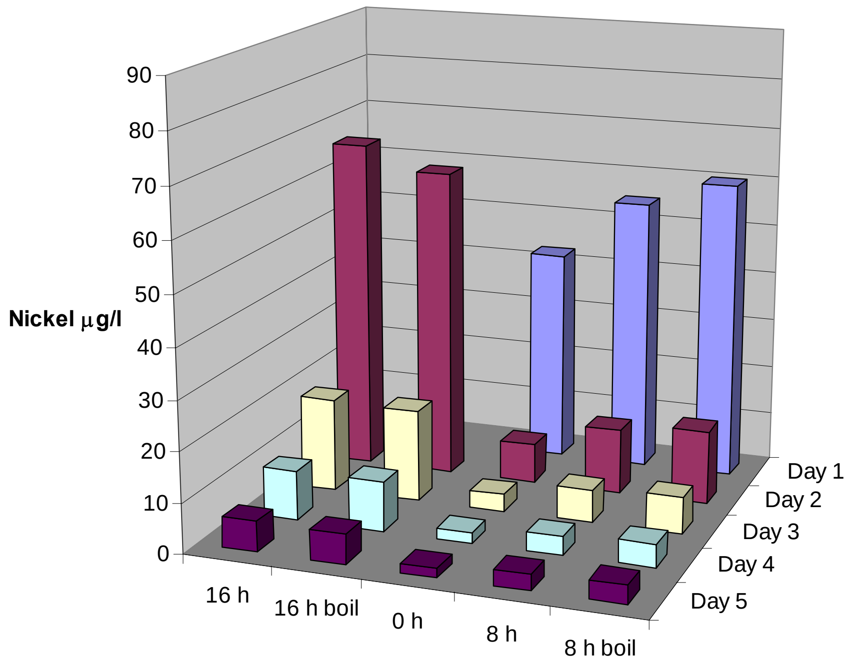

Figure 3.8 Re-boiling results – Oakdale water, Kettle S, Replicate 3

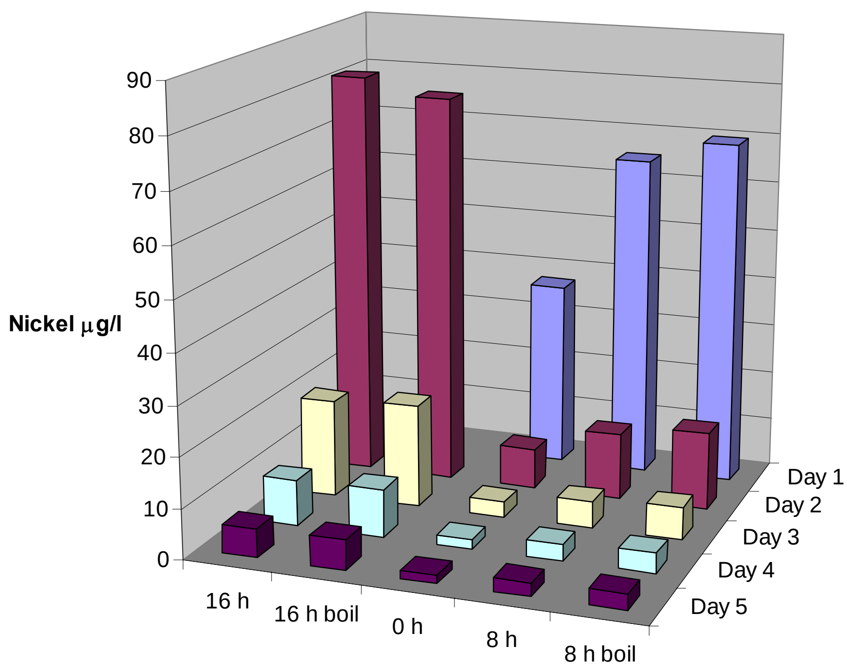

Figure 3.9 Re-boiling results – Oakdale water, Kettle S, Replicate 4

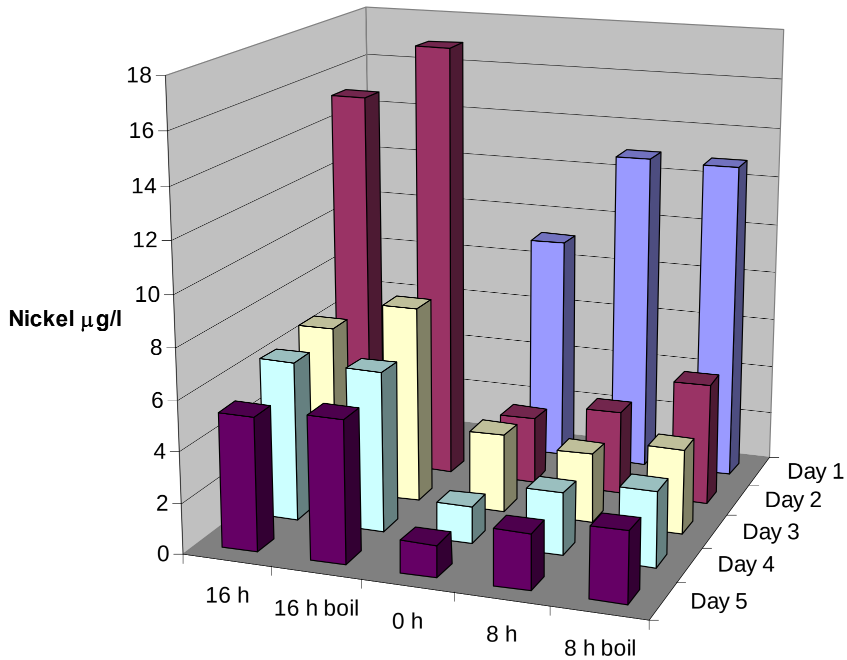

Figure 3.10 Re-boiling results – Oakdale water, Kettle T, Replicate 3

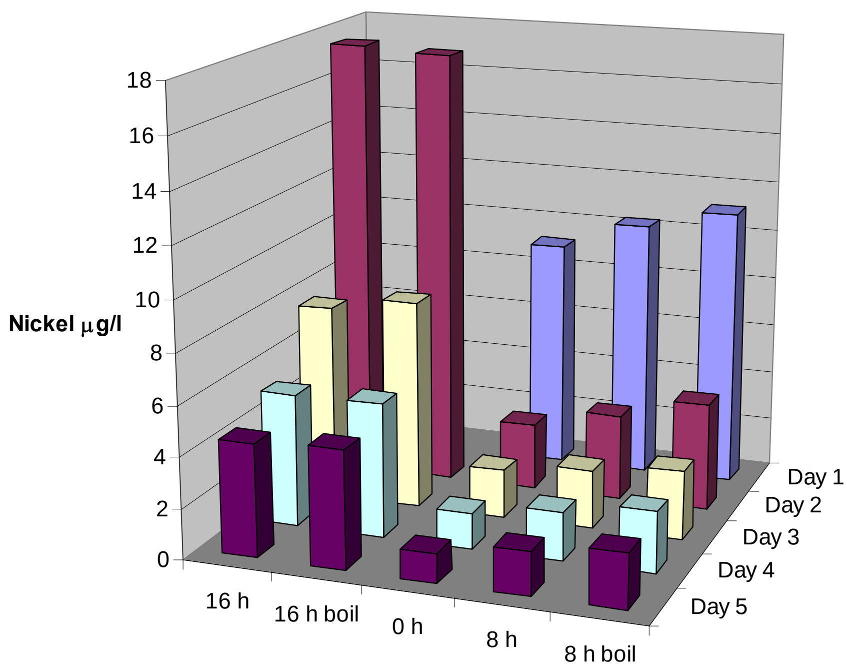

Figure 3.11 Re-boiling results – Oakdale water, Kettle T, Replicate 4

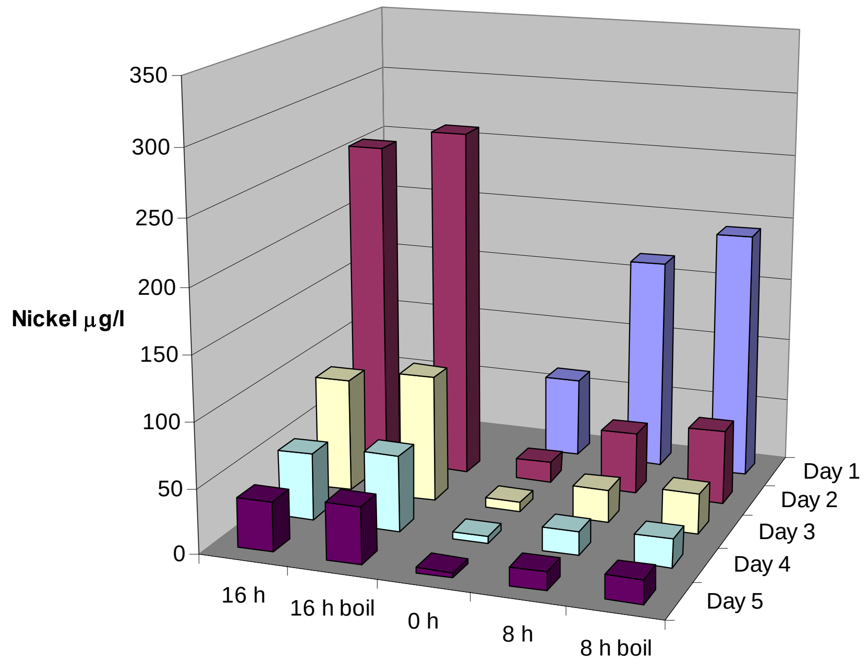

Figure 3.12 Re-boiling results – Deionised water, Kettle S, Replicate 3

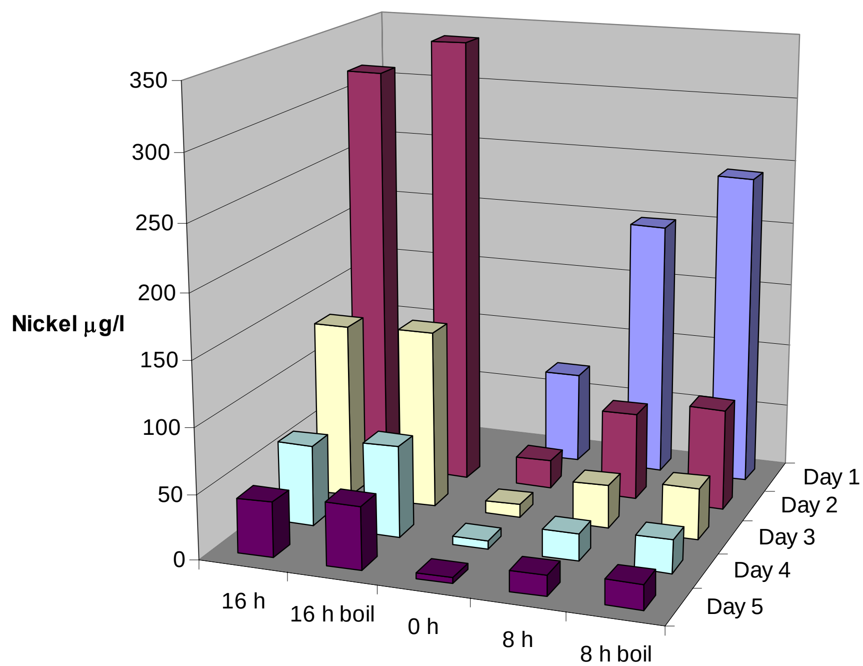

Figure 3.13 Re-boiling results – Deionised water, Kettle S, Replicate 4

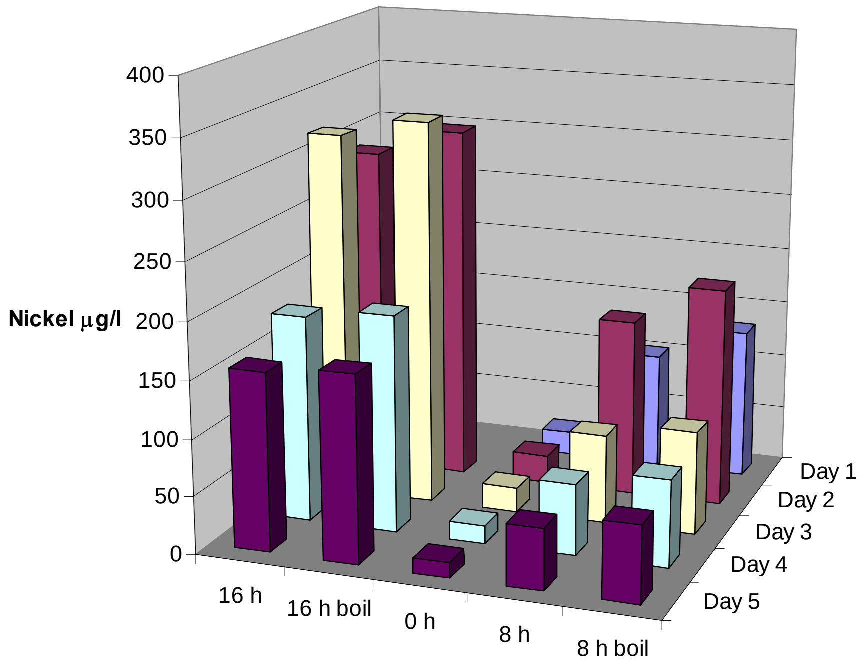

Figure 3.14 Re-boiling results – Deionised water, Kettle T, Replicate 3

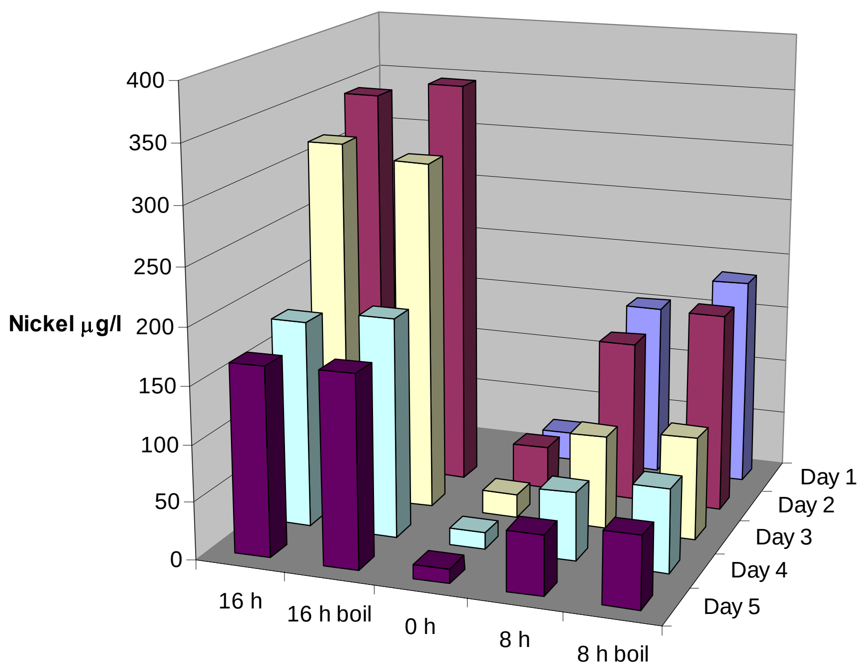

Figure 3.15 Re-boiling results – Deionised water, Kettle T, Replicate 4

4. DISCUSSION

4.1 Extended boiling tests

The nickel results for kettle Q were generally very similar to the corresponding blank values, confirming the suitability of this kettle as a control.

Nickel was initially undetectable in the Oakdale blank water but the concentration later rose to ~1-5 µg/l. The reason for this is unclear as all water samples were taken from the same laboratory tap.

There was little leaching of nickel into Oakdale water. In the DWI work (Jackson *et al*. 2003a) only limited testing was done using Oakdale water that had not been filtered. In the DWI work, Oakdale water was boiled twice in Kettle K; the first boil yielded 80 µg/l Ni (307 µg/l after standing for 24 hours) and the second gave 22 µg/l (49 µg/l after 24h).

Nickel did leach into deionised water. However, the concentrations were not particularly high after the first week of the experiment. The trends in nickel concentrations were as expected, i.e. for a given standing time concentrations tended to decrease as the experiment progressed, and for a given sampling day the concentrations increased with increasing standing time of water in the kettle.

Statistical analysis confirmed that there were highly significant differences between all standing times at the beginning of the experiment (days 1, 2 and 5). Later (days 15 and 25) the differences between 0 and 5 minutes standing time were not significant. The differences between nickel concentrations from the three models of kettle with deionised water were highly statistically significant; the order of increasing nickel concentrations was Q < S < T. With deionised water, Kettle T2 gave consistently higher nickel concentrations than T1; no other consistent differences between replicates were observed.

4.2 Re-boiling tests

As expected, little leaching of nickel occurred with the control kettle Q. The '0 h' results for kettles S and T with deionised water were in broad agreement with the corresponding values obtained during the first five days of the extended boiling tests. Greater nickel leaching was observed with Oakdale water compared with the extended boiling tests, although the nickel concentrations were still lower than with deionised water.

As can be seen from Table 3.3 prolonged standing times of 8 and 16 hours had a much greater effect on nickel concentrations than re-boiling the water that had stood in the kettles. For example with kettle T and deionised water, standing for 8 hours more than tripled the nickel concentration and, after re-boiling, a further 16 hours standing time caused the concentration to approximately double. The effect of standing time was greater in deionised water than Oakdale water. The relative effects of re-boiling were much smaller – re-boiling after 8 hours standing increased nickel concentrations by about 20% for both models of kettle with both waters. Re-boiling after 16 hours standing gave a smaller relative increase.

4.3 Occurrence of nickel-plated kettle elements[6]

In 2003 exposed kettle elements represented 30% of the kettle market but by February 2006 this had fallen to only 13%. Not all exposed elements are nickel-plated; some are stainless steel. Nickel was not released from kettles with stainless steel elements with any water in this study or the two earlier ones.

The average lifespan of a kettle is 2.4 years. Hence the majority of the user base now has concealed element kettles, which do not leach nickel. All kettle manufacturers offer concealed elements in their range, usually in all mid-priced and premium models. Argos, which is one of the largest retailers in kettle sales, offers 69 kettles in its on-line catalogue; of these 64 (93%) have concealed elements. Exposed elements are most commonly found in budget price kettles retailing below £10, often having a shorter lifespan, or travel kettles which are less frequently used.

[6] Information from Anna Gilbert, Corporate Affairs Manager, Brita Water Filter Systems Ltd., Personal Communication, 2007.

5. CONCLUSIONS

1. Water boiled in kettles with exposed nickel-plated elements contained elevated concentrations of nickel. This corroborates the results of earlier studies but the magnitude of nickel concentrations in the present study was less than observed in previous studies.

2. Nickel leaching was very low from a control kettle with a stainless steel element.

3. For the kettles with nickel-plated elements, leaching was greater with deionised water than with soft tap water; this effect was statistically significant.

4. There were highly significant differences between the nickel concentrations in deionised water with the three models of kettle tested.

5. Nickel concentrations fell over the 12-week period of the test.

6. Nickel concentrations increased with increasing standing time from 0 to 30 minutes after boiling; this effect was statistically significant.

7. There were no statistically significant differences between replicate kettles except for the model of kettle giving the highest nickel concentrations with deionised water.

8. In re-boiling tests, prolonged standing of water for 8 and 16 hours caused large increases in nickel concentrations from kettles with nickel-plated elements. The increase in nickel concentrations following re-boiling was much smaller.

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APPENDIX A DETAILED EXPERIMENTAL RESULTS

The results for calcium and alkalinity are given in Table A.1 (the results for deionised water, measured only on Day 1, were alkalinity <2.5 mg/l and calcium <2 mg/l).

Table A.1 Calcium and alkalinity in Oakdale water

Day	Ca mg/l	Alkalinity mg/l $CaCO_3$
1	35.4	64.3
8	18.8	41.6
16	18.8	33.6
21	18.7	35.0
27	18.7	34.7
33	21.9	36.7
40	17.8	31.7
45	18.4	29.6
50	16.9	28.7
55	19.8	27.7
60	26.5	33.7

Table A.2 Nickel results in µg/l – Oakdale water, Kettle Q

		Kettle Q Replicate 1				Kettle Q Replicate 2			
Day	**Blank**	**0 min**	**5 min**	**15 min**	**30 min**	**0 min**	**5 min**	**15 min**	**30 min**
1	<0.5	2.54	0.78	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2	<0.5	0.62	0.67	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
9	<0.5	8.11	7.69	8.25	8.53	2.27	2.20	2.58	2.29
10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
11	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
12	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
13	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
14	0.87	0.58	0.65	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
15	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
16	1.71	2.19	2.20	2.52	3.16	0.97	0.94	0.91	0.87
17	0.83	2.51	2.44	2.72	3.54	0.76	0.75	0.76	0.83
18	4.93	2.62	2.54	2.93	3.57	0.86	0.83	0.80	0.81
19	2.71	1.89	1.86	2.12	2.83	0.82	0.84	0.82	0.90
20	3.23	1.40	1.60	1.75	2.19	0.65	0.68	0.63	0.62
21	1.13	1.77	1.56	1.76	2.42	<0.5	<0.5	<0.5	<0.5
22	1.52	1.96	1.80	1.97	2.68	1.86	1.83	1.67	1.58
23	1.81	1.36	1.55	1.43	1.77	1.93	1.83	1.77	1.71
24	2.18	2.49	2.40	2.37	2.68	1.83	1.66	1.77	1.54
25	0.84	1.56	1.45	1.48	1.80	0.74	0.77	0.71	0.69
26	0.88	–	–	–	1.99	–	–	–	0.74
27	1.54	–	–	–	1.62	–	–	–	0.69
28	2.21	–	–	–	1.45	–	–	–	0.58
29	2.27	–	–	–	1.18	–	–	–	0.51
30	4.47	–	–	–	4.46	–	–	–	4.26
31	3.62	–	–	–	2.21	–	–	–	<0.5
32	1.66	–	–	–	1.52	–	–	–	<0.5
33	486	–	–	–	1.30	–	–	–	<0.5
34	2.40	–	–	–	1.45	–	–	–	<0.5
35	1.41	–	–	–	1.49	–	–	–	0.54
40	0.63	–	–	–	2.05	–	–	–	<0.5
45	<0.5	–	–	–	0.72	–	–	–	0.51
50	<0.5	–	–	–	0.93	–	–	–	<0.5
55	<0.5	–	–	–	<0.5	–	–	–	0.82
60	1.04	–	–	–	1.83	–	–	–	0.75

Table A.3 Nickel results in μg/l – Oakdale water, Kettle S

		Kettle S Replicate 1				Kettle S Replicate 2*			
Day	Blank	0 min	5 min	15 min	30 min	0 min	5 min	15 min	30 min
1	<0.5	1.98	1.84	2.86	3.23	1.77	2.08	3.08	3.57
2	<0.5	<0.5	<0.5	0.62	0.72	<0.5	<0.5	0.55	0.85
3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.69
6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
9	<0.5	1.03	0.97	1.03	1.28	<0.5	<0.5	<0.5	<0.5
10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
11	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
12	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
13	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
14	0.87	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
15	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
16	1.71	0.86	0.77	0.75	0.90	0.72	0.67	0.81	0.87
17	0.83	0.80	0.83	0.89	0.81	0.82	0.83	0.92	0.98
18	4.93	1.05	1.08	1.21	1.52	1.06	1.13	1.35	1.63
19	2.71	1.91	1.88	1.93	2.26	2.60	2.65	2.79	2.83
20	3.23	1.15	1.13	1.43	1.82	1.32	1.25	1.98	1.91
21	1.13	1.01	1.04	1.34	1.68	1.10	1.17	1.50	2.26
22	1.52	1.15	1.16	1.44	1.93	1.27	1.42	1.86	2.97
23	1.81	1.12	1.16	1.38	1.64	1.27	1.40	1.64	2.61
24	2.18	1.71	1.57	1.83	1.98	1.31	1.41	1.58	2.12
25	0.84	1.08	1.02	1.14	1.32	1.08	1.06	1.23	1.47
26	0.88	–	–	–	1.10	–	–	–	1.05
27	1.54	–	–	–	1.12	–	–	–	–
28	2.21	–	–	–	0.58	–	–	–	–
29	2.27	–	–	–	0.58	–	–	–	–
30	4.47	–	–	–	4.84	–	–	–	–
31	3.62	–	–	–	0.53	–	–	–	–
32	1.66	–	–	–	<0.5	–	–	–	–
33	486	–	–	–	<0.5	–	–	–	–
34	2.40	–	–	–	<0.5	–	–	–	–
35	1.41	–	–	–	<0.5	–	–	–	–
40	0.63	–	–	–	<0.5	–	–	–	–
45	<0.5	–	–	–	<0.5	–	–	–	–
50	<0.5	–	–	–	<0.5	–	–	–	–
55	<0.5	–	–	–	<0.5	–	–	–	–
60	1.04	–	–	–	0.94	–	–	–	–

* Kettle S Replicate 2 ceased to function on Day 27.

Table A.4 Nickel results in μg/l – Oakdale water, Kettle T

Day	Blank	Kettle T Replicate 1				Kettle T Replicate 2			
		0 min	5 min	15 min	30 min	0 min	5 min	15 min	30 min
1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2.07
2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
6	<0.5	<0.5	<0.5	<0.5	<0.5	0.57	0.68	<0.5	<0.5
7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
9	<0.5	1.53	1.75	1.71	1.43	1.24	0.98	0.95	0.99
10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
11	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
12	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
13	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
14	0.87	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
15	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
16	1.71	0.78	0.81	0.77	0.84	0.72	0.74	0.76	0.92
17	0.83	0.88	0.86	0.92	1.00	0.88	0.90	1.04	1.29
18	4.93	1.03	1.04	1.13	1.22	1.14	1.18	1.33	1.80
19	2.71	3.19	1.19	1.18	1.22	1.29	1.21	1.35	1.50
20	3.23	0.91	0.85	0.93	1.06	1.17	1.20	1.34	1.75
21	1.13	0.96	1.05	1.04	1.33	1.01	1.11	1.24	1.75
22	1.52	1.12	1.06	1.28	1.57	1.25	1.26	1.42	2.01
23	1.81	1.17	1.17	1.44	1.35	1.15	1.05	1.31	2.03
24	2.18	1.57	1.40	1.50	1.69	1.94	1.58	1.70	1.91
25	0.84	0.98	0.98	1.04	1.10	0.99	1.04	1.05	1.32
26	0.88	–	–	–	1.21	–	–	–	1.95
27	1.54	–	–	–	0.91	–	–	–	0.97
28	2.21	–	–	–	<0.5	–	–	–	0.55
29	2.27	–	–	–	0.51	–	–	–	<0.5
30	4.47	–	–	–	4.52	–	–	–	4.39
31	3.62	–	–	–	<0.5	–	–	–	<0.5
32	1.66	–	–	–	<0.5	–	–	–	<0.5
33	486	–	–	–	<0.5	–	–	–	<0.5
34	2.40	–	–	–	<0.5	–	–	–	<0.5
35	1.41	–	–	–	<0.5	–	–	–	<0.5
40	0.63	–	–	–	<0.5	–	–	–	<0.5
45	<0.5	–	–	–	<0.5	–	–	–	<0.5
50	<0.5	–	–	–	<0.5	–	–	–	0.95
55	<0.5	–	–	–	<0.5	–	–	–	0.66
60	1.04	–	–	–	1.00	–	–	–	1.05

Table A.5 Nickel results in μg/l – Deionised water, Kettle Q

		Kettle Q Replicate 1				Kettle Q Replicate 2			
Day	**Blank**	**0 min**	**5 min**	**15 min**	**30 min**	**0 min**	**5 min**	**15 min**	**30 min**
1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
5	<0.5	<0.5	<0.5	0.62	<0.5	<0.5	<0.5	<0.5	<0.5
6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
9	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
11	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
12	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
13	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
14	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
15	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
16	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
17	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
18	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
19	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
20	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
21	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
22	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
23	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
24	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
25	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
26	<0.5	–	–	–	<0.5	–	–	–	<0.5
27	<0.5	–	–	–	<0.5	–	–	–	<0.5
28	<0.5	–	–	–	<0.5	–	–	–	<0.5
29	<0.5	–	–	–	<0.5	–	–	–	<0.5
30	<0.5	–	–	–	<0.5	–	–	–	<0.5
31	<0.5	–	–	–	<0.5	–	–	–	<0.5
32	<0.5	–	–	–	<0.5	–	–	–	<0.5
33	<0.5	–	–	–	<0.5	–	–	–	<0.5
34	<0.5	–	–	–	<0.5	–	–	–	<0.5
35	<0.5	–	–	–	<0.5	–	–	–	<0.5
40	<0.5	–	–	–	<0.5	–	–	–	<0.5
45	<0.5	–	–	–	<0.5	–	–	–	<0.5
50	<0.5	–	–	–	<0.5	–	–	–	<0.5
55	<0.5	–	–	–	<0.5	–	–	–	<0.5
60	<0.5	–	–	–	<0.5	–	–	–	<0.5

Table A.6 Nickel results in μg/l – Deionised water, Kettle S

Day	Blank	Kettle S Replicate 1				Kettle S Replicate 2			
		0 min	5 min	15 min	30 min	0 min	5 min	15 min	30 min
1	<0.5	18.0	28.0	57.9	76.0	18.2	30.1	57.3	77.3
2	<0.5	6.16	12.4	25.8	34.4	8.00	13.3	26.1	31.9
3	<0.5	4.70	9.81	17.2	20.2	5.97	10.1	23.4	19.0
4	<0.5	3.58	6.78	11.6	15.5	5.06	7.55	12.5	17.1
5	<0.5	4.60	6.84	14.4	11.4	4.73	8.09	14.1	18.1
6	<0.5	3.19	5.90	11.1	14.2	3.74	6.56	12.1	16.0
7	<0.5	3.22	5.33	11.1	12.9	3.51	6.70	11.0	15.1
8	<0.5	2.63	4.70	8.72	11.8	3.36	5.19	9.94	11.5
9	<0.5	2.72	3.48	6.45	8.22	2.19	3.77	6.81	9.17
10	<0.5	1.90	3.41	6.47	7.65	2.02	3.85	7.33	9.74
11	<0.5	1.03	2.42	5.80	6.82	2.04	3.15	7.22	8.24
12	<0.5	1.61	2.26	4.46	5.69	1.93	2.92	5.62	6.47
13	<0.5	1.70	2.58	5.24	5.86	1.60	2.59	4.62	5.64
14	<0.5	1.14	1.85	3.77	4.64	1.02	1.56	3.67	4.82
15	<0.5	1.94	2.09	4.18	5.08	1.09	1.69	3.70	5.32
16	<0.5	1.23	1.85	3.16	4.09	1.03	1.65	3.46	4.45
17	<0.5	1.10	1.55	2.80	3.57	1.00	1.67	3.16	4.00
18	<0.5	1.02	1.45	2.64	3.39	0.86	1.35	2.44	3.13
19	<0.5	2.00	0.93	1.29	2.39	3.13	0.71	1.19	2.24
20	<0.5	0.63	1.06	1.69	1.99	0.68	1.20	1.87	2.29
21	<0.5	0.52	0.99	2.14	2.27	0.47	1.11	1.88	1.98
22	<0.5	0.54	0.97	1.83	2.05	0.58	1.03	2.30	2.13
23	<0.5	0.77	0.89	1.47	1.79	0.64	0.92	1.55	1.80
24	<0.5	<0.5	0.83	1.58	2.03	<0.5	0.77	1.41	2.10
25	<0.5	<0.5	0.82	1.32	2.37	<0.5	0.80	1.31	1.61
26	<0.5	–	–	–	1.39	–	–	–	<0.5
27	<0.5	–	–	–	1.31	–	–	–	1.24
28	<0.5	–	–	–	1.24	–	–	–	1.17
29	<0.5	–	–	–	1.29	–	–	–	1.82
30	<0.5	–	–	–	1.17	–	–	–	1.14
31	<0.5	–	–	–	1.10	–	–	–	1.01
32	<0.5	–	–	–	1.03	–	–	–	0.94
33	<0.5	–	–	–	0.96	–	–	–	0.95
34	<0.5	–	–	–	0.95	–	–	–	0.95
35	<0.5	–	–	–	0.91	–	–	–	0.91
40	<0.5	–	–	–	0.67	–	–	–	0.65
45	<0.5	–	–	–	0.55	–	–	–	0.59
50	<0.5	–	–	–	0.62	–	–	–	0.57
55	<0.5	–	–	–	0.63	–	–	–	0.61
60	<0.5	–	–	–	0.85	–	–	–	0.84

Table A.7 Nickel results in μg/l – Deionised water, Kettle T

Day	Blank	Kettle T Replicate 1				Kettle T Replicate 2			
		0 min	5 min	15 min	30 min	0 min	5 min	15 min	30 min
1	<0.5	28.6	48.2	85.2	126	35.2	57.2	98.4	145
2	<0.5	11.5	29.2	53.3	73.2	18.9	35.1	67.0	83.7
3	<0.5	8.86	22.2	47.3	33.6	14.8	25.6	42.5	62.4
4	<0.5	7.08	12.8	21.5	31.5	13.6	19.1	29.7	41.6
5	<0.5	7.70	19.8	13.1	29.0	11.3	27.0	16.8	38.9
6	<0.5	6.77	11.8	19.0	26.8	10.3	17.0	23.7	35.1
7	<0.5	6.68	11.9	19.4	26.4	10.9	15.3	25.3	36.0
8	<0.5	6.38	10.3	17.4	23.4	10.3	14.8	14.4	32.8
9	<0.5	6.97	9.97	15.3	24.9	10.6	13.9	22.9	32.9
10	<0.5	7.63	10.5	17.3	24.4	10.9	13.3	26.3	34.9
11	<0.5	6.85	9.11	14.5	21.0	9.38	13.5	20.4	28.1
12	<0.5	7.57	9.81	15.6	23.6	10.6	21.9	31.9	10.8
13	<0.5	6.86	8.61	15.9	22.2	10.6	13.0	22.4	31.2
14	<0.5	6.42	8.96	15.2	20.7	10.6	12.5	19.7	29.2
15	<0.5	6.12	7.85	14.0	21.9	10.0	13.0	24.3	36.2
16	<0.5	7.55	10.6	15.8	23.2	11.2	15.4	22.6	32.8
17	<0.5	8.22	11.0	18.2	24.0	11.5	14.4	23.0	31.0
18	<0.5	7.63	10.9	16.3	22.0	9.68	12.7	19.7	28.9
19	<0.5	7.54	9.53	15.4	22.1	10.0	12.4	20.7	30.4
20	<0.5	6.32	7.46	13.7	18.3	10.7	12.6	19.9	28.6
21	<0.5	4.69	8.20	15.2	22.5	6.50	10.4	20.4	25.7
22	<0.5	6.53	9.26	17.8	28.5	8.57	12.2	23.9	35.1
23	<0.5	7.18	9.06	14.7	22.1	9.34	11.5	18.9	27.6
24	<0.5	3.54	7.43	12.7	19.6	5.68	10.5	16.3	27.0
25	<0.5	4.20	7.43	13.4	19.7	7.76	11.6	18.1	26.7
26	<0.5	–	–	–	14.2	–	–	–	20.2
27	<0.5	–	–	–	14.4	–	–	–	19.2
28	<0.5	–	–	–	15.1	–	–	–	21.2
29	<0.5	–	–	–	15.9	–	–	–	22.1
30	<0.5	–	–	–	13.7	–	–	–	20.3
31	<0.5	–	–	–	12.9	–	–	–	18.3
32	<0.5	–	–	–	12.4	–	–	–	17.2
33	<0.5	–	–	–	13.1	–	–	–	17.3
34	<0.5	–	–	–	13.9	–	–	–	16.6
35	<0.5	–	–	–	12.2	–	–	–	15.0
40	<0.5	–	–	–	11.5	–	–	–	14.4
45	<0.5	–	–	–	10.7	–	–	–	14.3
50	<0.5	–	–	–	9.53	–	–	–	13.0
55	<0.5	–	–	–	10.4	–	–	–	12.1
60	<0.5	–	–	–	10.4	–	–	–	14.0

Table A.8 pH of waters before boiling – re-boiling tests

Sample day	Oakdale water	Deionised water
1	7.63	7.12
2	7.48	7.13
3	7.43	6.98
4	7.45	6.95
5	7.44	7.06

Table A.9 Results of re-boiling – Oakdale water – Ni concentrations in μg/l

Kettle	Day	16 h	16 h boil	0 h	8 h	8 h boil
Q 3	1	–	–	1.59	1.70	1.96
	2	1.57	1.54	0.75	0.65	0.71
	3	1.22	1.24	0.91	0.62	0.72
	4	0.78	0.78	0.53	0.52	0.53
	5	0.64	0.68	<0.5	<0.5	0.52
Q 4	1	–	–	2.03	1.76	1.80
	2	1.40	1.38	<0.5	<0.5	<0.5
	3	0.99	1.09	0.59	0.73	0.82
	4	0.80	0.72	6.6	6.62	6.33
	5	6.76	6.23	1.67	1.69	1.76
S 3	1	–	–	42.7	54.9	60.2
	2	66.8	62.3	7.98	13.0	14.7
	3	18.8	18.5	3.54	6.55	7.43
	4	9.86	9.93	2.03	3.77	4.66
	5	6.09	5.98	1.84	3.10	3.68
S 4	1	–	–	37.2	64.9	69.6
	2	81.5	78.4	8.00	13.2	15.6
	3	19.6	20.7	3.09	5.51	6.54
	4	9.12	9.56	1.82	3.34	4.00
	5	5.82	6.00	1.50	2.57	3.02
T 3	1	–	–	9.11	12.9	12.8
	2	15.3	17.5	2.67	3.34	4.87
	3	6.72	7.88	3.14	2.79	3.39
	4	6.36	6.36	1.45	2.46	2.97
	5	5.31	5.63	1.25	2.18	2.75
T 4	1	–	–	9.17	10.3	11.1
	2	17.6	17.4	2.65	3.41	4.27
	3	7.75	8.30	1.92	2.34	2.74
	4	5.27	5.33	1.42	1.93	2.40
	5	4.48	4.67	1.14	1.72	2.15

Blanks all <0.5 μg/l except for 1.12 μg/l on day 5.

Table A.10 Results of re-boiling – Deionised water – Ni concentrations in μg/l

Kettle	Day	16 h	16 h boil	0 h	8 h	8 h boil
Q 3	1	–	–	2.05	1.80	2.00
	2	2.55	2.67	0.62	<0.5	0.54
	3	0.77	0.82	<0.5	<0.5	<0.5
	4	0.59	0.57	<0.5	<0.5	<0.5
	5	<0.5	<0.5	<0.5	<0.5	<0.5
Q 4	1	–	–	1.75	1.73	1.90
	2	2.73	2.77	<0.5	<0.5	<0.5
	3	0.72	0.78	<0.5	<0.5	<0.5
	4	<0.5	<0.5	<0.5	<0.5	<0.5
	5	<0.5	0.85	<0.5	<0.5	<0.5
S 3	1	–	–	62.6	166	194
	2	258	274	16.0	47.5	57.5
	3	89.0	99.1	7.49	26.1	31.7
	4	52.3	59.2	4.97	17.8	21.9
	5	38.6	43.9	3.91	14.1	18.1
S 4	1	–	–	71.9	200	244
	2	321	348	22.2	67.8	79.1
	3	136	138	9.85	33.6	40.3
	4	62.9	70.6	5.92	21.1	25.9
	5	42.7	48.6	4.47	15.7	19.1
T 3	1	–	–	21.1	103	133
	2	289	314	24.5	157	193
	3	321	338	21.8	78.5	90.7
	4	181	190	15.4	62.3	76.2
	5	156	163	13.1	53.2	66.6
T 4	1	–	–	25.5	153	184
	2	347	360	37.4	142	175
	3	318	307	20.3	82.2	90.2
	4	181	192	14	59.6	73.3
	5	166	168	12.1	52.2	62.1

Blanks all <0.5 μg/l.

APPENDIX B STATISTICAL DATA

Table B.1 Mean nickel results in µg/l – Day 1 – Red >20 µg/l, Blue >10 µg/l

	Standing time (minutes)							
	0		5		15		30	
Kettle	**Deionised**	**Oakdale**	**Deionised**	**Oakdale**	**Deionised**	**Oakdale**	**Deionised**	**Oakdale**
S	**18.10**	1.88	**29.05**	1.96	**57.60**	2.97	**76.65**	3.40
T	**31.90**	0.25	**52.70**	0.25	**91.80**	0.25	**135.50**	1.16
Q	0.25	1.40	0.25	0.52	0.25	0.25	0.25	0.25

Table B.2 Mean nickel results in µg/l – Day 2 – Red >20 µg/l, Blue >10 µg/l

	Standing time (minutes)							
	0		5		15		30	
Kettle	**Deionised**	**Oakdale**	**Deionised**	**Oakdale**	**Deionised**	**Oakdale**	**Deionised**	**Oakdale**
S	7.08	0.25	**12.85**	0.25	**25.95**	0.59	**33.15**	0.79
T	**15.20**	0.25	**32.15**	0.25	**60.15**	0.25	**78.45**	0.25
Q	0.25	0.44	0.25	0.46	0.25	0.25	0.25	0.25

Table B.3 Mean nickel results in μg/l – Day 5 – Red >20 μg/l, Blue >10 μg/l

Kettle	Standing time (minutes)							
	0		5		15		30	
	Deionised	Oakdale	Deionised	Oakdale	Deionised	Oakdale	Deionised	Oakdale
S	4.67	0.25	7.47	0.25	**14.25**	0.25	**14.75**	0.47
T	9.50	0.25	**23.40**	0.25	**14.95**	0.25	**33.95**	0.25
Q	0.25	0.25	0.25	0.25	0.44	0.25	0.25	0.25

Table B.4 Mean nickel results in μg/l – Day 15 – Red >20 μg/l, Blue >10 μg/l

Kettle	Standing time (minutes)							
	0		5		15		30	
	Deionised	Oakdale	Deionised	Oakdale	Deionised	Oakdale	Deionised	Oakdale
S	1.52	0.25	1.89	0.25	3.94	0.25	5.20	0.25
T	8.06	0.25	**10.43**	0.25	**19.15**	0.25	**29.05**	0.25
Q	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

Table B.5 Mean nickel results in µg/l – Day 25 – Red >20 µg/l, Blue >10 µg/l

Kettle	Standing time (minutes) 0		5		15		30	
	Deionised	Oakdale	Deionised	Oakdale	Deionised	Oakdale	Deionised	Oakdale
S	0.25	1.08	0.81	1.04	1.32	1.19	1.99	1.40
T	5.98	0.99	9.52	1.01	**15.75**	1.05	**23.20**	1.21
Q	0.25	1.15	0.25	1.11	0.25	1.10	0.25	1.25

Table B.6 Regression results – Dependent variable: √(Nickel concentration)

		Parameters								
		Constant	**Kettle S Oakdale**	**Kettle T deionised**	**Kettle T Oakdale**	**Kettle Q deionised**	**Kettle Q Oakdale**	**Standing time 5 minutes**	**Standing time 15 minutes**	**Standing time 30 minutes**
Day 1	Coefficient	**2.050**	**-1.394**	**0.379**	**-1.939**	**-2.149**	**-2.160**	**0.300**	**0.683**	**0.917**
	t pr.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Sig @ 95%	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day 2	Coefficient	**1.5176**	**-1.394**	**0.5064**	**-1.615**	**-1.615**	**-1.589**	**0.3925**	**0.755**	**0.9032**
	t pr.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Sig @ 95%	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day 5	Coefficient	**1.4877**	**-1.075**	**0.3353**	**-1.116**	**-1.088**	**-1.116**	**0.295**	**0.2908**	**0.4925**
	t pr.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Sig @ 95%	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Day 15	Coefficient	**1.0895**	**-0.657**	**0.6839**	**-0.657**	**-0.657**	**-0.657**	**0.086**	**0.3026**	**0.4396**
	t pr.	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.257	<0.001	<0.001
	Sig @ 95%	Yes	Yes	Yes	Yes	Yes	Yes	**No**	Yes	Yes
Day 25	Coefficient	**0.8099**	**0.0283**	**0.9004**	**0.0012**	**-0.321**	**0.0109**	**0.1174**	**0.2431**	**0.357**
	t pr.	<0.001	0.73	<0.001	0.989	0.004	0.896	0.078	<0.001	<0.001
	Sig @ 95%	Yes	**No**	Yes	**No**	Yes	**No**	**No**	Yes	Yes

Reference level: Standing time 0 minutes, kettle S and deionised water