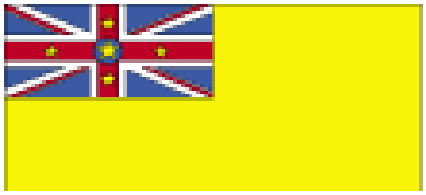
Niue

Groundwater Analysis



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Introduction

The primary source of the water supply in Niue is groundwater which is extracted through secure boreholes across various locations on the island. The water is pumped into reservoirs and reticulated with no further treatment.

The Niue Water Division, Public Works department is responsible for operating and maintaining the water supply with the Niue Department of Health doing surveillance water quality testing.

The quality of groundwater in Niue is generally very good as per the Department of Health water quality test results. In order to maintain the good quality of water that Niue enjoys, the water supply division is implementing drinking water safety planning and integrated water resources management.

The Department of Health has also developed a national drinking water quality monitoring programme (October 2009) which outlines critical parameters to analyse within the available resources (capacity and funding) and from a drinking water safety planning aspect.

Upon request by Niue (John Hetutu, Department of Health) and as part of their regional Water Quality Monitoring and Drinking Water Safety Planning activities, SOPAC and WHO supported the water quality analysis of groundwater in Niue.

Objectives

- Determine the concentration of selected chemical constituents (calcium, magnesium, sodium, chloride, sulphate, nitrate as NO_3, iron, manganese, lead and copper) in the groundwater
- Determine the hardness of the groundwater
- Determine the concentration of selected organic constituents (pesticides) in the groundwater
- Use the results as an advocacy tool to support good quality groundwater
- Use results to support the Niue drinking water quality monitoring programme

Methodology

Discussions with Niue on groundwater analysis commenced in February 2010. The objectives and scope of the study were agreed upon by the Niue Department of Health, SOPAC and WHO. It was decided that selected chemical constituents, metals and pesticides would be analysed from water boreholes.

The bores selected were: all the 16 drinking water production boreholes of PWD (samples were collected from the tap at base of bore), the 3 monitoring bores, central, northern and southern (samples were collected using waterra internal Powerpump-2) and the Vaiea farm borehole (sample was collected from the main supply pipe at the bore).

Refer to Map 1 for the sampling sites.

Map 1. Map of Niue showing the water sampling sites

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The chemical constituents and metals selected for analysis included calcium, magnesium, sodium, chloride, sulphate, nitrate as NO_3, iron, manganese, lead and copper. The hardness of the water was also determined.

Selection of pesticides

A fair amount of discussion surrounded the analysis of pesticides. The criteria agreed to use comprised the following:

- Which pesticide is used (imported) in Niue? Information for this was obtained from the Niue Customs department.
- What are the active ingredients present in the pesticides available in Niue?
- Does the active ingredient present have a guideline value relating to health in the WHO guidelines or any international standard for example the United States drinking water standards?
- Any people perception that should be considered? Some people suspect that the Niue groundwater is contaminated with paraquat.
- Cost of the analysis. Testing for pesticides is very expensive hence not every active ingredient can be tested within a reasonable budget (and in fact should not be tested just for the sake of testing).

The pesticide organic constituents to measure were derived from the table below (inventory of commonly used pesticides in Niue).

Pesticide name	Active ingredient	Used on farms
Gramoxone (weed killer)	Paraquat (27.6%)	Yes
Round up (weed killer)	Glyphosate	Yes
Green Guard (weed killer)	Chlorothalonil and thiophanate-methyl	Yes
Attack (insecticide)	Pyrethrins and piperonyl butoxide	Yes
Target (insecticide)	Pirimiphos methyl (95g/L) and permethrin (5g/L)	Yes
Miltek C (fungicide)	Triadimefon (100g/L) and carbendazim (200g/L)	Yes
Kotek (fungicide)	Mancozeb (480g/L)	Yes
Derris Dust	Rotenone (5g/Kg)	-
Baysol (snail and slug bait)	Methiocarb (20g/Kg)	-
Copper Oxychloride (fungicide)	Copper oxychloride (500g/Kg)	-
Lime Sulphur (fungicide)	Polysulphide (15%)	-
Super Copper DF (fungicide)	Cupric Hydroxide (400g/Kg)	-
Sting (weedkiller)	Glyphosate 12%	Yes
Taratek 5F	Chlorothalonil and thiophanate methyl	Yes
Manzate 200DF	Mancozeb (750g/Kg)	Yes
Bravo (fungicide)	500g/L chlorothalonil	Yes
Agral LN (insecticide/fungicide)	Ethoxylated nonylphenol	Yes

NB: The NPK fertiliser is also used on farms. Analysis of nitrate was done as part of chemical analysis.

The active ingredients identified in the above table from the pesticides used in Niue currently **do not** have a health guideline value stated in the WHO Drinking Water Quality Guidelines (WHO, 2004) due to insufficient information and evidence available at present.

The United States has established standards for three of the active ingredients identified in the table above. These include paraquat, glyphosate and chlorothalonil (PANNA, no date). The rest of the active ingredients do not have any drinking water standard currently in the US standards.

Hence for the purpose of this study the three pesticide active ingredients which met the agreed criteria and were selected for testing included paraquat, glyphosate and chlorothalonil.

AsureQuality laboratory in New Zealand was chosen for supplying the sample bottles and performing the analysis. The sample collection and analysis happened during the period June-July 2010. The complete set of results was received in August 2010. The total cost for the analysis was NZD 13,260.00.

Results

The table below shows the results of the analysis for the individual borehole water sample tested.

Sample Bore name	Chloride (ppm)	Nitrate-Nitrogen (ppm)	Sulphate (ppm)	Calcium (ppm)	Copper (ppm)	Iron (ppm)	Lead (ppm)	Magnesium (ppm)	Manganese (ppm)	Sodium (ppm)	Total Hardness ppm $CaCO_3$	Paraquat mg/L	Glysophate mg/L	Chlorothalonil mg/L
SP 1	10.7	0.46	1.87	49.3	<0.005	<0.005	<0.005	8.35	<0.005	7.57	158	<0.001	<0.001	<0.001
SP 2	10.8	0.53	1.67	54.6	<0.005	<0.005	0.006	7.90	<0.005	7.14	169	<0.001	<0.001	<0.001
SP 3	13.3	0.20	2.01	56.8	<0.005	0.005	<0.005	17.4	<0.005	8.56	213	<0.001	<0.001	<0.001
SP 4	15.1	0.22	2.21	57.5	<0.005	<0.005	<0.005	16.1	<0.005	9.79	210	<0.001	<0.001	<0.001
SP 6	10.1	0.15	1.57	63.8	<0.005	<0.005	<0.005	21.5	<0.005	6.00	245	<0.001	<0.001	<0.001
Tuapa	25.6	0.19	3.76	62.2	<0.005	<0.005	<0.005	21.4	<0.005	6.77	241	<0.001	<0.001	<0.001
Namukulu	29.6	0.10	4.24	63.4	<0.005	<0.005	<0.005	16.9	<0.005	17.7	228	<0.001	<0.001	<0.001
Hikutaivake	20.7	0.39	2.89	66.0	<0.005	<0.005	<0.005	13.5	<0.005	13.0	220	<0.001	<0.001	<0.001
Toi	32.7	0.32	4.61	64.0	<0.005	<0.154	<0.005	19.6	<0.005	21.8	241	<0.001	<0.001	<0.001
Mutalau	29.1	0.20	4.13	63.1	<0.005	<0.005	<0.005	19.0	<0.005	17.9	236	<0.001	<0.001	<0.001
Lakepa	20.7	0.36	2.80	66.2	<0.005	<0.005	<0.005	21.0	<0.005	13.6	252	<0.001	<0.001	<0.001
Liku	29.4	0.27	3.81	67.9	<0.005	0.013	<0.005	18.2	<0.005	17.6	244	<0.001	<0.001	<0.001
Hakupu	15.4	0.007	2.26	51.2	<0.005	0.015	<0.005	7.49	<0.005	9.89	159	<0.001	<0.001	<0.001
Vaiea	15.7	0.25	2.62	53.4	<0.005	0.007	<0.005	6.22	<0.005	9.54	159	<0.001	<0.001	<0.001
Avatele	13.6	0.41	2.08	48.6	<0.005	<0.005	<0.005	6.66	<0.005	8.38	149	<0.001	<0.001	<0.001
Tamakautoga	10.7	0.09	1.70	52.4	<0.005	<0.005	<0.005	10.1	<0.005	6.73	172	<0.001	<0.001	<0.001
Southern Monitoring	529	0.20	0.20	74.1	<0.005	0.032	<0.005	48.4	<0.005	312	396	<0.001	<0.001	<0.001
Central Monitoring	529	0.21	0.21	72.7	<0.005	0.032	<0.005	48.3	<0.005	323	396	<0.001	<0.001	<0.001
Toi North Monitoring	34.2	0.36	4.87	62.7	<0.005	0.154	<0.005	19.1	<0.005	20.1	235	<0.001	<0.001	<0.001
Vaiea FB	12.4	0.44	1.77	49.7	<0.005	<0.005	<0.005	6.45	<0.005	7.95	151	<0.001	<0.001	<0.001

Result Interpretation and Discussions

The following section discusses the results obtained from this study.

Chloride, Sulfate, Calcium, Iron, Magnesium and Sodium

Nearly all natural waters contain traces of dissolved chemical elements. Some of these are naturally occurring in groundwater (due to geology) and WHO **has not** set any health based guideline values for these. From the Niue groundwater results these include chloride, sulphate, calcium, iron, magnesium and sodium.

It is however useful to note the natural composition of these elements present in Niue drinking water bores. It should also be noted that the contents of groundwater vary depending on the location and depth. The depth of the drinking water bores at which water is extracted in Niue range from 35 m to 45 m.

Element	**Concentration range (ppm)**
Chloride	10.1 - 32.7
Sulfate	1.57 - 4.61
Calcium	48.6 - 67.9
Iron	<0.005 - 0.013
Magnesium	6.22 - 21.5
Sodium	6.00 - 21.8

The concentration of chloride for both the southern and central monitoring bores was 529 ppm. The concentration of sodium in the southern and central monitoring bores was 312 ppm and 323 ppm respectively. The concentration of these two elements (chloride and sodium) fall significantly outside the upper limit of the above range for drinking water bores. This could be due to the depth at which the samples were collected. The sample depth for both the southern and central bores was about 70 m below the ground level. The results indicate that at this depth there was brackish water present (seawater mixing with the freshwater lens) in the two monitoring bores during the time of sampling.

The concentration of the elements in the northern monitoring bore and the farm bore were within (or just outside) the above ranges. The northern monitoring bore was sampled at a depth of about 50 m.

Total Hardness

Hard water is water that has high mineral content. Hard water minerals primarily consist of calcium and magnesium cations, and sometimes other dissolved compounds such as bicarbonates and sulfates. Calcium usually enters the water as either calcium carbonate ($CaCO_3$), in the form of limestone and chalk, or calcium sulfate ($CaSO_4$), in the form of other mineral deposits. Since the natural geology of Niue is limestone, the groundwater is expected to be rather hard.

Hard water is generally **not harmful** to one's health and WHO has not proposed any guideline value for hardness in drinking water.

It is however useful to know the hardness of the Niue drinking water bores and classify the water type according to the guideline in the table below. It should be noted that the hardness of groundwater can vary depending on the location and depth.

Hardness (ppm)	**Water type (classification)**
0-60	Soft
61-120	Moderately hard
121-180	Hard
>181	Very hard

[adapted from Hard water, no date]

The hardness of Niue drinking water bores ranged from 149 ppm to 252 ppm which indicates that the groundwater of Niue is hard to very hard, which is expected because of the natural geology of Niue.

The hardness for both the southern and central monitoring bores is 396 ppm and falls outside the upper limit of the hardness range for drinking water bores. This could be due to the depth at which the samples were collected resulting in increased concentration of sodium and chloride.

The hardness of the northern monitoring bore and the farm bore is within the drinking water bore hardness range.

Nitrate

The concentration of nitrate in all the bores sampled ranged from 0.09 ppm to 0.53 ppm. The WHO health based guideline value for nitrate is 10.0 ppm hence the results indicate that there is **no nitrate contamination** of the bores at the time of sampling.

At very high levels in drinking water, nitrate may impact human health, particularly for infants. Infants less than 6 months of age may develop a condition called methemoglobinemia (blue baby syndrome), which causes a bluish colour around the lips that spreads to the fingers, toes and face, and eventually covers the entire body. If the problem is not dealt with immediately, the baby can die.

Nitrate pollution may occur from fertiliser runoff or seepage into groundwater and from discharge of human and animal waste. High nitrate levels from agricultural sources may also indicate that there may be a problem with other agricultural pollutants such as pesticides. Nitrate contamination which can be linked to a sewage discharge may also indicate unacceptably high levels of microbiological contamination and should be addressed as a matter of priority.

Copper

The concentration of copper in all the bores sampled was <0.005 ppm. The WHO health based guideline value for copper is 2.0 ppm hence the results indicate that there is **no copper contamination** of the bores at the time of sampling.

Acute gastrointestinal effects can occur at high copper levels. Staining of laundry and sanitary ware occurs at copper concentrations above 1 ppm. At levels above 2.5 ppm, copper imparts an undesirable bitter taste to water; at higher levels, the colour of water is also impacted.

Lead

The concentration of lead in all the bores sampled ranged from <0.005 ppm to 0.006 ppm. The WHO health based guideline value for lead is 0.01 ppm hence the results indicate that there is **no lead contamination** of the bores at the time of sampling.

Lead is a general toxicant that accumulates in the skeleton. Infants, children up to 6 years of age and pregnant women are most susceptible to its adverse health effects. Lead is toxic to both the central and peripheral nervous systems. Lead is exceptional in that most lead in drinking-water arises from plumbing in buildings and the remedy consists principally of removing plumbing and fittings containing lead.

Manganese

The concentration of manganese in all the bores sampled was <0.005 ppm. The WHO health based guideline value for manganese is 0.4 ppm hence the results indicate that there is **no manganese contamination** of the bores at the time of sampling.

At levels exceeding 0.1 ppm, manganese in water supplies causes an undesirable taste in beverages and stains sanitary ware and laundry. The presence of manganese in drinking-water, like that of iron, may lead to the accumulation of deposits in the distribution system. Concentrations below 0.1 ppm are usually acceptable to consumers. Even at a concentration of 0.2 ppm, manganese will often form a coating on pipes, which may slough off as a black precipitate.

Pesticides

The concentration of the three pesticide active ingredients, paraquat, glyphosate and chlorothalonil, which were tested were all <0.001 mg/L. The WHO guidelines do not state any guideline value for these active ingredients. The table below shows the US drinking water standard for these active ingredients.

Active Ingredient	**US Drinking Water Standard (mg/L)**
Paraquat	0.2
Glyphosate	4
Chlorothalonil	0.5

The results obtained of <0.001 mg/L are significantly low than the above US drinking water standards hence there is **no pesticide contamination** from the active ingredients tested at the time of sampling.

This also conforms to the extensive analysis of persistent organic pollutants (POPs) done in Niue in 2004 (including drinking water) which concluded that there was no threat from POPs contamination. The results obtained for paraquat in the 2004 study of <0.001 mg/L (PoP's in PIC's, 2002) is the same as this 2010 analysis, indicating no increase in concentration to a detectable level.

Conclusion and Recommendations

The groundwater analysis in Niue was successfully conducted in partnership between the Niue Department of Health, SOPAC and WHO.

The results provided useful information in determining the natural composition of the Niue drinking water bores for chemical constituents such as chloride, sulphate, calcium, iron, magnesium and sodium. The presence of these elements in the water is not of health concern. As expected because of the natural geology of Niue, the results also indicated that the Niue drinking water bores supply hard to very hard water. However, hard water is not harmful to human health.

The concentration of the chemical parameters, nitrate, copper, lead and manganese tested that are of health concern were all significantly lower than the WHO guideline values indicating no contamination at the time of sampling. The concentration of the selected pesticide active ingredients, paraquat, glyphosate and chlorothalonil which are most possible to be present in Niue groundwater are also significantly lower than the US drinking water quality standards.

Based on the results obtained it can be concluded that there is no contamination of the Niue groundwater from the chemical constituents and pesticides tested.

The following recommendations should be considered to maintain the good quality of Niue groundwater.

- The drinking water safety planning framework of risk assessment and risk management should be maintained and continued to be implemented to protect the pristine quality of Niue's groundwater
- The drinking water safety planning approach should be implemented within the larger framework of Integrated Water Resources Management (IWRM) to ensure everyone from the community to cabinet understand their responsibility and contribute to protecting Niue's water resource
- Microbial analysis of drinking water bores should remain the priority parameter to test as stated in the Niue drinking water quality monitoring programme and as is currently practiced, with chemicals and pesticides tested periodically or when a contamination risk is suspected
- The Department of Health and the Water Division should continue collaboration on water quality monitoring and water resources assessment to enable useful data on water quality and quantity for informed decision making.
- Appropriate partnerships should be established as part of the IWRM approach to monitor import of new pesticide brands. Application of pesticides is generally not of concern if active dialogue with farmers on appropriate pesticide application is done.

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