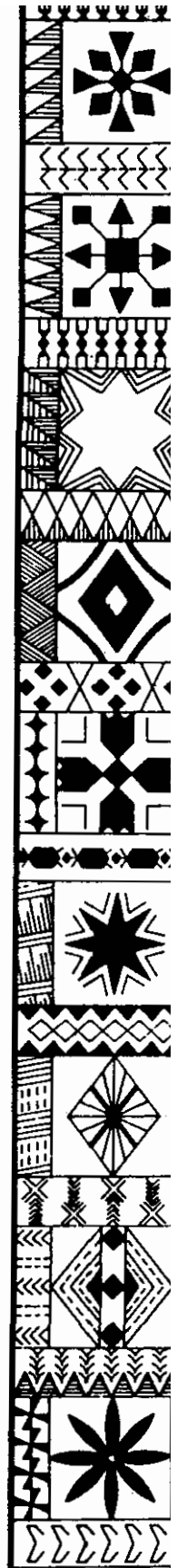


INSTITUTE OF NATURAL RESOURCES
UNIVERSITY OF THE SOUTH PACIFIC

ENVIRONMENTAL STUDIES
REPORT NO. 39

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REPORT



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**WATER QUALITY STUDIES ON SOME DRINKING WATER
SUPPLIES IN THE KINGDOM OF TONGA**

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ABSTRACT

A survey of the primary and secondary standards of drinking water quality was carried out in the Tongatapu, Ha'apai and Vava'u groups in the Kingdom of Tonga. The report summarises the results and has three parts.

Part I of the report presents results of a survey of the trace metal concentrations in well water in the Vava'u and Ha'apai groups. Seven sites in Vava'u and two in Ha'apai were sampled and analysed for fifteen elements. From the results it was concluded that drinking water in Vava'u and Ha'apai levels of trace metals had concentrations within the WHO maximal desired limits.

Part II of the report presents results of a survey of pH, turbidity, chloride and total hardness of drinking water in Tongatapu. Drinking water samples in Tongatapu generally have pH values in the range 7.0-7.5, are clear of coloured material, have little turbidity, but contain appreciable amounts of chloride and dissolved calcium carbonate. While most samples were within the WHO desirable maximal limits many samples had chloride and hardness levels above the limits set by the Tonga Health Authorities.

The report ends (Part III) with results and discussion of a survey of the concentrations of trace metals in drinking waters from Tongatapu. Ten sites were sampled and analysed for twenty seven elements. Examination of the results shows that all samples were within the WHO maximal limits and there was no obvious patterns in the variation of concentration of most trace metals in the samples.

GENERAL INTRODUCTION

The government policies of most South Pacific countries have been amended recently to encourage foreign investment supporting local industrial development. The detrimental effects on the environment of such developments are often swamped politically by the perceived economic gains and have usually gone unchecked. This shift in national policies together with the increasing awareness of the potential toxicity of metals and metallic compounds have led to calls for a renewed effort directed towards the monitoring of the behaviour of these elements in all phases of our environment. It is therefore important to design a surveillance system to evaluate the effects on the environment of the industrial and public projects being implemented in the various South Pacific Island nations. In some parts of the world baseline data on various environmental samples such as drinking water, waste water, coastal water, etc., have been well documented. These analytical data are essential as they serve as a basis for all monitoring of environmental pollution. The measurement and control of pollutants should be integral parts of the activities of local water and health authorities and development companies. Of particular importance is a World Health Organisation report in 1971 and 1984 which indicated safe levels of drinking water as having arsenic concentrations less than 0.05 mg/L, cadmium concentration less than 0.01 mg/L and so on down the list (WHO, 1971 and 1984). A similar report to this effect was prepared for the Department of Interior by the U.S. Committee on Water Quality Criteria (U.S. Department of Interior, 1968). Unfortunately, essential baseline data for natural waters in Tonga are virtually non-existent in some areas. This report presents some of such data for water samples from the Kingdom of Tonga.

PART I

SURVEY OF THE CONCENTRATIONS OF THE TRACE METALS IN WELL
WATER IN THE VAVA'U AND HA'APAI GROUPS

INTRODUCTION

As noted in the general introduction, baseline data on natural waters in Tonga is very limited. This is particularly true for the Vava'u and Ha'apai groups. This section presents data from the analyses of some groundwater samples in these two island groups obtained by a study of wells used for drinking water supplies.

EXPERIMENTAL PROCEDUREI. Sampling

- Water samples were collected by the author with the assistance of an officer of the Tonga Water Board. The sites are clearly numbered in Figure 1. The sites were Ha'alaufuli, Tu'anekivale, 'Eneio, Mangia, Tu'anuku, Longomapu lagoon, Neiafu and Holonga in Vava'u, and Pangai and Faleloa in Ha'apai.

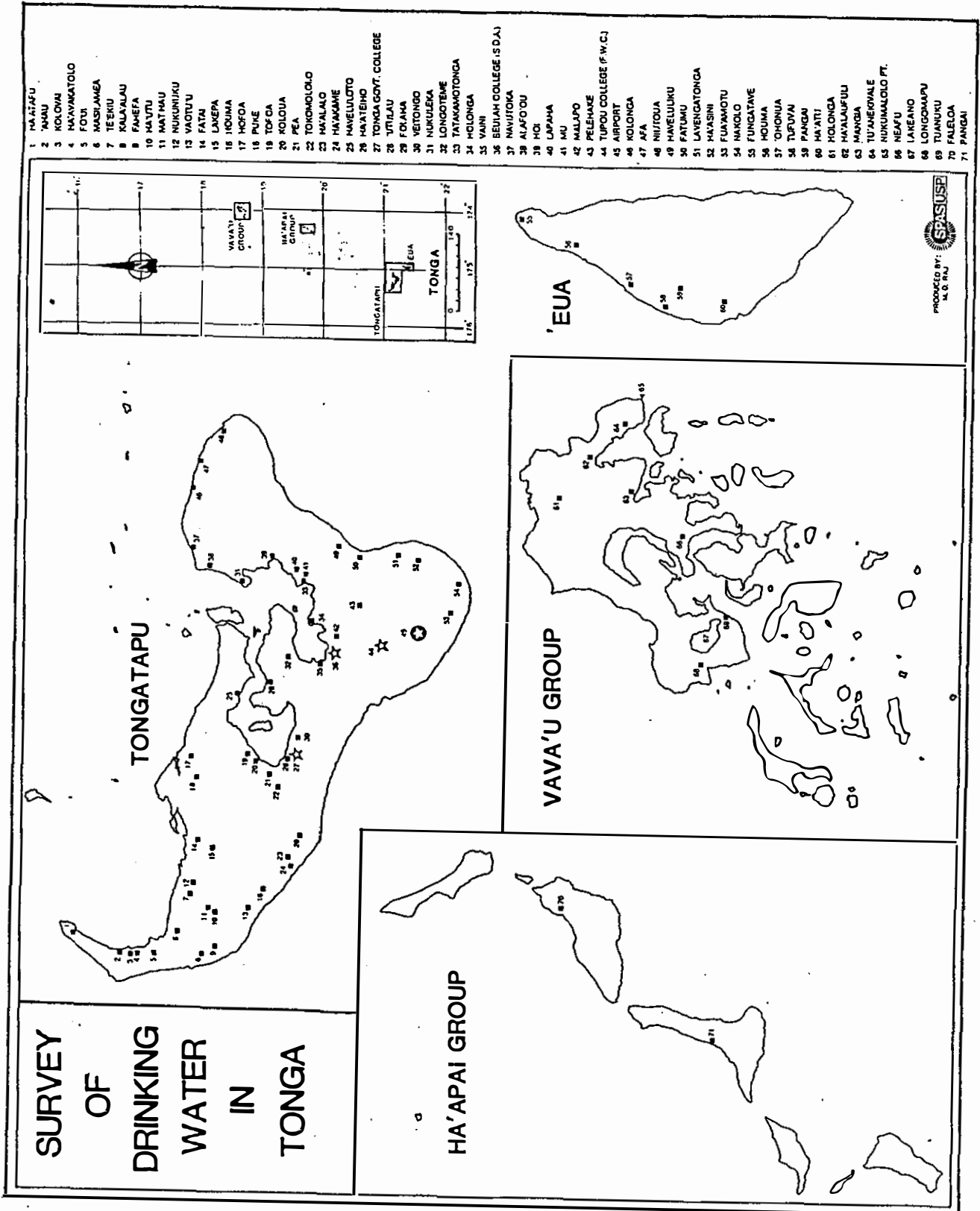
The samples were drawn directly from the well where possible; otherwise they were taken from the water tap immediately leading out to the tank where the water is stored (after pumping) prior to distribution. The samples were collected in acid washed plastic bottles and acidified with analytical grade concentrated hydrochloric acid to give a final HCl concentration of 0.04 mol/L. Other standard analytical procedures for sampling were also followed.

II. Apparatus and Reagents

A Perkin Elmer HG 2380 atomic absorption spectrophotometer (AAS) with accessories HGA 300 graphite furnace atomizer (GFAAS), a laboratory-made hydride generator (HGAAS), air-acetylene and acetylene-nitrous oxide flames AAS, were used in this study. Optimum conditions were used throughout.

All standards were of the highest purity grade chemicals available and stock solutions prepared were typically 1,000 mg/L. High purity deionized water was used in the preparation of all solutions. Working solutions were prepared immediately prior to each day's run.

Figure 1. Location of Sampling Sites



III. General Procedure

Flame atomic absorption spectroscopy (FAAS) has become widely used and accepted in trace and ultratrace determinations because of the low detection limits that can be achieved. Preliminary experiments indicated that trace metal concentrations in the samples were far below the detection limits of the FAAS.

As a result several methods were used in the actual analysis, namely, preconcentration and extraction of the metal with complexing agent 1-pyrrolidinedithiocarbamic acid ammonium salt (APDC) and methyl isobutyl ketone (MIBK) organic solvent prior to the determination by FAAS, or GFAAS in which replacement of flame with a graphite furnace atomizer giving 6-10 times more sensitivity than FAAS as an atomization medium, and by coating the surface of the graphite tubes with a solution of either zirconium or lanthanum salts, which are known to form low volatility carbides with graphite at high temperature (Sneddon and Fuavao, 1985). These minimize the loss of analyte through the graphite porous walls. The complete coating procedures can be found elsewhere (Sneddon and Fuavao, 1985). These coated graphite tubes improve the sensitivities of some elements by a factor as high as four times when compared to the commercially available graphite tubes (Table 1). This improvement is attributed to the formation of layer of metal carbide over the graphite surface, preventing the analytes from coming into physical contact with the reactive graphite surface. Such improvements in sensitivity together with standard additions allowed for direct determination of some trace metals in the samples. Each element was determined by two of the above methods for comparative purposes.

Standards and samples were treated with a composite solution of caesium and strontium prior to analysis for calcium. The composite Cs-Sr solution together with a solution of calcium chloride were added to samples prior to the analysis of magnesium.

Determination of arsenic and selenium required pretreatment digestion of samples with a mixture of (1 + 1) nitric and sulphuric acids. The residue was then dissolved in 1 ml perchloric acid, evaporated and brought into solution in a 4 ml concentrated hydrochloric acid prior to dilution with distilled water.

TABLE 1**SENSITIVITIES¹ OF VARIOUS ELEMENTS BY GFAAS USING
ALTERNATIVE COATED SURFACES**

<u>Commercial Elements</u>	<u>Surface</u>	Enhancement Factor ² vs
		<u>Graphite Tube</u>
Al	Zr-coated	3.0
	La-coated	2.5
Mn	Zr-coated	2.1
	La-coated	3.2
Pb	Zr-coated	3.0
Fe	Zr-coated	4.0
	La-coated	3.5

1. Defined as the concentration which gives 1% absorption or 0.0044 absorbance unit.
2. Defined as the ratio between sensitivity of an element in commercial graphite furnace and coated tubes GFAAS. Aluminium with a sensitivity of 3.43 ng and 1.17 ng in commercial graphite and coated graphite tubes, respectively has an enhancement effect of about 3 times.

RESULTS AND DISCUSSION

The concentrations of various metals together with the respective methods of analysis and precision are presented in Table 2. The pH of all samples at the time of collection was in the range of 7.0-7.5. The chloride concentrations of water samples from these sites had been determined two weeks prior to sampling by the Tonga Water Authorities to be between 200-450 mg/L and the total hardness values were within acceptable international standards of 100-500 mg/L (WHO, 1971).

Examination of Table 2 shows that elements such as arsenic, selenium and mercury concentrations are well below the recommended limits, whereas calcium and others are on the borderline of safe limits suggested by the World Health Organisation.

The validity of the analyses was confirmed by the analysis of National Bureau of Standards (NBS) water sample No. 1643 B. Triplicate analysis of this water sample for copper, lead, manganese, selenium and zinc gave good agreement with the certified values as shown in Table 3.

TABLE 2

TRACE METAL CONCENTRATIONS IN WELL WATER SAMPLES FROM VAVA'U AND HA'APAI, TONGA

Sample	Concentration (mg/L)														
	Fe	Al	Ca	Cd	Cr	As	Se	Mg	Mn	Pb	Cu	Hg	Na	K	Zn
WHO limits*	(0.3-1.0)	(0.2)	(75-200)	(0.005)	(0.05)	(0.05)	(0.02)	(50-150)	(0.1-0.5)	(0.05)	(1.0-1.5)	(0.01)	(200)		(5-15)
VAVA'U															
Ha'alaufuli	0.08	0.05	46.6	0.014	0.008	0.002	0.002	16.1	0.1	0.010	0.034	0.002	64.3	15.0	0.004
Tu'anekeviale	2.1	0.60	71.1	0.014	0.008	0.005	0.005	156.3	0.1	0.012	0.016	0.002	156.8	52.1	0.030
'Eneio	0.11	0.65	70.3	0.011	0.002	0.002	0.009	242.5	0.1	0.009	0.018	n.d.	n.d.	85.9	0.006
'Eneio (seawater)	0.72	0.73	486.8	0.012	0.008	0.002	0.010	127.2	0.1	0.113	0.028	0.002	n.d.	60.2	0.012
Longomapu-Ano (lake)	0.50	0.76	46.8	0.018	0.002	0.001	0.007	266.3	0.1	0.054	0.006	n.d.	n.d.	85.0	0.018
Neiafu	0.40	n.d.	60.0	n.d.	n.d.	0.001	0.002	30.0	0.1	n.d.	n.d.	0.002	n.d.	70.1	n.d.
Ho'longa	0.60	n.d.	52.0	n.d.	n.d.	0.001	0.002	35.0	0.1	n.d.	n.d.	n.d.	n.d.	77.0	n.d.
Mangia	0.40	n.d.	55.9	0.014	0.008	0.001	0.002	26.0	0.1	0.009	0.005	n.d.	n.d.	60.2	0.006
Tu'anuku	0.40	n.d.	54.3	0.014	0.008	0.002	0.001	97.1	0.1	0.046	0.010	0.002	n.d.	30.2	0.004
HA'APAI															
Pangai	0.30	n.d.	80.6	n.d.	n.d.	0.002	0.004	192.5	0.1	n.d.	n.d.	0.002	n.d.	64.2	n.d.
Faleloa	0.14	n.d.	51.8	0.014	0.008	0.001	0.001	26.9	0.1	0.028	0.018	0.002	371.3	18.7	0.012

* shows the permissible and maximum allowable concentration in water
(Source: WHO 1984 Guidelines for Drinking Water Quality, Vol. 1, WHO, Geneva)

Methods

Fe	Zr-coated graphite furnace AAS	Precision (%) - relative standard deviation of at least 4 consecutive analyses
Al	Zr-coated graphite furnace AAS	4.3
Ca	FAAS	3.5
Cd	FAAS	3.0
Cr	FAAS	3.0
AS	HGAAS	3.0
Se	HGAAS	4.0
Mg	FAAS	3.1
Mn	FAAS	4.0
Pb	La-coated graphite furnace AAS	4.0
Cu	FAAS	3.0
Hg	Hg Generator	3.0
Na	FAAS	5.0
K	FAAS	5.0
Zn	FAAS	5.0

CONCLUSION

The concentrations of trace metals in the drinking water in Vava'u and Ha'apai generally are within the WHO maximal desired limits. With the opening of new industries in the absence of environmental impact assessment studies into their possible effects on the limited water supplies in Tonga and the fact that some elements are on the borderline of WHO safe limits, it is clear that regular monitoring of trace metals in drinking water should be established and maintained.

TABLE 3
CONCENTRATION OF CONSTITUENT ELEMENTS IN NBS REFERENCE
MATERIAL NO. 1643 B

<u>Results</u> <u>Elements</u> <u>(ng/g)</u>	Certified Concentration <u>(ng/g)</u>	Experimental <u>Concentration</u>
Copper	21.9 ± 0.4	20.0 - 23.2
Lead	23.7 ± 0.7	23.0 - 25.1
Manganese	28.0 ± 2	27.0 - 29.0
Selenium	9.7 ± 0.5	8.2 - 11.0
Zinc	66.0 ± 2	67.6 - 70.0

The values presented are lowest and highest concentration of the triplicate analysis that were carried out.

PART II

A SURVEY OF pH, TURBIDITY, CHLORIDE AND TOTAL HARDNESS
OF DRINKING WATER IN TONGATAPUINTRODUCTION

Little published information is available on water quality in Tonga. This is particularly true of drinking water supplies. In an attempt to determine whether or not drinking water in Tongatapu complies with the WHO primary water quality standards (WHO, 1971) a survey was made in January 1987 of samples for pH, turbidity, chloride content and total hardness. The WHO standards for drinking water require colour 5-50 units, turbidity 5-25 units, pH 7.0-8.0, chloride concentration 200-600 mg/L and total hardness 100-500 mg/L CaCO_3 . The Health Authorities in Tonga have set the following standards for drinking water: pH 5.8-6.8, turbidity <2 units, chloride concentration <200 mg/L and total hardness <300 mg/L CaCO_3 (Tonga Ministry of Health, unpublished data, 1985).

EXPERIMENTAL PROCEDURE

Water samples were collected from taps located in various parts of Tongatapu on 13 January, 19 January, 27 January, 3 February and 16 February 1987. Samples (1 litre) were collected in plastic bottles and taken immediately to the laboratory for analysis. All the analyses were carried out at the Central Health Laboratory, Ministry of Health, Nuku'alofa, Tonga. pH values were determined using a pH meter calibrated with appropriate buffer solutions. Turbidity was determined using the Hach DR-EL test reagents and procedures (Manuel, DR-EL Methods, 1978). Chloride contents were determined by silver nitrate titration using potassium chromate as indicator. Total hardness was determined using EDTA titration using Erichrome Black T indicator. The detection limit by this procedure was 0.5 mg CaCO_3 /L.

RESULTS AND DISCUSSION

The results of the analyses are given in Table 4. In addition to the data given, all samples were checked for colour and were found to be clear. As can be seen from Table 4 all samples were free from turbidity.

Examination of the data in Table 4 shows that while most samples were within the WHO desirable maximal limits many samples had chloride and hardness levels above the limits set

by the Tonga Health Authorities. Of the 73 samples tested 4 had chloride contents above the WHO limit and 22 had chloride contents above the Tonga Health Authority limits. Since many of the water supplies are drawn from wells/boreholes in near coastal areas, high levels of chloride due to seawater intrusion are to be expected.

For hardness, however, 5 samples were above the WHO limit and 58 (i.e. 79%) were above the Tonga Health Authority limit. Since the water samples are drawn from a limestone substratum, high levels of dissolved CaCO_3 are expected. Assuming an average temperature of 25°C , the saturated CaCO_3 concentration at pH 7 in equilibrium with calcite under closed condition would be of the order of 400 mg/L (ignoring the influence of other salts) (Stumm and Morgan, 1970). Thus it can be seen that a major portion of the hardness is related to the contact of the groundwater with the calcium carbonate substratum.

TABLE 4

WATER QUALITY DATA FOR SOME TONGATAPU DRINKING WATER SAMPLES

<u>Location</u>	<u>Date</u>	<u>pH</u>	<u>Turbidity</u>	<u>Cl</u> <u>(mg/L)</u>	<u>Hardness</u> <u>(mg CaCO_3/L)</u>
Lab. Water (before ion exch.)	13/1/87	7.0	0	132	340*
	16/2/87	7.3	0	9	n.d.
Lab. Water (after ion exch.)	13/1/87	7.0	0	24	36
Queen Salote Wharf	13/1/87	7.1	0	128	380*
	19/1/87	7.1	0	140	336
Toni Newland factory	13/1/87	7.1	0	132	368*
Dateline Hotel	13/1/87	7.1	0	116	364*
	19/1/87	7.1	0	128	344*
Kiteau Tofui bakery	13/1/87	7.1	0	116	364*
	19/1/87	7.1	0	124	368*
Tutomu factory	13/1/87	7.1	0	140	356*
	19/1/87	7.2	0	128	368*
Fakavainga factory	13/1/87	5.6 ⁺ *	0	132	200*
	19/1/87	7.1	0	128	364*
Desiccated coconut factory	13/1/87	7.1	0	132	360*
	19/1/87	7.2	0	132	368*
Vaiola hospital	13/1/87	7.0	0	132	344*
	19/1/87	7.0	0	132	348*
Hofoa	19/1/87	7.2	0	148	352*

Puke	19/1/87	7.1	0	640 ⁺ *	588*
Matafonua	19/1/87	7.1	0	200*	452*
Nukunuku I	19/1/87	7.1	0	80	380*
Nukunuku II	19/1/87	7.2	0	80*	352*
Te'ekiu	19/1/87	7.1	0	232*	480*
Masilamea	19/1/87	7.1	0	336*	520 ⁺ *
Fo'ui	19/1/87	7.0	0	676 ⁺ *	628 ⁺ *
Ha'avakatolo	19/1/87	7.2	0	1384 ⁺ *	908 ⁺ *
'Ahau	19/1/87	7.0	0	554*	604 ⁺ *
Lakepa	27/1/87	7.2	0	116	356*
Matahau	27/1/87	7.1	0	140*	376*
Kala'au	27/1/87	7.2	0	248*	424*
Fahefa	27/1/87	7.2	0	212	400*
Ha'utu	27/1/87	7.4	0	184	388*
Vaotu'u	27/1/87	7.2	0	180	380*
Houma	27/1/87	7.2	0	116	340*
Ha'akame	27/1/87	7.2	0	100	328*
Ha'alalo	27/1/87	7.2	0	72	304*
'Utulau	27/1/87	7.4	0	100	324*
Matangiake	27/1/87	7.4	0	40	304*
	3/3/87	7.5	0	216	340
Tokomololo	27/1/87	7.2	0	84	304
Pea I	3/2/87	7.5	0	72	290
Pea II	3/2/87	7.5	0	72	290*
Ha'ateiho I	3/2/87	7.2	0	136	320*
Ha'ateiho II	3/2/87	7.2	0	128	330
Veitongo	3/2/87	7.2	0	104*	200*
Folaha	3/2/87	7.2	0	536	400*
Nukuhetulu	3/2/87	7.1	0	200*	410*
Longoteme	3/2/87	7.2	0	324	380*
Vaini I	3/2/87	7.2	0	168	300*
Vaini II	3/2/87	7.4	0	164	312
Malapo	3/2/87	7.4	0	128*	288*
Holonga	3/2/87	7.4	0	268	392*
'Alakifonua	3/2/87	7.3	0	56*	340*
Tatakamotonga I	3/2/87	7.4	0	440*	440*
Tatakamotonga II	3/2/87	7.4	0	460*	450*
Hoi	3/2/87	7.4	0	308	407*
Nukuleka	3/2/87	7.4	0	184*	312*
Talafo'ou	3/2/87	7.4	0	208	337*
Haveluliku	16/2/87	7.4	0	769 ⁺ *	485*
Fatumu I	16/2/87	7.6	0	160	345*
Fatumu II	16/2/87	7.2	0	160	340*
Lavengatonga	16/2/87	7.2	0	84	315
Ha'asini	16/2/87	7.2	0	62	295*
Hamula	16/2/87	7.4	0	44	310*
Nakolo	16/2/87	7.2	0	63	310
Fua'amotu I	16/2/87	7.6	0	20	275
Fua'amotu II	16/2/87	7.4	0	20	265
Fua'amotu Air- port	16/2/87	7.4	0	n.d.	290
Pelehake I	16/2/87	7.5	0	34	290
Pelehake II	16/2/87	7.5	0	34	280
Tupou College	16/2/87	7.5	0	34	270

11.

Beulah College	16/2/87	7.4	0	200*	350*
Tonga College	16/2/87	7.4	0	144*	365*
Lapaha	16/2/87	7.4	0	452	475
Hu'atolitoli	16/2/87	7.4	0	129	295

† Above WHO Desirable Maximal International Standard for drinking water

* Above Tonga Health Authorities limit for drinking water

CONCLUSIONS

Drinking water samples in Tongatapu generally have pH values in the range 7.0-7.5, are clear of coloured material, have little turbidity, but contain appreciable amounts of chloride and dissolved calcium carbonate. While these latter two parameters are usually within the WHO maximal desired limits for drinking water, they often exceed the limits set by the Tongan Health Authorities. Care must be exercised in pumping to avoid increased saline intrusion and chloride levels. Regular monitoring of chloride and hardness levels in drinking water should be established/maintained/continued.

PART III**SURVEY OF THE CONCENTRATIONS OF THE TRACE METALS IN
DRINKING WATER FROM TONGATAPU****INTRODUCTION**

There are two categories for the standard of water quality. They are primary and secondary. Primary standard (Part II) deals with basic safety standard of water quality whereas secondary standard is more specific with regard to radiation level, concentrations of heavy metals, etc. The quality of drinking water can be assessed accurately when components of both categories are known (Wang, 1979).

A survey of the concentrations of heavy metals in drinking water in Tongatapu was carried out and compared with the WHO guidelines for drinking water quality. Tonga has not yet set limits for concentrations of heavy metals in drinking water and at present the WHO limits are accepted as the criteria for water quality in the Kingdom.

EXPERIMENTAL PROCEDURES**I. Sampling**

The water samples were collected on the third week April, 1988 by an officer of the Tonga Ministry of Health in acid washed one litre plastic bottles. They were acidified with analytical grade concentrated hydrochloric acid to give a final HCl concentration of 0.04 mol/L. Other standard analytical procedures for sampling were also followed. The sampling sites are clearly numbered in the attached map of Tonga.

II. Apparatus

A Perkin Elmer Inductively Coupled plasma emission Spectroscopy (ICP) located in the School of Chemistry, University of New South Wales in Australia, was used in this study. Optimum conditions were used throughout.

The analyses were carried out in two modes, namely, Simultaneous ICP and Sequential ICP. To be certain that the effects of the matrix usually associated with water samples which may partly be corrected in the simultaneous mode are minimized, each sample was analysed in a sequential mode ICP and the data compiled by MONOBACA Computer program where the background emissions and fluctuations in the ICP source were taken into account. Consider potassium as an example to

illustrate how this programme was used. The wavelength for potassium was scanned as shown in Figure 2. The scans for sample and standard (or blank) were superimposed on each other. The computer is then programmed to determine the emission intensity of a reference point and subtract this value from the total emission intensity taken at the maximum of the scan, to correct for the background. The reference point was arbitrary picked at the threshold of the scan of peaks where it is quite near to the actual wavelength of potassium without affecting the sensitivity of the emission system. Furthermore, the effects of the matrix on the analytical signal were closely monitored by the computer which allowed the analyst to take steps to improve the sensitivity and precision of the analysis. Table 5 shows the detection limits of the ICP procedures used.

TABLE 5

DETECTION LIMITS* (mg/L) OF TRACE HEAVY METALS IN ICP

<u>Elements</u>	<u>Detection Limits</u>
Al	0.019
As	0.029
B	0.009
Ba	0.002
Bi	0.012
Cd	0.004
Co	0.002
Cr	0.001
Cu	0.003
Fe	0.003
K	1.55
Mg	0.004
Mn	0.003
Mo	0.002
Na	0.680
Ni	0.002
Pb	0.011
Sb	0.024
Se	0.003
Sn	0.034
Ti	0.002
V	0.004
W	0.005
Zn	0.005
Zr	0.060

* Concentration giving a signal-to-noise of 2

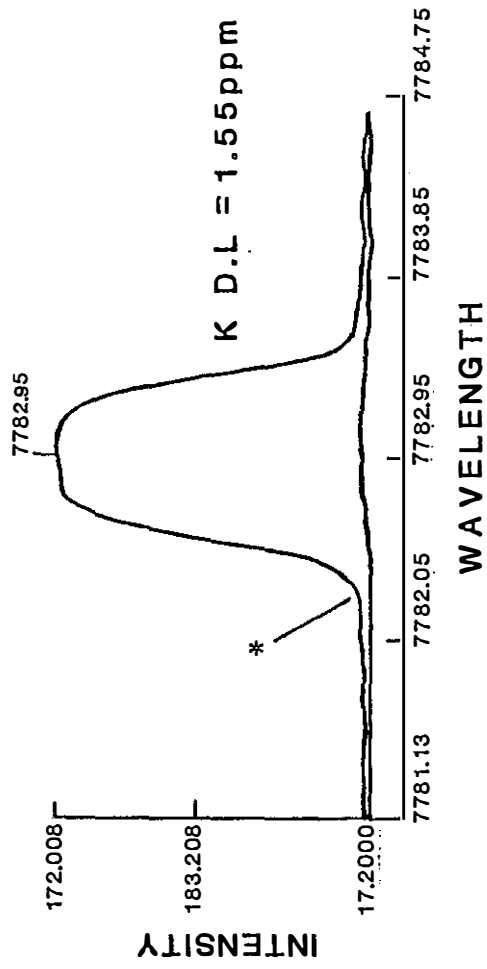


Figure 2. Wavelength Scan for K in ICP-MONOBACA Computer Program
 (* arbitrary reference point)

RESULTS AND DISCUSSION

Ten sites were sampled. Each sample was analysed for twenty seven elements and the results of the analyses are given in Table 5. Precisions of the analysis were analytically acceptable with values of less than 5% for all elements, and all concentrations were blank corrected. Accuracy of the results of trace heavy metal concentrations in water was confirmed by the analysis of NBS water samples no. 1643 B which gave concentrations within $\pm 10\%$ of the certified values.

Examination of Table 5 shows that all samples were within the WHO maximal limits. With the exception of sodium, magnesium and possibly potassium and silicon no significant variation in the concentrations of each metal is observed in the samples. There is no obvious explanation for the variation of magnesium concentrations.

CONCLUSION

Drinking water samples in Tongatapu generally have trace metals concentrations below the WHO maximal limits. There is little variation in the concentrations of most trace metals in the ten samples analysed. However, it is highly recommended that a surveillance programme be established to regularly monitor the trace metal constituents in the drinking water especially with the opening of new industries which are certain to put pressure on the limited water resources and may have adverse effects on the quality of water in Tongatapu.

The authors anticipate that this document will lay the foundation for a systematic surveillance programme for monitoring of the quality of drinking water in the Kingdom.

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