

**SURVEILLANCE OF DRINKING WATER QUALITY  
IN THE PACIFIC ISLANDS:**

**A Situation Analysis and Needs Assessment**

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## **Introduction**

Water has a major impact on human health, and the provision of an adequate supply of safe and good quality drinking water is vital to communities worldwide. It is important as a means to reduce disease, and as the medium through which disease-causing agents may be transmitted.

Negative impacts on human health derive from an inadequate supply, poor hygiene practices in its use, and from the consumption of water contaminated with pathogenic organisms or toxic chemicals. The adequacy of supply may be influenced by such factors as the quantity, quality, and continuity of supply, access and cost.

The economic and social well-being of small countries such as the Pacific Islands is greatly influenced by the quality and quantity of their water, but their ability to effectively manage the water sector is often constrained by their small size and limited human resource base. In many island countries factors such as climate variability, increasingly variable rainfall, accelerating storm water runoff and increasing demand for water are so significant that they threaten their economic development and the health of their people.

In these countries as in all developing countries, the foremost risk to human health is from the consumption of water that is contaminated with pathogenic micro-organisms, and the risk of acquiring waterborne diseases increases with the level of contamination. Contact with contaminated water, the contamination of food, and poor personal or domestic hygiene transmit these pathogens, and good sanitation and proper disposal of excrement is essential to prevent transmission of disease.

Serious problems may result from chemical contamination of water resources from naturally occurring chemicals, the use of agricultural chemicals, and from the by-products of human activities. The physical quality of drinking water too may affect its acceptance by consumers with turbidity, colour, taste and odour affecting consumer perceptions, which may make unacceptable otherwise safe supplies, turning consumers in favour of more pleasant but more harmful sources.

The purpose of this report is to collate information on the current state of drinking water surveillance in the Pacific Island countries and provide an analysis of the needs of the region based on country reports submitted to the World Health Organization, Western Pacific Region "Workshop on Drinking Water Quality Surveillance and Safety" held at Nadi, Fiji from 29 October to 1 November 2001 and the "Pacific Regional Consultation on Water in Small Island Countries" held in Sigatoka, Fiji, from 29 July to 3 August 2002. From these sources a number of significant deficiencies capacity to conduct essential resource assessment, surveillance and monitoring has been documented.



## **The Region**

The Pacific Islands lie in Oceania, a region that by name and by nature is characterised by water. The Pacific Ocean occupies a third of the world's surface and within this vast expanse, spread out over 28 million square kilometres of ocean, are nearly 30,000 islands of which some 1,000 are populated. Nearly all lie within the boundaries of the Tropics and consist of 22 separate political entities of which 15 are independent. The total population numbers some 7.5 million in a total land area of 552,000 km<sup>2</sup>, representing only 0.12% of the global population and 0.37% of the world's land surface.

It is these countries that make up the Pacific Islands of this report and with the exception of Papua New Guinea and Fiji, are classified under the United Nations' definition as "small island states", that is those with less than half a million inhabitants, and with a land area of less than 10,000 square kilometres, with many considerably smaller or less populated than these defined values. Papua New Guinea is by far the largest both physically and demographically, with over 62% of the population and 84% of the landmass of this Pacific Island group. The smaller Pacific Island Countries, excluding Papua New Guinea account for only 89,000km<sup>2</sup> (0.06%) of its land area and 2.8 million people (0.04%) of its population, and have uniquely fragile water resources.

Geologically the islands can be roughly classified into two main groups, the "high" islands, and the "low" islands. The high islands are typically mountainous, often volcanic islands with narrow coastal plains and surrounded by fringing coral reefs such as Fiji, the Solomon Islands and Vanuatu. The low islands are characterised by limestone reefs above submerged volcanic cones, or by uplifted coral atolls that rarely rise more than 70 metres above sea level such as Kiribati, Marshall Islands and Tuvalu. Nauru and Niue are examples of isolated uplifted limestone islands. Individual island states may also be represented by both types, as in the case of Samoa or French Polynesia.

Most of the population in Pacific Island Countries live in coastal areas in rural villages, small towns and the peri-urban areas on the fringes of the main centres, with the populations becoming increasingly concentrated on a single island or in one main town. Population densities of the islands vary from as low as 8 people per km<sup>2</sup> in Vanuatu to an extreme of approximately 40,000 per km<sup>2</sup> on Ebeye in the Marshall Islands.

## **Situation - Supply**

"Water, water everywhere, nor any drop to drink....." Samuel Taylor Coleridge in his "Rime of the Ancient Mariner" may have been describing a common problem in the Pacific Island states, where despite being located in the greatest body of water on earth, the provision of sufficient potable water remains a considerable challenge.

Fresh water is an essential but endangered and extremely limited resource in most of the Pacific Islands, and due to natural and population pressures many of the nations face crisis conditions in providing unpolluted potable water to their citizens. Surveys and assessments have repeatedly shown that in some countries, such as Micronesia and Papua New Guinea, less than half the population have access to a safe potable water supply. Estimates from the WHO-UNICEF Joint Monitoring Program for 2002 are shown in the table below.



## Pacific Islands: Improved Drinking Water and sanitation Coverage (2002)

COUNTRY	Improved Drinking Water Coverage (%)			Improved Sanitation Coverage (%)		
	Total	Urban	Rural	Total	Urban	Rural
American Samoa	ND	ND	ND	ND	ND	ND
Cook Islands	95	98	88	100	100	100
Fiji				98	99	98
French Polynesia	100	100	100	98	99	97
F.S. Micronesia	94	95	94	28	61	14
Guam	100	100	100	99	99	98
Kiribati	64	77	53	39	59	22
Marshall Islands	85	80	95	82	93	59
Nauru	ND	ND	ND	ND	ND	ND
New Caledonia	ND	ND	ND	ND	ND	ND
Niue	100	100	100	100	100	100
Northern Mariana Islands	98	98	97	94	94	96
Palau	84	79	94	83	96	52
Pitcairn	ND	ND	ND	ND	ND	ND
Papua New Guinea	39	88	32	45	67	41
Samoa	88	91	88	100	100	100
Solomon Islands	70	94	65	31	98	18
Tokelau	89	-	89	74	-	74
Tonga	100	100	100	97	98	96
Tuvalu	93	94	92	88	92	83
Vanuatu	60	85	52	50	78	42
Wallis & Futuna	ND	ND	ND	ND	ND	ND

Data from WHO-UNICEF Joint Monitoring Program – 2002 Estimates.

[http://www.wssinfo.org/pdf/JMP\\_04\\_tables.pdf](http://www.wssinfo.org/pdf/JMP_04_tables.pdf)

Water supplies vary from centralised systems consisting of source works, transmission pipelines and networks of distribution pipes to consumers in urban areas, to rainwater collection, groundwater extraction and, on high islands, the gathering of water from small streams and springs in villages and households in rural areas.

Water usage tends to be quite low, on a per capita basis in villages, but higher in urban areas, because of leakage from reticulation due to poor maintenance, and the greater use of household appliances.

Communal water supply systems are often managed by village or community “water committees” who may rely on a “user pays” system to provide income as is common in Tonga and are the basis of rural water supply implementation and operation. In other Pacific Island countries, public water supplies are operated by island councils (Kiribati) or municipal administrations (Federated States of Micronesia) who may also charge a fee to consumers.

The freshwater resources of these countries derive from natural sources such as surface water, groundwater and rainwater, or from water that has been treated in some way for human consumption through such processes as desalination, bottled water manufacture, treated wastewater or by importation, particularly during droughts.

Surface waters capable of being utilised as drinking water sources are relatively common in the high islands, where they are found in the form of temporary or permanent streams, springs and water bodies, and are the main source of fresh water where cost-effective gravity-fed water systems can be used. This resource provides the major water supply for such countries as French Polynesia, Papua New Guinea, Palau and the high islands of the Cook Islands. Surface water is rarely found on the low coral atolls and limestone islands due to the high permeability of the terrain, and where it does exist it is often in transient or shallow, brackish lakes.



Groundwater is a source of drinking water in most of the Pacific Islands, and the primary source on some (Kiribati). It exists in two basic forms, the type found in the larger and higher islands such as Fiji, Vanuatu and the Solomon Islands, where rainfall permeates through the soil and rock to create a groundwater formation above the water table where it is retained by impermeable strata, or, as in the case of the low-lying islands as a “lens” of freshwater, recharged by the percolation of rainwater, and floating on the denser salt or brackish water beneath.

While the freshwater “lens” implies a distinct freshwater aquifer, in reality there is a transition zone between freshwater and seawater with no distinct boundary and the potable zone may be defined on the basis of a salinity criterion such as chloride ion concentration or electrical conductivity. The lenses are often asymmetrical with the deepest portions displaced towards the lagoon side of the island with a typical thickness of 10-20 m, with a transition zone of a similar thickness as in the case of Tarawa and Majuro atolls. The zones themselves are not static but vary according to fluctuations in recharge and groundwater abstraction rates.

The volume of freshwater in these lenses is proportional to the size of the island, and is likewise influenced by rainfall, permeability of the underlying strata, and the degree of mixing resulting from tidal movements and the extraction rate of water from the lens.

Rainfall is the source of all surface water and groundwater resources, but is important in its own right through the use of catchments. These can vary from large-scale sealed catchments relying on channelling the rainfall into storage tanks, or recharging the freshwater lens by using impervious surfaces to small systems based on roof collection. Some of the smaller islands (Cook Islands and Tuvalu) rely almost entirely on the collection of rainwater from individual household roof and storage tank systems, while for others it is a supplementary source of water for domestic needs such as cooking.

Desalination is a less common method of drinking water production with systems based on a distillation or a membrane processes, the most common method used in small island countries being Reverse Osmosis. Desalination can be expensive and complex, and production costs are higher than from natural water sources due to the high energy and operating expenses. The complexity of the process also causes problems in maintaining the system, and in the provision of sufficient trained personnel for operation, and many units lie abandoned around the Pacific.

## **Situation - Pressures on Supply**

Because of the reliance on rainfall to replenish surface and groundwater, and as a direct supply of fresh water, any variability increases the vulnerability of the islands. The El Niño effect has caused widespread variations in precipitation, causing droughts in some regions and heavy rainfall in others.

Droughts deplete rainfall collection supplies, and reduce the freshwater lenses, aquifers and surface waters in many of the countries. Impacts are first felt in systems with small water storage capacities where shallow aquifers can be affected by a relatively short period of below average rainfall, whereas more extensive aquifers may have sufficient storage to be little effected by droughts lasting several years. These prolonged droughts cause a reduction in the quality of available water as they become brackish, as has occurred in Kiribati, the imposition of water rationing in most islands of the North Pacific, restricted access to drinking water in the Marshall Islands, and even to the declaration of a national emergency as occurred in Micronesia in 1998.

Conversely, intense rains have overwhelmed and damaged collection systems and during severe tropical storms have contaminated the freshwater lenses with salt water through inundation and infiltration making them unusable for long periods. Climate change also increases the possibility



of a rise in sea level that threatens not only to damage the freshwater resources, but also to submerge some of the lowest-lying islands, such as Tuvalu, the Marshall Islands and Micronesia.

In some cases over-extraction of freshwater from the limited groundwater supplies has led to saltwater intrusion and finally to exhaustion of the supply. However, groundwater modelling studies have shown that impacts are not detrimental provided that land is not permanently lost through inundation, and that extraction is carried out at a sustainable rate.

Where freshwater is particularly deficient, alternative supplies have been sought through such measures as desalination, as used in Nauru and the Marshall Islands or by shipping in a proportion of its requirements as in the case of Nauru and some of the smaller islands of Fiji and Tonga. Efforts to reduce the pressure on fresh water supplies have resulted in the use of non-potable water such as seawater for toilet flushing on some islands for example Kiribati and the Marshall Islands.

Adding to the natural pressures on freshwater resources, and representing a greater short-term threat is the increasing demand for drinking water from a rapidly expanding population. Although some islands are experiencing a small decline in population (Tokelau and Niue) the population of the region as a whole is expected to double in the next twenty-five years due to improved health care, the relatively high birth rate, and the steady or declining death rate. Compounding the problem is the movement of the expanding population into existing or new urban areas, which are without sufficient or adequate water supply systems and have the added demand from household appliances, and from leakage and wastage in the distribution system. This extra strain on old or poorly maintained infrastructure results in increased losses of valuable drinking water.

Sanitation systems are likewise often insufficient or unsatisfactory, and without the proper controls, regulations or mechanisms to dispose of human waste, it finds its way into water supply system causing chemical and biological contamination. This waste enters the groundwater systems through highly permeable soils common on low-lying islands resulting in a rise in diarrheal and other infectious water-borne diseases. Although the majority of water suppliers advise consumers to boil their water before drinking, outbreaks of cholera and typhoid are still common occurrences in the Pacific.

Many of the small islands have neither sufficient water resources nor suitable soil conditions for irrigated agriculture, but in some of the high volcanic islands where soils are suitable irrigation is possible, but is practised on a relatively small scale. The production of cash crops, such as rice and sugarcane, involve high water use and are generally limited to the well-watered high islands such as Fiji. Although still limited, the use of agricultural chemicals also raises the potential for contamination.

Industry in the Pacific Islands is limited, the exceptions being extensive mining operations in Papua New Guinea and New Caledonia and some small scale manufacturing in Fiji and Samoa. The growth in tourism however has resulted in a greater demand for potable water, and may represent a substantial proportion of total water consumption in some small islands.

Conservation and protection of the water sources offers greater sustainability, and improved management through better maintenance and operating will reduce leakage and wastage of valuable water. Pro-active strategies include planning for greater collection and storage of rainwater, the development of procedures for balancing water use between times of flood and drought, and examination of cost and benefits of technological solutions such as desalination for use in times of greatest need.



## **Surveillance - Situation and Needs**

With so many diverse threats to water supplies in the Pacific Island region, governments and water suppliers are under pressure to ensure the quality of drinking water reaching consumers by means of surveillance and monitoring programs. These agencies must provide the frameworks to develop the legislative and operational requirements needed to improve water supplies to meet community needs.

Despite the vast size of the region many of the needs of the Pacific Island nations are similar. Their populations and resource bases are small, and they all face climatic challenges to a resource that is increasing coming under threat. They confront severe logistical challenges in organizing safe drinking-water supply, and a standard "sampling and analysis" approach to surveillance and monitoring is rarely sufficient to ensure quality for these isolated geographically dispersed countries. Decentralised programs utilising on-site testing, local sanitary surveys and community engagement through education and participation have been identified by the countries as being the most likely to be effective.

Current programs in the Pacific Islands are characterised by common problems of a lack of legislation, fragmented responsibility, under-resourcing, and a lack of capacity to carry out the necessary surveillance and monitoring.

The national reports suggest that these shortcomings are not recent, but have affected the Pacific Islands countries for a long time, and have prevented progress in the management, planning and development of their limited water resources, and is revealed by an unsystematic, uncoordinated approach to surveillance and monitoring in the region.

The fact that these deficiencies have persisted for so long indicates that issues of water resources and quality do not rate as high as they should on national agendas, coming to the fore only during periods of crisis brought on by climatic conditions such as drought or flood, or by health indicators such as increasing trends in water-borne disease. As a result these countries have identified that there is need for politicians and policy makers to be made more aware of the importance of the provision of an adequate quantity of safe water to their citizens.

Strategies are needed that increase the recognition of the importance of clean safe water, and ensure that it is a priority issue on international, national and public agendas. These strategies should build and increase the Pacific Island nations capacity to effectively manage their water, and help them develop a common understanding of policies, institutional frameworks, and practices of sustainable development using internationally set targets, goals and objectives that are sensitive to regional conditions.

Rationalization and re-alignment of existing policies and standards or the development, adoption, implementation and enforcement of new and improved legislation for water and sanitation are required, which recognises the differing needs of urban and rural environments. For those island states with very limited water resources, there is a need for separate demand management programme, policies and strategies.

The low priority given to surveillance and monitoring was often identified as resulting from a lack of a national strategy, legislation, policies, regulations, management procedures, standards and guidelines for drinking water quality. Often where they do exist, there is no legal framework, and insufficient resources to adequately police or enforce them. Quality assurance and control procedures and mechanisms are rarely in place to ensure that monitoring measurements are valid, and very little risk management assessment is done. Effective implementation and monitoring of standards together with a quality assurance program is needed.



Based on these needs, a series of strategies will be required to move forward; strategies that recognise, and understand the unique constraints on the Pacific Island Countries due to their small size and increasing population with its attendant competition for land use, vulnerability to natural and man-made hazards, including drought, cyclones and urban pollution.

Many of the current weaknesses were perceived to be at the political level with the fragmentation of responsibility for water related matters. Often the responsibility lies between water suppliers, within several individual government agencies, or with private companies and non-government organisations. These organisations, even within government, rarely collaborate or share information, work within different mandates, and have different visions, goals and objectives. This typically results in confusion of roles and overlap of responsibilities, with duplication of effort in some areas and gaps in others. Information is often stored in different formats or is retained in hard-copy files that are difficult to transfer and analyse. Without the ability to correlate and analyse the information a holistic assessment of the national, or local situations cannot be made. A majority of the countries identified a lack of collaboration and poor sharing of information as problems.

The reports highlight the lack of distinct areas of responsibility between governments and utilities that makes creating partnerships and collaboration difficult. Partnerships that are inclusive of all stakeholders groups were seen to be of great importance particularly for disadvantaged groups who suffer most from an inadequate and unsafe water supply, and are often directly affected by measures taken.

Standards, monitoring and surveillance programs may follow historical patterns of monitoring, where parameters are decided on past experience, current resources and technical capacity. The first step in any review is to assess and prioritise what parameters are essential to ensure the safety of water. This may result in the development of new, or the rationalising of existing standards. By using available tools and techniques, critical parameters are defined, and programs reoriented to focus on these, and put into place the human and physical resources and technical capacity to measure and enforce them. The existing lack of base line monitoring data limits opportunities to effectively manage water resources or develop adaptation strategies and the ever-changing industrial and agricultural practices and demography of the region requires that the type and frequency of monitoring needs regular assessment and review in light of the varying risks.

With the wide range of environments in the region water suppliers need to adopt a mixture of appropriate water supply technologies to allow affordable access by all consumers and conserve reserves by minimising water leakage, wastage, illegal connections and unregistered consumption. The quality of water supplied should be subject to analysis and supported by sanitary inspections to ensure that it complies with current standards. Ensuring proper control requires that the supplier and the surveillance agency work closely together, while remaining independent. This deficiency was highlighted in many country reports where cooperation or collaboration between relevant agencies was deemed to be lacking.

Local issues too show many problems that are common across the region, with the most frequently identified being the need to improve public awareness of the importance of protection, conservation, economic value and correct use of the limited water resources at their disposal. Involving the public ensures that goals are met, while giving a large degree of ownership and control to the community. Of particular benefit is the communication of the lessons learned from demonstrated successful programs to communities with similar issues.

This public involvement in programs is critical if strategies and action plans are to be successfully carried out, particularly where surveillance and monitoring form part of a community or water resource management plan. With public involvement it is important that capacity is developed with a specific focus on skills training coupled with effective



dissemination of appropriate information. This two-way knowledge transfer was identified as a key factor for success, where the community can have input at the planning stage, and information is returned on how these plans will affect the community. This exchange of knowledge was reported to be currently lacking in the region.

Awareness raising programs are particularly important where new technologies or management procedures are introduced. Obtaining appropriate advice on programs and tools to use for public education, and the involvement of mass media, was a common requirement in the region particularly in the smaller nations. The reports make clear that sufficient long-term support for water quality programs is necessary to raise public awareness on the importance of water quality and safety.

Where simple field-testing is used at the local level in surveillance and monitoring programs the provision of standardised equipment, methods and reporting formats was seen as essential for national and regional consistency. The reports highlighted the sanitary survey as a cost-effective measure that was consistently under-utilised in the region whereby a current assessment of the overall situation could be rapidly made.

Regionally, the country reports identified that there is a need to develop and use guidelines and programmes that strengthen inter-regional and intra-regional partnerships, build national capacity, and maximise available resources in a collective way, ensuring that they are inclusive, appropriate, sustainable, and provide a network of support for the needs of member countries.

The development of internet-based and electronic delivery of learning materials, and the dissemination of relevant data, research and information offers an opportunity to increase the networking capabilities of countries, provide remote training, build capacity, share models of best practice, and promote consistency of reporting across the vast distances that are a feature of the region.



## **Appendix A – Country Reports**

### **American Samoa**

#### **Background**

American Samoa lies roughly on a line between Hawaii and New Zealand, about 1430 km. from Honolulu, and 990 km. from Auckland. The independent State of Samoa lies about 80 km. to the west. American Samoa is a Territory of the United States of America, and its population is predominantly native Samoan, who are nationals of the United States. The Territory is comprised of the main island of Tutuila and its small neighbouring island of Aunu'u, the three islands of the Manu'a group 100 km. to the east, Swain's Island 320 km. to the north, and the uninhabited Rose Atoll about 120 km. east of Manu'a.

#### **Water resources and supply**

Ground water and surface water provide the water supply to the population of American Samoa of whom 95% of the population have access. The problems that confront the water supply are mainly due to human activities, including animal faeces and improper sewage and wastewater disposal. Increasing agricultural activities combined with surface runoff are introducing chemicals into the water supply system. As a result, there have been isolated cases of diarrhoea, gastroenteritis, and typhoid.

#### **Water quality surveillance and monitoring**

One of the main priorities and concerns of American Samoa Government is Drinking Water Quality Surveillance and Safety, which is implemented and enforced by three agencies namely the American Samoa Environmental Protection Agency (ASEPA), American Samoa Power Authority (ASPA), and the Department of Health. Water quality parameters measured vary considerably from area to area.

ASEPA is responsible for the measurement of bacteriological parameters and testing and sampling activities. Water samples are collected on a daily or weekly basis and any necessary control measures are instituted based on the outcome of analysis.

ASPA mainly deals with construction, catchment protection, installation of water meters, and billing, which is on monthly basis. From the viewpoint of health, surveillance is primarily based on inspection and consultation related to existing recorded conditions.

Health education is used to motivate the public and to enlist their participation. Applicable territorial and federal laws and regulations such as the Water Act 1965 and Health Ordinance 1959 are enforced by the above-mentioned agencies. Prosecution results from non-compliance.

#### **Needs analysis**

The needs identified include the provision of adequate resources to enable improvement of surveillance programs, risk assessment and management guidelines and to strengthen enforcement activities. These activities can be used to review or amend existing standards. The continued raising of public awareness of health and hygiene practices related to water supply and use is also required.

#### **Reference**

1. Country Report- American Samoa, Workshop on Drinking Water Quality Surveillance and Safety: 29 October — 1 November 2001, Nadi, Fiji, Mr Pasesa Lafitaga, Chief Environmental Health Officer, Department of Health, Pago-Pago



## **Cook Islands**

### **Background**

The 13 inhabited and two uninhabited islands comprising the Cook Islands are located in the South Pacific between latitude 8-22° South and longitude 156-167° West. They lie between Tonga and Samoa to the west and French Polynesia to the east, and comprise a Northern Group of seven coral atolls, and the Southern Group of nine islands of mainly volcanic origin. The total land mass is 237 km<sup>2</sup> spread over 1,830,000 km<sup>2</sup> of ocean.

The highlands are covered with tropical vegetation, while the lowlands and valleys are used for agriculture, the mainstay of the island economy. Tourism is playing an increasingly important role in the economy since the opening of the Rarotonga International Airport in 1974.

The largest island and the capital is Rarotonga, it is the most developed of all the islands, and is home to the Central Administration of the Cook Islands Government, and more than half of the total population of around 19,500.

### **Water resources and supply**

The water supply for Rarotonga is drawn from surface water from 12 intakes located in the centre of the island. Of the supply intakes, four take the water directly, five use in-stream filtration, and the remainder use off-stream intakes. This water is passed through gravel filters and gravity fed to consumers. The twelve intakes supply a total of between 7,000 and 21,000 m<sup>3</sup> per day.

### **Water quality surveillance and monitoring**

Water quality sampling is carried out by the Environmental Health Protection section of the Cook Islands Ministry of Health, Division of Public Health who are responsible for aspects of environmental health throughout Rarotonga and the outer islands. These include the management of environmental health protection, and public health awareness programs. The section is responsible for the management of water pollution and domestic and industrial waste

Samples are taken every 4 months and are analysed for faecal and total coliform contamination at Rarotonga Hospital laboratory, and both have been detected at above guideline values in these water samples.

### **Needs analysis**

The needs identified include developing a national environmental health protection strategy to prevent and control communicable and chronic disease, and to promote the value of health through public education programs.

### **Reference**

1. Country Report -Cook Islands, Workshop on Drinking Water Quality Surveillance and Safety, 29 October - 1 November 2001 Nadi, Fiji: Mr Porinae Emile, Senior Health Inspector, Public Health Department, Ministry Of Health, Rarotonga
2. WPRO site



## **Federated States of Micronesia**

### **Background**

The Federated States of Micronesia (FSM) is a grouping of 607 small islands in the Western Pacific about 4023 km southwest of Hawaii, lying just above the Equator. Generally speaking, FSM comprises what was known as the Eastern and Western Caroline Islands. While the country's total land area amounts to only 701 km<sup>2</sup> it occupies more than 2.6 million km<sup>2</sup> of the Pacific Ocean, and ranges 2735 km from East (Kosrae) to West (Yap). Each of the four States centres around one or more "high islands", and all but Kosrae include numerous atolls. Chuuk State has a total land area of 127 km<sup>2</sup> and includes seven major island groups. Pohnpei State has 345 km<sup>2</sup> of land area, of which 130 is accounted for by Pohnpei Island, the largest in FSM. Yap State is made up of 4 large islands, 7 small islands, and 134 atolls, with a total land area of 118 km<sup>2</sup>. Kosrae is essentially one high island of 109 km<sup>2</sup>.

Pohnpei is the main island of FSM with a population of approximately 35,900, about one-third of the total, and constitutes about one-half of the total land area (297 km<sup>2</sup>). A further half the population lives in Chuuk State. Pohnpei is divided into 5 municipalities the central one being the town where most of business and government facilities are located.

### **Water resources and supply**

Even though rainfall is plentiful in all four states, for the most part the water supply is inconsistent from public water systems. Residents supplement their supply with individual rainfall catchments, however, steady improvements in the reliability of the public water supply are continually being made.

Surface water is the major sources of drinking water with rainwater and groundwater also used. The capital, Kolonia, and some parts of the Netland Sokehs are served by treated surface water. Kolonia is primarily dependent on the surface water collected from a dam some 3 km from the town, combined with three deep production wells. All are in good condition and produce safe water. Most people in the urban areas have access to reliable and safe water for human consumption.

The surface water that supplies Kolonia and nearby area in Sokehs and Nelt is treated by a conventional process of sedimentation, filtration, and disinfection with calcium hypochlorite.

In the rural areas, most water supplies are obtained from streams and catchment intakes, and about half of the people in rural areas have access to potable water. The smaller outlying atolls utilise mostly rainwater catchments, which is a cause of some concern as during droughts they run out of water.

Animal and human faeces are the main sources of contamination of water supplies in Pohnpei. Much of the surface water is exposed to animal and human wastes and other contaminants because of a lack of protection, and wastewater and run-offs during floods and heavy rainfall.

The four urban centres in FSM each have a sewerage system. Outside the urban centres, however the population relies on different forms of septic tank systems. Water seal and dry composting toilets are enjoying wider usage, particularly in remote villages and outer islands.

Pohnpei has one sewage treatment plant located in Kolonia and over 500 homes are connected to the sewage system. This type of treatment plant is the trickling filter type and the treated sewage is discharged directly into Sokehs Harbour.

The municipalities utilise septic tanks and pit latrines. An EPA sanitary inspection revealed that over 2000 homes had either no sanitary facilities, or substandard facilities.



Pohnpei does have a sanitary landfill, located in Kolonia, managed by a private company and the Pohnpei state government provides funds for the operation of this landfill, and provides collection of garbage from all homes in Pohnpei who can afford to pay.

Pohnpei has a problem with high levels of water related diseases, the most common include diarrhoea, gastroenteritis, intestinal worms, cholera and amoebiasis

### **Water quality surveillance and monitoring**

Key agencies involved in water supply in Pohnpei are:

- The Pohnpei Utility Corporation responsible for improvement, rehabilitation, operation, maintenance, and management of urban and rural water supply systems.
- The Pohnpei Environmental Protection Agency who are responsible for water quality control, monitoring, and public education.
- The Office of Public Works responsible for construction and review of urban and rural water supplies.
- Private water bottling companies who supply bottled water in urban areas

The Pohnpei legislature enacted Pohnpei Environmental Protection Act of 1992, which become law in 1995. This legislation established the Pohnpei Environmental Protection Agency under the Authority of a Board, and this Board has the power to issue regulations. So far, it has issued 17 regulations including those for Safe Drinking Water. This regulation sets out the standards to be followed for all public water supplies.

Water quality surveillance and monitoring is the responsibility of the supplier, the Pohnpei Utility Corporation for all urban treated water and municipal community water systems. The Pohnpei Environmental Protection Agency monitors all water systems including private companies that manufacture water. The private bottling companies also monitor their product.

### **Needs analysis**

The needs identified include the training of laboratory personnel, improved data management, and the sharing of information amongst different departments and agencies. A need to strengthen public education in the water quality monitoring program, and to improve enforcement was also noted.

### **Reference**

1. Country Report: - Federated States of Micronesia, Mr Moses Pretrick, FSM Environmental Health Coordinator, FSM National Government, Palikir, and Mr Elden Hellan, Executive Director, Pohnpei Environmental Protection Agency, Pohnpei State Government, Kolonia. Workshop on Drinking Water Quality and Surveillance and Safety, 20 Oct – 01 Nov 2001, Nadi, Fiji
2. Federated States of Micronesia web site - <http://www.fsmgov.org/>



## **Fiji**

### **Background**

The island state of Fiji is located in the South West Pacific. It is composed of over 300 islands. Within the island groups, there are two main islands, Viti Levu and Vanua Levu. The capital Suva and main tourist centre of Nadi are located on Viti Levu. Politically and administratively, the country is divided into 3 Divisions, the Central/Eastern Division including Suva, Western Division including Nadi, and the Northern Division, which includes Vanua Levu and the outer islands.

Fiji's population is estimated at 775,000, making it the second largest island state in the Pacific after Papua New Guinea. The majority of the population lives in rural areas and only 20% of the population is classified urban. Approximately 75% of the population lives on Viti Levu with 18% living on Vanua Levu, and the remainder on outer islands.

Of the total population 98% have access to water supply in urban areas while only 63% had access in rural areas.

The two major islands of Viti Levu and Vanua Levu are mountainous volcanic islands. Vanua Levu is still volcanically active and some thermal activity has been recorded in recent years. Viti Levu is the largest of the islands stretching 106km from North to South and 146km from East to West.

### **Water resources and supply**

The Eastern region of Viti Levu (including the capital Suva) receives a high annual rainfall averaging more than 3000mm per year while other areas of the country record just under 2000mm per annum. Due to this abundance of rainfall, combined with the mountainous topography of the Islands, Fiji is mainly reliant on surface water as its water source.

The capital city of Suva with an estimated population of 168,000 is primarily dependent on the surface water collected from two catchment areas in the centre of the island. The remaining smaller villages are dependent on groundwater and surface water intakes. The intakes are susceptible to seasonal fluctuations, and drought is of major concern throughout the rural and outer island areas.

Some community development programmes are promoting the use of rainwater for emergencies during these periods of drought and the South Pacific Applied Geoscience Commission (SOPAC) is working with the hydrology section of the Department of Mineral Resources to evaluate the quantity of water available throughout Fiji through a technical steering committee.

During droughts water is barged or trucked into communities by the Public Works Department (PWD) loaned from private vendors during the emergency. Although the tanks and water bowsers are chlorinated before use, there is limited control on the quality of water provided or on quality control of the tanks.

Suva is served by treated surface water through a combination of in-house and yard connections while other urban areas such as Levuka, Nabora, Nadi and Lautoka are dependent on treated surface water, while some of the smaller supplies are reliant on groundwater reticulation systems.

The surface water that supplies Suva is extracted from two major sources. This water is treated by sedimentation, filtration, disinfection with calcium hypochlorite, and fluoridation with sodium silica fluoride.



The distribution network for the town has been designed for 150litres per capita per day but most households consume more than 200 litres, with some rates as high as 500 litres.

In the Global Water Supply and Sanitation Assessment in 2000, the coverage of the population in Fiji with access to an improved water supply was recorded as 43% for rural areas and 51% for urban areas indicating that water coverage throughout Fiji remains low. This is particularly evident in the rural areas where the Fiji Public Works Department (PWD) considered 51% as an over-optimistic estimate.

A recent study undertaken by SOPAC of Pacific Water Utilities indicated that Suva has the highest percentage of people served with reticulated water in the Pacific Islands, and that in 1997, more than 100,000 domestic connections were recorded. The reliability of supply is estimated at 100% (24 hours) and although service levels are high in Suva, the percentage coverage for all urban areas of Fiji suggests a large deficit in service provision and functionality. Recent data from the Suva Municipal Area indicated that's residents are paying an average of US\$0.2 per m<sup>3</sup> of water consumed with, on average, rural communities paying more than urban communities for water supply.

Fiji has higher levels of agricultural and industrial activity than its neighbouring countries of Samoa and Tonga, and a survey to identify and quantify the volume of unwanted Persistent Organic Pollutants (POP's) and associated environmental contamination in Fiji found that stockpiles of pesticides are the major environmental threat. Agricultural chemicals are the greatest chemical pollutants in use.

Also of concern are microbiological pollutants from unsafe faecal disposal, vector control and solid waste management. Sewerage is the major form of faecal disposal in Suva and other major urban areas. The municipal area of Suva is serviced by a sewerage treatment plant, a secondary plant based on biological filters where the sludge is digested and dried, with on-site disposal of the dried sludge. The final effluent from the system is pumped into the sea. The plant is currently processing sludge from 60,000 households but will soon expand to 250,000 with overseas funding.

Households not connected to the mains sewerage system practise on-site sanitation such as pour flush, septic tank systems and pit latrines. Currently, there is no standard design of septic tanks that are mostly unlined, allow subsurface pollution, and are not monitored by the Public Health Department to ensure regular desludging. Tanks are emptied by a private-public co-operative, which includes the Department of Public Works (PWD). Sludge is disposed of at the wastewater treatment plant in Suva, and in sludge drying pits in other urban areas.

With the disposal of faecal matter in unlined septic tanks, the drinking water quality of groundwater is susceptible to increased levels water-borne disease causing agents, and possible high levels of nitrates.

The South Pacific Regional Environment Programme (SPREP) is planning to improve solid waste collection and disposal in the Pacific Islands as current disposal methods use un-lined landfill sites, unsolicited dumping or by burial and burning. To improve the system, a domestic waste collection is proposed with collection occurring 2 to 3 times per week in urban areas, charged to the individual household. The revenue from the collection will be used to improve methods of disposal.

Notifiable diseases data from the Department of Health records high levels of water-related diseases and although the numbers of cases are reducing, the methods of data collection must be questioned. A health study undertaken in rural communities in 1995 indicated higher levels of recorded water-borne diseases than at the national level. Through consultation at the community level, it was discovered that on average 27,000 persons per year were effected by diarrhoea in



the 59 communities corresponding to one case per person per year. Noting that rural communities did not register diarrhoea unless they saw an increased level of blood in their stool it was concluded that data is only representative when collected at the community level in rural areas. As well as diarrhoea, data indicates high levels of ill-defined intestinal infections, and in 1999 hospital admissions indicated a drastic increase in recorded levels of gastro-enteritis.

### **Water quality surveillance and monitoring**

No country specific water quality standards exist in Fiji and the participating agencies are currently using WHO Drinking Water Quality Guidelines.

The agencies responsibilities for Water Supply at the national level include the Public Works Department (PWD) responsible for capital works, systems rehabilitation, operation and maintenance, management and cost recovery, and water quality, and the Public Health Department, Ministry of Health responsible for water quality monitoring and health education. The Mineral Resources Development Department are responsible for borehole siting and drilling, the South Pacific Applied Geoscience Commission (SOPAC) for research and hygiene promotion, and private bottling companies for bottled water supply.

At the local and rural level, various Water Committees are responsible for operation and maintenance, together with NGO's involved in health education.

There are currently four major types of water quality monitoring programmes in Fiji including those conducted by the National Water Quality Laboratory, Public Works Department (PWD) for urban treated water and the Public Health Department, Ministry of Health (MoH) for urban, rural and private water supplies. The Institute of Applied Sciences (USP) also samples urban and rural water supplies, and private bottling companies (including Fiji Water) tests private bottling plants

There is no official exchange of information between these agencies and results from PWD and USP are treated as confidential and information is not shared voluntarily with the Public Health Department.

Although the frequency of sampling is agency specific, there are some common factors between the programmes that focus on piped water supplies in urban areas, and areas of surveillance that do not relate to areas with lowest coverage. Very limited water quality testing is being done in the rural areas, on the outer islands, or on non-piped water supplies.

The Public Works Department (PWD) collects and analyses samples from within the urban treated water supply of Suva, Nadi and other major cities. The majority of samples are collected in the Central/Eastern Division, which includes the capital city of Suva while the least number of samples collected were from the Northern Division (which includes the majority of the remoter outer Islands). However, since 2000, the number of samples collected has increased, and by May 2001 some 20 samples per week were collected from the Suva distribution system, and 10 samples from 14 piped water systems throughout the rest of the country.

The frequency of sampling also varies according to the location. In Suva, samples are taken weekly, in the Western Division, they are taken fortnightly, and for the Northern Division and Southern side of Viti Levu, samples are taken once per month. Fixed-point sampling is undertaken on each of the distribution systems, and occasional household testing is undertaken depending on availability of human resources.

In areas further from Suva, samples are collected in sterilised bottles, and returned in an icebox below 4°C from the west of the Island or from Vanua Levu, usually in less than 6 hours.



Limited field-testing is being undertaken by the PWD despite the presence of field-testing kits after the kits were used to monitor microbiological and physical parameters during a recent evaluation of a rural water supply found the results to be questionable.

Overall some 200 drinking water samples are analysed per month and the data from analyses are collected by laboratory technicians and recorded. The data is analysed by the chief Laboratory Technician and recorded in a monthly report for the Board of Directors of the Public Works Department. Data is not shared with the Ministry of Health.

The Chief Health Inspector leads the Public Health Department, which has over 100 health inspectors (HI's) throughout Fiji working for the Department. The level of theoretical knowledge amongst the HI's is very high. The inspectors from the three Divisional Headquarters collect samples in the field from a number of fixed and random points. In Lumbasa (Northern Division) and Lutoka (Western Division) there are two Clinical laboratories with facilities to analyse water samples. However, due to a lack of reagents these are not currently operational. Samples are therefore sent to Suva to be analysed at the Koronivia Research Station at the Department of Agriculture due to the lack of a suitable public health laboratory.

This lack of resources results in samples only being collected on request and records indicate that on average, 15 samples are collected per month from all divisions, which is low enough not to be representative. The Department has a high level of human resources and knowledge but are limited by their physical resources and lack of a cohesive program.

The Institute of Applied Sciences is a semi-commercial institution based at the University of the South Pacific (USP). The Institute analyses water on request and samples from 10 of the major Hotels in Fiji plus private supplies are analysed on a monthly basis.

Private Bottling Companies including Fiji Water undertake regular testing of their own supplies and limited quality control is in place to crosscheck results from individual suppliers

In summary, there are a number of different agencies testing water quality but there is very little exchange of information between the agencies and no quality control from an independent surveillance agency.

The PWD are currently collecting samples from both surface and groundwater sources with the major focus of the work being on measuring the efficiency of the treatment processes in the piped supplies. A combination of field and laboratory testing is used depending on the parameter to be tested. Testing is for physical and microbiological parameters. Occasional samples collected from rural areas analyse a range of microbiological, chemical and physical parameters including total and thermotolerant coliform, temperature, pH, conductivity, colour, turbidity, TDS and the chemical parameters alkalinity, total hardness, ammonia, nitrite, nitrate, ortho-phosphorous, chlorides, iron, manganese, aluminium, copper, silica, aluminium and copper. Equipment is also available for BOD and COD testing, but arsenic is not being regularly tested.

The Public Health Department is currently only testing for physical and biological parameters, but insufficient available data has made it difficult to define the exact parameters tested.

The Institute of Applied Sciences tests for a range of parameters similar to that of the PWD and BOD and COD are also tested on request. Pesticides samples are currently sent to New Zealand but from 2002 will be able to be analysed in the USP laboratory.

The laboratories undertaking water quality analysis include the Public Works Department, the Mineral Resources Development Department, Koronivia Chemistry Laboratory of the



Department of Agriculture and the Institute of Applied Sciences at the University of the South Pacific (USP). There are also a number of other private laboratories.

The Public Works Department Laboratories are located at the wastewater treatment plant in Kinoya, Suva. The laboratories were renovated in the year 2000 with the addition of new equipment, and a new acting Chief Laboratory Technician with a staff of 10 experienced and highly motivated technicians. The laboratory has the facilities to undertake tests on major microbiological, physical and chemical parameters and conduct analysis of wastewater and drinking water.

The WHO Drinking Water Quality Guidelines are being used, and the staff are aware of the importance of having Standard Operation Procedures (SOP's) specific to the Fiji conditions but there are currently no quality control tests being undertaken, and samples are not compared with other laboratories.

The laboratory of the Institute of Applied Sciences is housed on the campus of the University of the South Pacific (USP) and was established in 1997. The laboratory functions on a semi-commercial basis and is in an excellent condition and is staffed by a highly experienced and skilled team of 20 laboratory technicians. The laboratory undertakes tests on all major microbiological, physical and chemical parameters and plans to begin pesticides and PCB testing. To undertake these tests to a high standard, all the equipment used is recorded in a log book and quality control tests are done daily, weekly or monthly depending on requirements. Local technicians undertake routine monthly calibration and a New Zealand based company visits the laboratories once a year to assure maximum efficiency of all equipment used.

The laboratory has its own SOP's but is yet to be accredited by an International Review Committee and remain in provisional form. The SOP's cover all major testing and calibration of equipment. The laboratory uses the WHO Guideline Values for all parameters tested.

The laboratory is funded from a University of South Pacific grant, from donor donations of capital equipment and from testing fees for private samples. It is currently slightly under-utilised and could be considered as a possible regional laboratory to undertake chemical analysis.

The Laboratory of Mineral Resource Development Department is situated in the Department of Mineral Resources in Suva and receives funding from the United Nations Development Programme (UNDP). It was set up to test physical and chemical parameters on boreholes drilled by the Department, and uses the WHO Drinking Water Quality Guidelines.

The Korinovia Laboratory is located in the Ministry of Agriculture and undertakes tests on samples collected by the Public Health Department of the Ministry of Health.

The Public Health Department conducts house-to-house surveys although limited attention is paid to sanitary inspection of water facilities despite the inspectors having a high level of knowledge about possibly points of contamination, and the linkage between contamination and human health.

### **Needs analysis**

Due to limited funding assigned from the Ministry for Public Health for Environmental Health, physical resources such as transport, computers and water testing equipment limit the Health Inspectors ability to undertake field work and therefore a "holistic" water quality surveillance programme does not exist. Irregular house-to-house sanitary surveys are done but there is limited linkage of water quality surveillance to system improvement.



The Public Works Department has a team of laboratory technicians who undertake both the sampling and the testing of drinking water quality. The team analyse the results and then report them to the directors and engineers within the Department, however, limited feedback is given to the laboratory technicians as to the use of the data.

The USP and private companies test water quality on a private semi-commercial basis but there is limited co-ordination between the private and public sectors, and results are not shared, and there is no forum for discussion.

There is currently no effective independent water quality surveillance body in Fiji. The Public Works Department (PWD) is undertaking regular monitoring of treated urban piped water supplies and USP are monitoring water quality of a selected number of private companies. Both are acting independently and there is no official regulatory body.

Recommendations include the establishment of an independent drinking water quality surveillance body to regulate, legislate, analyse data, co-ordinate between agencies, and undertake water quality surveillance, particularly in “high risk” areas where coverage is at its lowest.

In the case of Fiji, it is recommended that the Environmental Health Department fulfil the function of an independent water quality surveillance agency for several reasons. The Health Inspectors have a high theoretical knowledge that could be used as base to launch a practical programme, the Environmental Health Department are keen to become more involved in water quality surveillance, appreciate its importance as an activity, and there are currently over 100 Inspectors dispersed through the islands who could act as focal points. It is also recommended that the Environmental Health Department should be given adequate support to fulfil the function of a water quality surveillance agency.

This support may be achieved by a change in Government Policy with a declaration signed by the in-coming Fijian Government expressing support for water quality surveillance. This should indicate support for a regulatory body and support to monitor not only low risk urban treated supplies, but also “high risk” rural and peri-urban untreated sources.

There should be a Legal Mandate whereby the outdated Public Health Act of the 1940’s should be updated. All key stakeholders should have input and achieve agreement. The Act should be used as a statutory law to assist Health Inspectors enforce appropriate Public Health standards.

There should be increased funding. A proposal should be written in conjunction with the Environmental Health Department for funding and presented to the Ministry of Health for external funding.

A Review of Technical Capacity through an evaluation of current laboratory facilities and potential partnerships is recommended at both the National and Regional levels.

A national focus person is needed to co-ordinate the process, and would be tasked with co-ordinating with key stakeholders in securing a declaration, and establishing the water quality surveillance agency.

Technical training and capacity building is needed in addition to general support in planning and management with technical back-up support, both in-country and through external consultants. Adequate staffing is required to initiate the process, and offer technical support and guidance.



## **Reference**

1. Workshop on Drinking Water Quality Surveillance and Safety 29 October — 1 November 2001 Nadi, Fiji - Country Report for Fiji by Mrs Waisale Delai Senior Health Inspector (Food Quality Control) Ministry of Health Suva and Mrs Unaisi T. Bera Acting Health Inspector (H/Grade) Ministry of Health, Suva
2. Needs Assessment of Drinking Water Quality Surveillance and Control in Fiji by Sam Godfrey Water, Engineering and Development Centre (WEDC) Institute of Development Engineering Loughborough University UK, September 2001
3. “Chemical Safety of Drinking Water: Identifying priorities using limited information”, Reports of workshops held in the Western Pacific Region of the World Health Organization. P A Kingston, FIJI – 14-23 September 2001.



## **French Polynesia**

### **Background**

French Polynesia is an Overseas Territory of France, covering an area of 4167 km<sup>2</sup> with a land area of 3521 km<sup>2</sup> including 35 high (mountainous) volcanic islands and about 183 low-lying coral atolls in 5 archipelagos. The Territory's nearest neighbours are Kiribati to the northwest and the Cook Islands (a dependency of New Zealand) to the west. Some 86% of the inhabitants live in the Society Islands, which constitute about one-half of the land area.

French Polynesia consists of 48 communes, or municipalities, of which 32 are on the high islands, and 16 in the low-lying islands. It has a population of 235,400 inhabitants as at January 1st, 2001 of which 93% live in the communes of the high islands

### **Water resources and supply**

The high islands of volcanic origin enjoy abundant surface or underground water resources thanks to a good rainfall and to natural reserves, contrary to the low-lying islands that are characterised by lower rainfall and, given the geology, by a very limited presence of fresh groundwater.

In the high islands, the water intakes in the upper catchments of rivers constitute the greatest source of supply of water. In Tahiti, the main island, where nearly 70% of the total French Polynesian population is concentrated, water intakes in rivers account for 80 to 90% of water production. This water resource is gravity driven and has the advantage of no energy costs, but it is vulnerable during heavy rainfall, which leads to an increase in turbidity.

The supply of water is the responsibility of the communes and is distributed via public collective networks allowing everyone to have access to water via a private connection.

In the low-lying islands of coral origin, water collection is carried out on an individual basis from rainwater, which is stored in individual tanks, and by tapping the fresh water "lens" via wells, or by desalination of seawater. The communes also have collective and public water tanks available for the inhabitants to come and draw water.

### **Water quality surveillance and monitoring**

Three statutory instruments have been adopted in French Polynesia, since 1999 regulating the hygiene of water, setting the potability standards, and establishing the monitoring programme for water quality intended for human consumption.

These provisions impose on any owner or manager of facilities for the supply of water intended for human consumption regulations that they must supply water to conform to set standards of potability. They must implement a programme of self-monitoring of the quality of supplied water (sampling for analysis by an approved laboratory) and inform the public on the quality of supplied water. The enforcement of these regulations is the responsibility of the Ministry for Health.

The Department of Hygiene and Public Health under the supervision of the Health Directorate, also checks the quality of the water supplied by the networks for collective and public use through its own sampling and analysis program by an approved laboratory,

In the year 2000, only 3 communes out of 48, including Papeete, the capital city, and representing only 18% of the total population were able to deliver continuous water supply throughout the year in conformity with potability standards.



Nonconformity of the water supplied by the other communes is not of chemical origin but only of microbiological origin, the reasons being the exploitation of surface water resources that are vulnerable to contamination from natural sources, leakage, and poor design or management of water treatment systems.

Nevertheless, efforts have been made by the communes, the government of French Polynesia and the French State to improve the sanitary quality of supplied water by drawing up master plans for the supply of drinking water by the communes. These plans for the supply of drinking water provides a description of the current state of water resources and of their exploitation, and prepares projects for equipment and facilities to be implemented to provide drinking water to the population.

Currently, out of the 29 communes in the high islands not supplying drinking water continuously, 79% (23 communes) have an approved master plan for the supply of drinking water. Almost all these communes have already begun work with the objective of improving the quality of the water they supply. The French State and the Territory of French Polynesia financed the design of the master plans and subsidises the communes to achieve the work.

Since 1997, the Territory of French Polynesia has granted 1.83 billion Pacific francs (approximately 13.3 million US dollars) in subsidies to the communes. These subsidies relate to some 90 operations for the supply of drinking water, such as studies, drilling boreholes, purchase of new hydraulic equipment and facilities, setting up of chlorination systems, and the repair of networks and hydraulic works. 85% of the total amount was allotted to rural communes, which account for a little more than half of the total population. In these communes, there remains much to be done.

In the communes of the urban areas, where water treatment systems by chlorination already exist (both well and badly managed), the subsidised operations primarily relate to bore-holes to mitigate the poor quality of river water during rainy periods, and to obtaining new hydraulic equipment and facilities.

Since 1997, 5.3 billion Pacific francs (approximately 38.4 million US dollars) have already been invested in these operations, the share of the Territory of French Polynesia amounting to 35% of the total cost of the operations. The French State's share to help the communes is 1.91 billion Pacific francs (approximately 13.8 million US dollars), that is, 36% of total expenditure.

### **Needs analysis**

Work is still necessary before every inhabitant of French Polynesia has access to potable water that conforms to the set standards of potability. Taking into account the cost of such works, this goal should be achieved in 8 years.

### **Reference**

1. Country Report - French Polynesia, Workshop on Drinking Water Quality Surveillance and Safety, 29 October — 1 November 2001, Nadi, Fiji, Madame Glenda Melix, Ingenieur Sanitaire, Chef du Service d'Hygiene et de Salubrite Pubuque, par interim Direction de Ia Sante, Papeete



## **Guam**

### **Background**

Guam, a United States Territory, is the largest and southernmost of the Mariana Islands and covers an area of 549 km<sup>2</sup>. The island comprises a northern, coralline limestone plateau and a mountainous area of volcanic origin in the south, rising to some 395 m. It is situated about 2 400 km. east of the Philippines, and its nearest neighbour is the Northern Mariana Islands to the north. It is approximately 48 km in length and varies from approximately 6.5 to 13.6 km in width. The combined population of civilian and military is 206,677 (1997)

The weather on Guam is warm and humid throughout the year. The mean annual temperature is about 27°C with rainfall ranging from 2000mm on the central and coastal lowlands to about 2800mm on the highlands in southern Guam. Guam has two primary seasons, rainy and dry. The rainy season lasts from July to October, the dry season from January through April.

The geologic structure of the island can be divided into two regions by a fault line, which runs across the island, roughly between Pago Bay on the East Coast to Asan on the West Coast. North of this fault line lies a limestone plateau broken by two volcanic intrusions. The limestone is fractured and porous permitting rapid percolation of surface waters. On this northern plateau there are no rivers or streams, but a fresh water lens lies beneath the limestone aquifer. South of the fault line, the area is defined as a mountainous volcanic region where the soil is rocky and relatively impervious to groundwater percolation. As a result there are some rivers and streams, but not many satisfactory wells.

### **Water resources and supply**

Guam is unique in many ways including its water supply situation. Because of the island setting, Guam must make full use of its available water resources. In order to optimise development of the island it is critical that the quantity of water available from various sources be defined as accurately as possible. The capacity of the northern groundwater aquifer is limited, as are all freshwater lenses on Pacific islands. Surface water runoff is also limited and varies with rainfall, topography and other physical characteristics of the various island watersheds.

Because of Guam's isolation as an island community, it is totally reliant on its own resources under all situations. This becomes readily apparent when typhoons periodically sweep the island. In assessing existing facilities, the ability to meet water demand under maximum day demand conditions and water quality was evaluated. Power supplies, water storage facilities, pumping equipment, water distribution and interconnections between various water systems were also considered.

The island's water resources are from groundwater in the Northern lens, rivers and streams in the South, and from springs in the central region.

The water quality of groundwater in the Northern lens is presently of good quality with the exception of several sub-basins that were polluted with bacteria and viruses from overflowing raw sewage at malfunction pumping stations. Guam obtains most of its water production from the groundwater contained in this aquifer.

Unlike the northern part of the island, southern Guam has more than 40 streams draining into the sea. There are two major sources of surface water; the Ugum River utilized by the Guam Waterworks Authority (GWA) and the Fena reservoir by the US Navy. The Ugum Water Treatment Plant provides approximately 1.2 MGD to the GWA Southern Water System.

Fena Reservoir is located in the watershed area on the eastern slope in southern Guam, having



an impoundment capacity of approximately 2.3 billion gallons. Besides rainwater in the watershed, it receives a water supply supplement from Almagosa and Bona Springs. The reservoir supplies water to the US Navy operations and personnel as well as military dependents and the civilian population via its own treatment plant.

In addition to groundwater and natural reservoirs, springs are another source of GWA water supply, and account for 2.8% of total production. The main sources are the Asan and Santa Rita Springs.

Most of the water is supplied via the Guam Waterworks Authority (GWA) through its Northern, Central and Southern water systems. Other systems include the military systems, Air Force and Naval, and smaller supplies operated by industries and hotels

The GWA water system has experienced operational problems including an unaccountable water usage rate, widely fluctuating pressures and periodic poor water quality. As a result the Guam Environmental Protection Agency (GEPA) conducted a comprehensive sanitary survey of the water systems for compliance with the regulations and to identify problem areas so that system improvements and procedures could be implemented. These improvements should lead to consumers having access to adequate quantities of good quality drinking water, and allow the water utilities to assess the effectiveness of their water systems and their operation and maintenance practices. Water from production wells are chlorinated and fluoridated prior to distribution, and stored in storage tanks or reservoirs.

Guam Earth Tech has built and operates a water supply system using ten production wells that will transfer to GWA at the expiration of the contract.

The U.S. Navy is Guam's second largest water producer using water from Fena Reservoir and the Bona and Almagosa springs.

Water from these sources is pre-chlorinated before dosing with aluminium sulfate and lime for coagulation. The water then flows into a clarifier where the settled solids are discharged and the clarified water flows to dual media filters for removal of the remaining turbidity. After filtration, the water is chlorinated for disinfection.

The Andersen Air Force Base is the third major water supplier on Guam utilising ten deep wells. A single treatment plant and pump process the water into a reservoir prior to the distribution system. The system currently serves a population of 4,500 with a design capacity to serve 7,700. All water produced by the Air Force is chlorinated and fluoridated and is regularly monitored. Chlorinators are operated at a constant rate and are manually set to function with pumps. Several resorts, hotels and small industries on Guam also supply water for their own needs.

While Guam has no history of any outbreak of waterborne diseases, there has been an alarming rise in cases of giardiasis, however it cannot be determined if this is due to water-borne transmission or to other causes.

### **Water quality surveillance and monitoring**

Guam EPA Safe Drinking Water Program was established for the implementation and enforcement of the Guam Primary and Secondary Safe Drinking Water Regulations in accordance with the Safe Drinking Water Act.

The major objectives are to ensure the public of a continuous supply of safe water for human consumption and for domestic purposes, to provide a comprehensive program for the prevention and control of drinking water pollution, and to obtain full compliance with the Safe Drinking Water Act and the Memorandum of Agreement between Guam Environmental Protection



Agency (GEPA) and the U.S. Environmental Protection Agency (USEPA).

GEPA has made several amendments to the Guam Safe Drinking Water Regulations since its creation in 1973. Before the adoption of the regulations, GEPA used WHO standards to regulate drinking water. In 1975 the Interim Federal Primary Drinking Water Regulations was promulgated (40 CFR 141) which came into effect on June 24, 1977. In March 27, 1978 the first Guam Primary Safe Drinking Water Regulations were adopted and implemented. The regulations were amended on February 25, 1983 to adopt the Fluoride, TTHM, Radionuclide, Combined Radium-226 and Radium-228, Gross Alpha particle Activity (including Radium-226), Tritium and Strontium. Presently GEPA is in the process of revising the regulations to adopt all provision of the Federal Safe Drinking Water Act (SDWA) as amended in 1986 and 1996.

Local laboratories certified by GEPA include the Water and Energy Research Institute (WERI) Lab at Mangilari, the Guam Waterworks Laboratory, Dededo, the Earth Tech (FENA) Laboratory Santa Rita, and Foremost Food Inc. Laboratory, Upper Tumon.

The Guam Public Supplies System use off-island laboratories to conduct analysis for compliance with the regulations. All laboratories that conduct analysis for compliance must be certified by the state where the laboratory is physically located. Only laboratories within the United States and certified by any state may conduct analysis for compliance.

Testing has revealed that on occasions both the Guam Waterworks Authority and the US. Navy failed to comply with the Safe Drinking Water Regulations for monitoring and reporting requirements, primarily for organic chemicals or for turbidity. However the Andersen Air Force Base (AAFB) was in full compliance with Guam Safe Drinking Water Regulations. All other Public Water Suppliers monitored all the required parameters, and all were in compliance with the regulations.

GEPA enforces the mandatory certification requirements of all operators for water and wastewater facilities in the island of Guam and all responsible operators are required to be certified comparable to the level of the system. GEPA is mandated to determine the level of each system operating in the Territory of Guam both civilian and military. GEPA is also mandated to conduct a sanitary survey of all water systems with a priority given to those systems with compliance problems. GEPA has issued several Notices of Violation and Compliance Orders to utilities that were not in compliance with the regulations.

### **Needs analysis**

A limitation identified in the implementation of the DWQ standards was the non-availability of a certified laboratory to conduct water samples analysis for compliance with the SDWA. The new turbidity standard has been identified as being too stringent for existing conventional treatment plants, particularly when raw water turbidity is high.

### **Reference**

1. Needs Assessment of Drinking Water Quality Surveillance and Control in Guam, October 29, 2001, Angel B. Marquez, Guam Environmental Protection Agency, Safe Drinking Water Program, Water Division



## **Kiribati**

### **Background**

Kiribati consists of three main island groups scattered over three million km<sup>2</sup> of sea in the Central Pacific, between 4°N and 3°S, and 172° E to 157° W. The total land area is 810.8 km<sup>2</sup>, divided into 33 low-lying coral islands, 10 of which are coral atolls.

The Gilbert Group consists of 17 islands (including Banaba, or Ocean Island) with a total land area of 285.7 km<sup>2</sup>. Tarawa atoll, in the Gilbert Group, where the capital is located, consists of more than 20 named islets, six of which, in the south, are linked by causeways.

The Phoenix Group consists of eight largely uninhabited islands with a total land area of just 28.6 km<sup>2</sup>, located some 1750 km east of Tarawa. The only inhabited island of the Phoenix group is Kanton (Canton) Island with a land area of 9 km<sup>2</sup>.

The Line Group consists of eight islands with a total land area of 496.5 km<sup>2</sup>, extending over a 2,100 km north-south line, between 3,280 and 4,210 km east of Tarawa, beginning some 800 km south of Hawaii. This Group includes the largest island in Kiribati, Christmas Island (Kiritimati), with an area of 388.4 km<sup>2</sup>.

Kiribati exemplifies to an extreme degree the development challenges facing a small, remote and resource-poor island state during a period of rapid global change. Basic development indicators (for health, education, life expectancy, etc.) are among the poorest in the Pacific Islands subregion. There is a high degree of vulnerability to external events. The environment is fragile and - particularly in rapidly-growing urban South Tarawa - deteriorating. There is considerable difficulty in providing adequate basic services to its people, especially the outer island rural majority. Despite this, the I-Kiribati - the people of Kiribati - have the advantages of a strong and resilient culture, a highly egalitarian society, strong democratic principles, extensive sea resources, and a record of prudent fiscal management. With well-planned, carefully-targeted and soundly implemented external assistance in support of sound government policies, the quality of life of the I-Kiribati can be expected to improve over time.

The total population of Kiribati according to the November 2000 census is 84,494, 92.4% of which live in the Gilbert Group of islands. The population of South Tarawa is 36,470, which is 43 % of the national total.

### **Water resources and supply**

There are two major potable water sources in the country; namely groundwater and rainwater. The major water source being groundwater occurring in the form of a water lens below the islands where the width of island is sufficient for it to form, as a result of rainwater infiltration. Rainwater is also used in the form of collected rainfall.

The main water supply for South Tarawa is piped from a subterranean water lens in the northern part of the atoll. This limited supply is over-stressed by poor reticulation to homes, growing demand and illegal connections, is threatened by housing encroachment onto land above the water lens and the widespread use of inappropriately located pit toilets, water-seal toilets, and (less often) septic tanks.

Relatively few houses have rainwater catchment tanks. Although well water is used mainly for washing, contaminated drinking water is a common source of illness. Rainfall varies between the islands, and from year to year. Droughts of up to 16 months duration are relatively common when as little as 200mm may fall in a year. There is also a large



difference between the islands in terms of rainfall average and distribution patterns. For instance, the annual rainfall in the Gilberts ranges from 1300mm near the equator to 2000mm on Tarawa, and over 3000mm in the northernmost islands.

Using rainfall as a source of water for drinking and other purposes has been the practice in Kiribati for many years. Water tanks of all sorts of materials and sizes have been installed by individuals and by public institutions to collect rainwater through roof gutters. The importance of collecting rainwater has long been recognised by the I-Kiribati, as shown by the recent enactment of regulations obliging house owners to construct gutters and tanks for the collection and storage of rainwater.

In principle, this collection of rainwater is a more efficient way of freshwater production than groundwater extraction, since fresh groundwater can only be extracted where sizeable lenses occur, and then only a small percentage of the mean annual rainfall on these lenses can be safely extracted over the long term. Rainwater catchments, by comparison, may catch up to 90% of the precipitation.

However, due to the unevenness of precipitation, frequently manifested in months-long droughts, the exploitation of rainwater for consumption requires construction of large storage facilities, whereas the atoll aquifers although relatively small in size, and sensitive to improper extraction have an inherent storage capacity that enables a constant withdrawal of their sustainable yield.

Consequently, rainwater collection can be regarded as a supplementary rather than a main source of water, as the storage tanks that are affordable by individuals and by institutions, do not have sufficient volume to store and supply water during prolonged droughts.

While freshwater lenses of sufficient yield appear to exist on all the Outer Islands, it is only on South Tarawa that utilising rainfall, as an additional source of water during prolonged droughts is considered economic in water production planning.

Significant quantities of usable groundwater are limited to the larger islands, where lenses of freshwater floating on seawater have developed underground. These "lenses" only occur where the central area of coral sands and rock is sufficiently wide, and the thickness is limited by the head of freshwater above sea level. The lenses are recharged through local rainfall, with the rate of permeation being high on porous ground. Some is lost by evaporation, particularly where there is vegetation, and the recharge rate is by the migration of fresh water towards the sea and through mixing with the underlying saline water.

These lenses are not symmetrical, being thicker towards the lagoon than towards the ocean due to the difference in permeability between the coarser-grained sediments usually occurring on the ocean side, and the finer-grained sediments on the lagoon side of the atoll. Other factors include the thickness of vegetation, and the rate of water extraction from the aquifer.

To date hydrogeological investigations have concentrated on Tarawa atoll and Kiritimati (Christmas) Island and have included drilling, geo-electrical soundings, water level observations, chemical and bacteriological analysis, pumping tests, analysis of rainfall and evaporation records and mathematical simulation of selected lenses under different extraction scenarios. In the Outer Islands some geo-electrical sounding has been carried out to identify exploitable lenses. Recent studies indicate that rainfall of greater than 50mm/day results in a capture of 17% of the total rainfall.

There are various types of water supply schemes found in Kiribati and include shallow wells and hand-pumps located in the villages and islands however there is no monitoring or recording of their operational status.



Open hand-dug wells are the traditional method used to obtain freshwater for basic needs. They are normally just a few meters deep, reaching the groundwater table, and are easily dug, supported by stonewalls and uncovered, leaving them open to contamination. They are often dug near to dwellings for convenience, but this exposes them to fouling by domestic animals and waste. Moreover, with the introduction of pit latrines in recent years, their proximity to the wells has caused many to become unsafe for drinking through cross-contamination, and in high-density housing areas old open dug wells have become a severe health hazard and must be earth filled and abandoned.

With the assistance of government and donor agencies, improvements have been made to these wells with supporting walls above the ground and a concrete apron and cover. Some of these wells have been equipped with a hand pump, mounted on top of the concrete cover, and while many of these pumps rapidly fall into disrepair, a simple diaphragm pump has proved to be reliable, and instruction in their manufacture and maintenance is being promoted.

This pump has proved to be the most effective and affordable method of extracting water from shallow wells, and will reduce the risk of transmitting disease through the traditional method of dipping a bucket in the well, however, these wells are still located too close to pit latrines.

Mainly on Kiritimati Island there are several open trenches some 150 m long and 3 m wide, dug to 50cm below the water table, from which diesel-operated pumps extract water. The sides of the trenches are supported by slabs of coral and are often covered with sheet metal or timber boards. Nevertheless, they are still open to contamination like the covered dug wells.

A more advanced design introduced in recent years uses in addition to a hand-dug well, a slotted plastic pipe, called a gallery, extending on either side of the well. This pipe is laid at a depth of 30-50cm below water level and the trench filled with gravel. The well and the gallery are located a few hundred meters away from the village in order to distance the source of water from sources of contamination, and to extract the water from the lens at a location where it is thickest. The freshwater is thus skimmed from the uppermost layer of the lens and from a larger water-table area, reducing the risk of "up-coning" of the underlying seawater.

Extraction of water from the well is by several methods. Simple diaphragm hand pumps are installed at convenient supply points in the village and suck the water from the well for a distance of up to 750m and are suitable for the conditions typical of a coral island; low, near-flat topography and small depths to the water table. Such systems consist of up to three pumps extracting water through a single main, each capable of supplying 10 families. The pumps are reliable and relatively easy to maintain with most problems attributable to air leakage.

With solar systems, electricity for the pump is generated by a set of photovoltaic panels, without a the use of a battery, and output is calculated on a conservative estimate of just 4 hours of sunshine per day. To supplement the supply during periods of little or no sunshine the design includes installation of gutters on roofs adjacent, and connected to ferro-cement or concrete block tanks raised on blocks.

A system of this type costs on average A\$36,500, or A\$105 per person and two villages on Tabiteuea North Island, 7 villages on Nikunau Island and one each on Arorae and Tamana Islands have been provided with systems funded by donor agencies.

Windmill pump designs have been erected in systems where later, solar pumps were installed to supplement or substitute the wind pumps; one or two still operate in a village on Arorae Island and one wind pump operates in a village on Tabiteuea South.

The New Zealand and Australian governments installed a basic reticulation system for South Tarawa in the early 1970's providing water through public standpipes, however the increasing



population lead to an outbreak of cholera, and the Australian government funded the extension of a reticulated supply to the whole population. Water is supplied from galleries in two freshwater lenses, chlorinated, and distributed through a rising main extending along the South Tarawa island chain into storage tanks or ground level reservoirs

Extensive hydrogeological investigations, estimated the sustainable yield of the two lenses at 1300 m<sup>3</sup>/day, which supplies a population of some 26,000, the port, hospital and several other large consumers. Delivery is restricted to 7 hours per day, while pumping from the lens remains constant. In the same area, seawater is piped inland to flush toilets and to dispose of the waste at sea. The increasing population in South Tarawa is placing strain on the limited water resources available, as most of the closest, suitable freshwater lenses have been utilised and extension to the lenses of North Tarawa would involve considerable cost. Compounding the situation is the under-utilisation of rainwater, with many houses and other buildings without rainwater collection facilities or in disrepair. Another issue is that of squatters on the water reserves with indications of pollution of the lenses.

The proximity of populated areas to the freshwater lenses, poses a threat to the quality of ground water and one of the principles of the design of improved systems for rural communities is to locate the source of water at a safe distance from the village and to provide latrines to prevent human excreta from being widely dispersed. Testing indicates that animal or human waste is polluting water lenses. The eviction of squatters and the declaration of water reserves have been partially successful, but may result in higher costs of compensation and lease payments and negotiations are continuing. One reserve is near the airport and there is concern that fuel and oil are contaminating the water, and any upgrade or expansion is likely to exacerbate the situation and would require barrier measures to prevent such pollution reaching the aquifer.

Chlorination is the only treatment applied to the water in South Tarawa. The water is chlorinated at source and at the farthest section of the system. However, the presence of hydrogen sulphide in the water makes chlorination ineffective as the majority of the chlorine dose is used to oxidise the hydrogen sulphide before it disinfects the water. It is proposed that an aeration chamber is incorporated before application of the chlorine. For rural water systems with the source some distance from the village it does not appear necessary to chlorinate the water. The WHO Drinking Water Quality Guidelines are being used in the absence of country specific water quality standards, however water quality data is non-existent, missing or difficult to locate. Lack of data also hampers estimates of safe water coverage, but for South Tarawa it is estimated at about 61%, and for rural areas it is estimated to be around 55%.

In rural areas water is provided free to people living in the outer islands while on South Tarawa the cost of water is charged on a flat rate basis to domestic users of approximately AUD\$2.00 per 1000 litres. Commercial and industrial users are charged on a volumetric basis.

Food-borne and insect or animal-borne diseases are the other major causes of illness. There is only limited information available on food security and nutrition but highly processed, imported, nutrition-poor foods are quite common.

The major pollution sources for the water supply systems are from pit latrines, septic tanks, leaks from the sewer pipes and piggery effluents. On North Tarawa and most outer islands, the effects are minimal as the water sources are located in a designated unpopulated area. However, on South Tarawa traditional landowners of designated water reserve areas are demanding compensation and some still reside on the water reserve, and the Government is working on strategies for them to vacate this land.

Sanitation is generally poor throughout South Tarawa, especially on the islet of Betio. Traditionally, the I-Kiribati uses the sea as their toilet. On the sparsely populated outer islands, this poses little public health risk. On South Tarawa, 53% of households regularly use the ocean



beach or the lagoon beach (where fresh sea water circulates much more slowly) as their toilet. This is an improvement over 1995 but continues to put health at risk.

The most common types of toilet facilities are pit latrines, compost and pour flush toilets (septic tank and sewerage system) However, the use of compost toilets is not widely accepted, and a survey indicated that only 6% of the South Tarawa population uses this type of toilet.

The only sewerage system serves major centres on South Tarawa and raw sewage is disposed of into the ocean without treatment except for maceration by sewage pumps. Advanced wastewater treatment facilities are owned and operated by private companies assisted by the Public Utilities Board for maintenance.

Other sanitation problems include high volumes of uncollected household garbage, the prevalence of such toxic pollutants as waste oils and chemicals, and large numbers of derelict vehicles and machinery. Food-borne and insect or animal-borne diseases are other major causes of illness. An important source of food-borne disease, especially on South Tarawa, is shellfish from lagoon waters that have been polluted by sewage. Flies, mosquitoes, and scavenging dogs and pigs are other disease vectors. For water-borne disease, an increasing national trend over time (with recent declines) is evident.

Solid waste management is the responsibility of the local council who collect garbage and dispose of it in designated landfills. The landfills are to be improved under an ADB loan. This applies only on South Tarawa where households are charged. In the outer islands households manage their own solid waste.

### **Water quality surveillance and monitoring**

The key agencies responsible for water supply in Kiribati are:

- The Public Works Department (PWD) who provide overall coordination of major water development works and support the operation and maintenance of rural water supplies,
- Ministry of Environment and Social Development Urban Rural Community Participation
- Public Health Department of the Ministry of Health (MoH), responsible for water quality monitoring and health education
- Public Utilities Board for the operation and maintenance of water supply.

Major donors involved in water supply include: AUSAID, Asian Development Bank (ADB), JICA, UNDP and SPC while the World Health Organization (WHO) has been involved in the provision of materials for water well improvement, and provision of pit latrines in the outer islands of the Gilbert group and is currently assisting in the provision of water quality monitoring equipment to the MoH.

Water quality surveillance monitoring programmes in Kiribati is carried out by three agencies:

- Public Utilities Board (PUB) for urban water supplies,
- Public Works Department (PWD) responsible for urban and rural water supplies
- Public Health Department Ministry of Health (MOH) responsible for urban and rural water supplies

The PWD and PUB perform tests for some physical and chemical parameters for both system efficiency and for development and design. The PWD tests rural water and the PUB urban water supplies while the MOH performs bacteriological and physical and chemical testing for public health purposes in both the urban and rural water supplies and sea water. Sampling frequency is agency specific, but focuses on reticulated urban supplies. Very little monitoring is done in the rural areas or outer islands

The Ministry of Health laboratory is based at the Central Hospital in Tarawa and carries out sampling and bacteriological analyses of water samples once a month, from several sampling



points in the South Tarawa reticulated system, and annually from selected points in the outer islands. In urban areas water monitoring is carried out under an arrangement with the PUB, and in the outer islands in conjunction with the routine visits of health inspectors.

The only laboratory, which handles water samples in Kiribati, is located in the Betio Hospital manned by one full time technician. Although the laboratory has the facilities to undertake tests on major microbiological, physical and chemical parameters this lack of staff and resources limits testing.

Testing by the MoH has shown that water supplied by the Tarawa Water Supply System (TWSS) is of good quality and can be attributed to the fact that the water sources are located in uninhabited areas and that the water is chlorinated both at the source and in the reticulation system. Though no similar results are available from Outer Island systems water quality in such systems should also be good, since they too utilize groundwater from areas located away from population centres. However, open pits in these areas are prone to contamination and that these unprotected water sources and individual rainwater catchments do not meet WHO guidelines.

Despite the apparent good water quality, a recent WHO report found that the leading cause of death in Kiribati continues to be diarrhoea, reflecting the poor condition of the water supply and sewerage systems particularly in high-density urban fringe areas of South Tarawa, and in rural areas where many people still use unprotected dug wells near sewage pits and poorly maintained toilet facilities, making them prone to various diseases.

As well as diarrhoea, the data indicates high levels of ill-defined intestinal infections, the highest incidence occurring in the age group up to four years, with between 500 and 1000 cases per 1000 children. However, this high Incidence of diarrhoea has in recent years begun to decrease. This may be due to factors other than an improved water supply such as health and health-related intervention programmes and under-reporting, which is common.

Concern has been expressed by WHO health experts that the frequent emptying of the TWSS pipelines during daily water shut-off periods may cause bacteriological pollution through the seepage of contaminated groundwater into empty pipes, however, there have been no indication that this is actually happening, and is only expected to occur in reticulation systems not in the main transmission line.

The main chemical concern is salinity of the water and the WHO guideline value of 600-mg/l chloride is considered reasonable. In the Outer Islands, during prolonged drought, and the lack of an alternative source, people are sometimes forced to drink undesirably saline water, extracted from wells situated close to the beach, which has been polluted by seawater intrusion into the aquifer. In Kiritimati Island, groundwater collection trenches have also become saline because of over-pumping. In South Tarawa two lenses became unusable as a result of this over-exploitation and from surface pollution, during the 1970s and 1980s. Pumping from the Teoraereke lens was discontinued in 1987 to allow the lens to recover from over-exploitation and seawater intrusion,

### **Needs analysis**

The most important identified need is the institutional strengthening *of* the existing three water-monitoring bodies. This may include identifying suitable field field-testing techniques, giving hands-on experience to the operators, and the provision of a database program relevant to water monitoring with technical training in information management.

There needs to be effective coordination among the drinking water stakeholders including the sharing and exchanging of information and ideas, and the revival of a coordinating committee.



Public health ordinances need to be reviewed and updated to include a national water quality standard.

Water quality monitoring and surveillance should be expanded to include the outer island communities.

On the regional level, Kiribati would like to recommend that WHO assist Pacific Island Countries to establish a regional laboratory to do chemical testing. This can be established within SOPAC or the Pacific Water Association in Suva, Fiji.

## **Reference**

1. Country Report for Kiribati, Mr Taboia Metutera, Water Engineering Manager, Public Utilities Board, Tarawa, and Mr Tianuare Taeuea, Senior Health Inspector, Ministry of Health, Tarawa Workshop on Drinking Water Quality Surveillance and Safety, 29 October - 1 November 2001, Nadi, Fiji
2. United Nations Common Country Assessment Kiribati 20 February 2002 Office of the United Nations Resident Coordinator Suva, Fiji February 2002



## **Marshall Islands**

### **Background**

The Republic of the Marshall Islands is located in eastern Micronesia at 4-19° North latitude and 160-173° East longitude. Of the 1,225 islands and islets in the Marshall Islands, only five are single islands. The rest are clustered into 29 atolls or "rings" of islands that are interconnected and surrounded by coral reef. These 34 low-lying coral atolls and single islands are scattered over 2 million km<sup>2</sup> of the Pacific Ocean, and the total land area is only 179 km<sup>2</sup>. Of the 34 atolls and islands, 23 are inhabited; two atolls are considered as "urban" centres, and the rest as the "outer" atolls. Some 20 % of the total area is classified as uninhabitable either because it was previously used as a nuclear testing site, or because it is now used for United States military purposes.

Majuro Atoll is the capital of the Republic. Ebeye Island, located on Kwajalein Atoll (the largest atoll in the world), is the sub-district adjacent to the United States military missile-testing base located on Kwajalein Island.

The estimated total population of the Marshall Islands in 2001 was 52,706. Currently, about 66% of the population resides in the two urban centres and the remaining 40% reside in the outer atolls. The urban centres have modern power plants assuring a relatively constant supply of electricity, and there is a public water supply, but supplies are inadequate for the growing urban population, especially in Ebeye.

### **Water resources and supply**

Water sources for the Marshall Islands include a mix of rainwater, groundwater and water from desalination and reverse osmosis plants. Normal rainfall is capable of supplying sufficient water, either collected directly or by recharging the groundwater resources, however, rainfall is not consistent from year to year and the islands are subject the periodic droughts caused by the El Niño effect. It was during the most recent event that the US government installed six desalination units in the islands, 4 on Majuro and 1 each on the Ebeye and Jaluit atolls to bring the water quality to within WHO standards for conductivity and chloride.

The Majuro Water Treatment plant treats raw water by chlorination and sand filtration, but limits supply to just 4 hours in the morning and 4 hours in the evening. To conserve water usage, a saltwater flush system is used for some latrines, and homes and businesses are equipped with rainwater capture and storage systems. Conservation is supported by low interest loans for rainwater catchment systems and toilets.

The only reticulated water supplies are in the urban centres of Majuro and Ebeye, and in the case of Majuro nearly 100% of the residents have access to safe water. For rural areas the residents have to rely on groundwater and rainwater, both from poorly constructed systems and only 20% of the rural population receive potable water. The major contaminants to water supplies are from latrines and septic tank systems, and from cemeteries.

### **Water quality surveillance and monitoring**

The agency responsible for water quality issues in the Marshall Islands is the Environmental; Protection Agency under the Minister for Health and Environment. Established in 1984 they are responsible for ensuring that the environment is not downgraded, and that the public water supplies are tested according to the Public Water Supply Regulations and the National Water Policy. Under these regulations a small water quality program is conducted using predominantly portable field kits. In the case of contamination, particularly biological, the public are informed by radio to boil their water, and to discard water that has been contaminated by saline intrusion.



Statistics have shown that there has a proportional increase in water-borne disease compared to population growth, and there has been an outbreak of cholera on Ebeye

### **Needs analysis**

Like many similar countries the Marshall Islands are constrained by a lack of funding and trained manpower to maintain a water quality monitoring program, and some form of aid is required, particularly in the outer islands to ensure sustainable groundwater extraction and improve water quality. Policies and regulations need to be implemented and enforced, and the public needs to be made aware of the importance of consuming good quality water and protecting water sources.

### **Reference**

1. Country report- Marshall Islands. Workshop on Drinking water quality surveillance and safety. 29 October-1 November 2001 Nadi, Fiji. Mr Abraham Hicking, Chief, Water and Sanitation, Marshall Islands Environmental Protection Agency, Majuro
2. WPRO web site



## **Nauru**

### **Background**

The Republic of Nauru is an isolated, raised limestone island located 41 km south of the equator at 0° 32' S. latitude and 166° 56' E. longitude with a land area of only 22 km<sup>2</sup>. It is surrounded by a fringing coral reef between 120 and 300 metres wide that drops away steeply. The land area consists of a narrow coastal plain from 100 to 300m wide known as the "Bottomside", surrounding a limestone escarpment rising some 30 m to a central plateau, known as "Topside".

Nauru is located in the dry belt of the equatorial oceanic zone, with diurnal temperatures ranging from 26°C to 35°C. Annual rainfall is extremely variable, averaging 2126 mm per year with a range of 280 to 4590 mm. Rain tends to be more frequent during the months of December to April, and prolonged droughts are common.

The coastal plain is a zone of sandy or rocky beach and fore dunes behind which are either relatively flat ground or low-lying lagoons filled with brackish water. Scattered limestone outcrops exist on both the coastal plain and on the intertidal flats of the fringing reef.

The raised central plateau, or Topside consists of coral-limestone pinnacles and limestone outcrops, between which lie extensive deposits of soil and phosphate rock, which has been extensively mined over the past century. The elevation is between 20 and 45m with some pinnacles and the highest point reaching just over 70m. There is a slightly brackish, freshwater lagoon located in the low-lying southwest-central portion of the island at an elevation of about 5 m above sea level.

### **Water resources and supply**

Apart from the lagoon, there are no surface freshwater resources except a few brackish ponds near the base of the escarpment, and an underground lake in a cave in the southeast. The only significant permanent freshwater resource is in the form of a freshwater "lens" often slightly brackish, lying above saltwater. The height of the freshwater lens and salinity vary relative to elevation, geology, terrain, abstraction rates and rainfall.

Studies indicate that the lens averages 4 to 5 m thick, being particularly well developed in the north-central and south-central parts of the island. The water becomes increasingly brackish with depth until it reaches the salt water at 80 m below sea level. Replenishment or recharge of the freshwater lens is dependent on rainfall.

Modelling studies indicate that a bore field on the Topside would yield a sustainable 1 to 2 l/second depending on the density of the bores. However, there is insufficient information to determine whether the groundwater lens beneath Topside can provide a reliable supply, particularly during prolonged droughts.

Groundwater on the Bottomside is tapped by several hundred wells, about one-third of which exceed the WHO recommended limit of 1500 mg/l Total Dissolved Solids.

The brackish groundwater from wells used as an alternative supply has high coliform and high dissolved solids and is not suitable as a potable supply, and increased extraction from the wells around the perimeter of the island could lead to seawater intrusion. Because of these limited resources the collection and storage of rainwater should be a top priority.

A modern desalination plant has been commissioned by Nauru Phosphate Company using the waste heat generated from the power station, and is the primary water supply for consumers and potable water from the plant is delivered to individual households by road tanker. The porous



nature of the terrain does not allow the construction of dams or reservoirs so storage is limited to household and institutional tanks.

The bulk of the potable water is supplied from the desalination plant, with the remainder made up of collected rainwater and brackish groundwater. However, during plant downtime for maintenance the island experiences severe water shortages. Compounding the problems is the current poor economic situation with increased diesel costs necessary to operate the power station, making it difficult to produce the expected water supply on a daily basis.

Nauru has faced a critical water shortage recently following a prolonged drought and breakdowns of the desalination plant and this has prompted a review of planning for future water supplies. The public and international community were informed of the national emergency and regional technical assistance was requested.

In response a WHO assessment found that the desalination plant coupled with rainwater collection was sufficient in periods of adequate rainfall, when the plant was fully operational, but during drought emergency plans and procedures need to be adopted. The desalination plant alone would be insufficient, and to supply demand during low rainfall would require an additional unit.

Backup storage would require a volume of water sufficient for 20 days, supplemented by increased collection and storage of rainwater, and sustainable groundwater extraction. Groundwater extraction from the lens has been estimated as being insufficient during droughts.

Conservation of water is being addressed by consideration of using grey water and sewage effluent for agriculture, and the repair of guttering on roofs, and household storage tanks for rainwater during the wet season.

Protection of the limited water resources is vital and involves containment and proper disposal of human waste from cesspits and septic tanks to avoid contamination of water and the environment. The refugee camps on the Topside which discharges grey water direct onto the surface of the porous terrain have exacerbated the situation.

Other potential threats to the quality of the groundwater resource includes contamination by cadmium, rubbish dump leachate and sewage.

Much of the water shortage in Nauru is due to, or accentuated by, faulty management, and unless action is taken the future will be dominated by recurring droughts. To address the situation there have been consultative meetings of stakeholders to draft a national strategy, public awareness campaigns have been launched on water conservation, and data and information has started to be collected on all aspects of water resources, supply and quality.

Under the Plan the condition of the water in the lens will be monitored, particularly near dumpsites for leachate contamination, and to determine the optimum extraction rates from bores located both on the Topside and Bottomside. Public awareness will continue with a focus on schools, including water conservation programs and the provision of drinking water coolers. Rainwater collection will be emphasised by examining the feasibility of collecting rainwater from the sealed airport, repair of household guttering and storage tanks, and domestic desalination units. Other national scale actions may include the replacement of the desalination plant with a unit operating principally on renewable energy, and the construction of a waste and sewage treatment plant to help protect the groundwater resources from contamination.

### **Water quality surveillance and monitoring**

The Department of Health is responsible for quality checking of the water supply and sanitation, however they have no laboratory, and testing is limited to odour and hydrogen sulfide testing



using paper strips. There are no field test kits and the standards used are those of the Health Department only.

The Nauru Rehabilitation Corporation and Nauru Phosphate Company are also responsible for data collection, surveys on water wells, and underground water quality and aquifers, but no further information is available.

### **Needs analysis**

Nauru continually faces a critical water shortage with a global trend towards unpredictable climate change and periodic droughts, compounded by rising population growth and higher living standards. Its dependence on a single desalination plant will not meet the expected water demand during low rainfall years.

To improve the situation requires a great deal of assistance, particularly in the current economic climate. Funding needs to be available from donor agencies with a commitment to assisting small island states with water and sanitation issues in the light of changing climatic conditions.

Capacity building is required in the form of training, technical assistance and advice in appropriate technologies for water and sanitation, resource materials for raising public awareness and in the drafting of a national strategy. This strategy should address issues of procurement and security of supply, protection of resources, and improved collection and storage of rainwater and will require a collective and collaborative approach by all stakeholders to avoid responsibilities being fragmented, resulting in gaps and duplication of effort in the supply and surveillance programs.

### **Reference**

1. Proceedings of the Pacific Regional Consultation on Water in Small Island Countries  
Sigatoka, Fiji, 29 July – 3 August 2002 - Country Briefing Papers - Nauru



## **New Caledonia**

### **Background**

New Caledonia is a French Overseas Territory located in the Pacific Ocean, lying south and slightly west of Vanuatu, some 1500 km. east of Australia and 1700 km. north of New Zealand. It comprises one large island and several smaller islands, with a total land area of 18,600 km<sup>2</sup>. The main island, New Caledonia (la Grande-Terre), is long and narrow, and has a total area of 16,750 km<sup>2</sup>, its island chain is continued by the Belep Archipelago to the north end of the island and the Isle of Pines and Huon Island to the south. Noumea, situated in the south of the main island is the administrative, political and economic capital of the country. Noumea contains along with the three peripheral townships MontDore, Dumbea and Paita, about 130,000 inhabitants of the total population of 210,000 of New Caledonia.

Politically and administratively, New Caledonia has a unique French status with responsibilities being shared by four authorities, the French state, New Caledonia government, the 3 provinces (South, North and Loyalty Islands) and 33 municipalities

### **Water resources and supply**

The availability of water in New Caledonia varies according to regions. On the East coast of the main island where there is much rainfall, water reserves provide ample water for the inhabitants, however on the much drier West coast water is often scarce and distribution points rare.

The islands of Mare and Lifou draw their water supply from underground fresh water "lenses" which are significant, and provide a sufficient resource but in other islands where there is a lack of ground or surface water, rainwater is the most significant source supplemented by desalination plants, as is the case on the islands of Ouvea and Tiga.

Noumea, the main city, is supplied by a dam with a 650,000 m<sup>3</sup> reserve on the Dumbea River situated 20 km to the north of the city, and by 2 pumping stations downstream of the dam, which draw groundwater. The whole system allows the supply of 52,000 m<sup>3</sup> of water per day during low water periods.

To address a projected medium-term water supply shortage in Noumea and surrounding townships a new groundwater supply was brought on-line in 2001 whereby 10 bores in the Tontouta valley bring water from 18 km away into two 4,000 m<sup>3</sup> reservoirs and thence by gravity feed to Noumea and the townships. This new groundwater resource generates 96,000 m<sup>3</sup> per day, and should provide sufficient water for the 62% of the total population who live in the area, for the next 50 years. The average water consumption in the city of Noumea is of 550 litres per day per person.

Countrywide publicly distributed water is characterised as raw water that has been disinfected with chlorine. In Noumea, the raw water is brought to the Mount Te treatment plant where it undergoes a conventional four-step treatment of flocculation, sedimentation, filtration and disinfection by addition of chlorine.

There is considerable variation in the price of water in New Caledonia, with some having fixed rates and some free. Those townships with water supplied by private leasing companies have prices worked out according to the cost of water production, purification and network maintenance. For urban Noumea, the price is based on offsetting the cost of the new supply facilities, treatment and supply.

Sanitation in rural areas is usually by septic tank or water closet, which flows through a filter to the soil surface where topography allows, whereas in the urban areas wastewater is treated via a connected network allowing treatment by filtration through activated mud.



Noumea has six large municipal purifying stations which treat wastewater for some 45,000 persons and 95% of the analysis carried out during the year 2000 on the discharged effluent were within EEC standards. Research undertaken by the Territorial Institute for Statistics and Economic Studies on the availability and use of toilets showed that 52% of the homes in the Loyalty Islands Province did not have toilets, 27% in the Northern Province, and 1% in the Southern Province.

### **Water quality surveillance and monitoring**

The broad responsibility for water management lies with the government of New Caledonia with particular responsibilities for the digging and boring of wells, access to groundwater resources and the implementation and application of laws related to public hygiene. It may also delegate some of its responsibilities to the provinces, if they agree. The provinces themselves may define the limits for the collection, and drilling of water resources and may also take responsibility in the territories. The municipalities take responsibility for the management of water supply and sanitation networks, and for general public sanitation policy and the control of pollution.

The entire water supply system for public consumption is protected by safety limits established by provincial decree. A 1979 territorial decree defines the standards for drinking water, however the organizations that control the water quality generally apply French standards.

For over 10 years, the Water Resources Observatory of the Veterinary Food and Rural Department of the Territory has carried out physical-chemical and bacteriological analysis at 1,000 sampling points, and biological analysis on 350 points with the aim of observing and describing the river and underground water quality of New Caledonia with an essentially environmental approach.

Drinking water surveillance and analysis is carried out on both the raw water and water supplied through the public distribution networks after treatment and disinfection. Analysis includes physical-chemical and microbiological parameters, and tests for the level of disinfection. In 2001 some 36% of the townships undertook analysis or had analysis undertaken of drinking water.

Three main public laboratories carry out water analysis related to health. They include the Mines and Energy Department laboratory which carries out physical-chemical analysis, the laboratory of Water Quality Surveillance of the Noumea City Council Hygiene Department which carries out physical-chemical and bacteriological analysis, and the laboratory of the Pasteur Institute of New Caledonia, a part government-owned laboratory that carries out bacteriological analysis.

There is also a private laboratory of the Caledonian Waters Company (a subsidiary of Ia Lyonnaise des Eaux), which carries out physical-chemical and bacteriological analysis. These laboratories are staffed with about 15 qualified staff that apply analytical methods that refer to either French standards or ISO standards. The parameters include physical-chemical measurements, natural chemicals, pollutants, and toxic chemicals and microbiological tests.

### **Needs analysis**

Although New Caledonia has very good technical standards, good human resources and equipment for the supply and treatment of water, it has identified that it needs to update standards and regulations regarding drinking water, and the frequency of monitoring.



While the country has treatment and purification systems in the urban areas, it needs to develop and implement suitable facilities for the treatment of drinking water, and the sanitary disposal of wastewater and excreta in rural areas.

Public education is required in the value and importance of water, its protection and treatment, and the necessity of a good water quality monitoring regime.

### **Reference**

1. Sanitary Management of Drinking Water in New-Caledonia by Frederic Hannecart, Health and Social Affairs Department Of New-Caledonia, for World Health Organization Workshop on Drinking Water Quality Surveillance and Safety, 29 October to 1 November 2001, Nadi), FIJI



## Niue

### Background

Niue is located in the South West Pacific ocean approximately 19° S latitude and 170° W longitude. The island is an elevated coral outcrop with a steep and broken coastline and fringing coral reef. It consists of two terraces, the lower coastal terrace being about 28 m. above sea level, while the upper terrace, which forms the bulk of the Island, is about 69 m. above sea level. It has a land area of about 259 km<sup>2</sup> with 13 villages spread around the coastal strip. The resident population is approximately 1700 with a further 18,000 expatriate citizens living overseas, mainly in New Zealand. The economy is substantially dependent on overseas aid predominantly from New Zealand.

### Water resources and supply

There is no surface water such as rivers, streams, pools or lakes on the island and water resources consist of an underground water “lens” and from the collection of rainwater. The rainfall permeates the porous coral until it reaches the saline water that lies under the island where its lower density allows it to form a pool over the salt water. This lens provides most of the fresh water used for human consumption, agriculture and industry. At present domestic use accounts for 86%, agriculture 10% and industry 5%.

While the lens has not been accurately quantified it is estimated to be a very large reserve lying between 35 and 100 metres depth. The aquifer strata is porous and is vulnerable to contamination from activities carried out on the surface, and any large scale contamination of the fresh water lens would pose a risk to the population and alternative sources are being examined. The current water quality of the lens suggests it is suitable for drinking untreated, and is piped directly to consumers, with all costs for pumping and distribution being met by government. To date there have been no known outbreaks of disease attributable to untreated water and no complaints, however current advice is to boil water for consumption.

There are measures in place to avoid over exploitation of any particular water bore which would allow salt-water intrusion, but the lens is sufficiently large to withstand several years of drought, and with good protection and management to avoid contaminating the lens, fresh water can continue to be pumped un-treated to the consumers, although regular testing is recommended.

Each village has its own water supply system consisting of a submersible pump and a water reservoir, which until recent times has had to operate continuously due to large losses from leakage. Most losses occur in the consumer’s household, from industry, and from reservoirs, resulting from overflows from unattended operation, and where the high cost of repairs often act as a deterrent to reporting. However, the implementation of a Waste Management Project involving a program of training and maintenance has achieved a 40% saving in electricity costs of pumping. A similar project for waste and sanitation is planned but has yet to be implemented due to financial constraints.

To supplement the groundwater resource the establishment of rainwater catchments would provide a low-cost alternative, but there is no current legislation. A policy introduced in the early eighties proved difficult and costly to implement and as a result householders were allowed direct connections to the supply.

Such community rainwater catchments and concrete holding tanks of between 50 to 120 kilolitres capacity were once the main source of fresh water during dry periods, but have been allowed to deteriorate and many have been demolished. Those remaining can be repaired, as a backup supply during drought, however there is no available funding from government.



There is sufficient water works infrastructure in place to sustain a population of about 5,000 but maintaining the system will require a skilled labour force and appropriate equipment. Many trained personnel have left the island, thus reducing the capacity to properly manage the high-demand system that is vital to the population.

Funding water supply is part of the government budget and there has been support from donor agencies, although with the falling population this has diminished, but a “user-pays” system with affordable rates may prove to be financially unsustainable.

Sanitation systems on the island are mostly of the septic tank type that do not comply with WHO standards, and the wet sludge from the tanks are pumped into areas sited away from fresh water bores. There is no suitable dump, and the existing site is being used as a transfer station prior to a new dump to be established on the southern side of the island.

Agricultural fertilizers and pesticides is an area of concern that is being addressed by the Pesticides Committee.

### **Water quality surveillance and monitoring**

There is a Water Resource Act passed by Government in 1996 however the lack of supporting regulations means that the Act cannot be legally enforced. Implementation of regulations has been held up by difficulties over the ownership of catchment areas where enforcement of the Act would deprive the landowners of the right to use their land for activities that may pose a threat to the groundwater. There has been some dialogue with landowners over government purchasing of water bores and water reservoir sites for the crown, but this has been temporarily suspended.

The Public Health Unit of the Health Department carries out tests for bacterial contamination on a quarterly basis and some samples have detected contamination in water bores where human habitation or other activity which might cause contamination is distant. The data however remains unverified.

There are only seven personnel employed under the Water Supply Division of Public Works Department responsible for managing the division on a daily basis. The Water Unit of Public Works is poorly equipped and staff are not trained to carry out proper maintenance to the system.

The political will to establish policies and legislation towards protecting the environment must have the approval and backing of the people, but public attitudes to water supply remain complacent until problems occur.

Regional organisations have in the past provided technical and financial assistance in running public awareness campaigns and media programs where water was included as part of the theme, with both public and schools taking part. Awareness programs exclusively for water campaigns were mostly run in schools targeting the young, so that future leaders of the country are aware of protecting the environment and the role that safe water plays, but continuation of funding for these awareness programs is a problem.

### **Needs analysis**

To address water related issues depends on the cooperation and collaboration of government and water supply utilities, through public involvement and engagement, and the continuing funding support from aid donors. Stakeholders should contribute equitably within a consultative process.

At government level there needs to be a national strategy for water, wastewater and waste. Actions might include implementing the National Waste Management Plan, establishing a



Water and Wastewater Committee, enforcing the Water Resource Act of 1996, legalising the Water Regulations and the re-introduction and enforcement of the Rainwater Catchment Policy.

Programs are needed to model the groundwater resources to understand its characteristics, optimum exploitation capacity, and vulnerability to contamination from human, agricultural and industrial activities.

Training and capacity building is needed in the areas of water, wastewater and sanitation and the provision of appropriate water quality equipment to allow field-testing for parameters that have been identified as a risk through an assessment process. Options are needed for difficult analyses such as fertilisers and pesticides that comply with WHO standards, such as using a well equipped centralised regional laboratory.

Public awareness programs have been identified as providing information on the protection and conservation of water supplies, particularly in schools, where the next generation of leaders will learn the importance of water to the life of the community.

## **Reference**

1. Proceedings of the Pacific Regional Consultation on Water in Small Island Countries  
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## **Papua New Guinea**

### **Background**

Papua New Guinea (PNG) consists of the eastern half of the New Guinea Island (with Indonesia to the west) and more than 1400 smaller islands of southeast Asia between the Coral Sea and the South Pacific Ocean. North of Papua New Guinea is the Federated States of Micronesia, south is Australia and to the east is Nauru and Solomon Islands. The total land mass is 452,860 km<sup>2</sup>. Other large islands are New Britain, New Ireland, North Solomons and Manus. Much of the terrain in the country is extremely rugged with high mountain ranges and steep valleys with fast flowing rivers in contrast to the extensive system of marshes along the coast. The country has only a few major roads, many areas being accessible only by air, by foot or by boat. The climate is tropical, warm and humid.

Administration of the Independent State of Papua New Guinea is a constitutional, parliamentary democracy with the Head of Government being the Prime Minister. For administrative purposes Papua New Guinea is divided up into 20 provinces, each administered by Provincial Governments. The provinces are: Western, Gulf, Central, National Capital District (NCD- comprising the capital Port Moresby), Mime Bay, Northern, S. Highlands, Enga, W. Highlands, Chimbu, E. Highlands, Morobe, Madang, East Sepik, West Sepik, Manus, New Ireland, E. New Britain, W. New Britain, N. Solomons.

The total population of the country is estimated at over 5 million with an average population density of 8.1 people/km<sup>2</sup>. Some 145,000 are located at the capital Port Moresby. The highest population is found in the Morobe Province, in the eastern part of the country while the inner mountainous part of New Guinea Island known as Highland region (Western, Southern and Eastern Highlands) ranks second. In 1990, the Highlands region contained about 37% of the total population. Generally speaking, the southern coastal provinces and the island provinces of New Ireland, North Solomons, East and West New Britain have lower populations than the interior highland and northern coastal areas.

The population of PNG is predominantly rural (84.6%). For the census, urban areas were defined as those which had a minimum population of 500 persons and a minimum population density of 195 persons per km<sup>2</sup>. Using this definition, the NCD was 100% urban with other provinces having high urban concentrations including Morobe and Manus. The provinces with the lowest urban populations were Ertga, Southern Islands and Chimbu. Since 1966, urban populations have grown more rapidly than the rural population, however, unlike many other Pacific Island countries, emigration to overseas countries is relatively low, but internal migration between provinces is considerable, particularly to the capital Port Moresby.

Economic activity is mainly based on agricultural products including fruits, and cash crops such as coffee or cocoa, followed by fishing and forestry. The country is well endowed with mineral deposits and the mining of gold, silver and copper are important activities. Tourism and industry plays only minor role in the economy at this time.

The burden of disease in PNG is predominantly from infectious diseases with significant morbidity and mortality from water-borne diseases due to a lack of proper water supply systems, inadequate amounts of safe water, poor sanitation and unhygienic conditions and practices especially in rural areas.

The common water-borne infectious diseases of public health importance include typhoid, dysentery and rotavirus-caused diarrhoeal diseases. These diarrhoeal diseases are responsible of one third of childhood deaths, and considerable malnutrition (the death rate from diarrhoea in children under 5 is 10.8/100,000 population). Typhoid is by far the most serious of these



diseases and is endemic in a number of provinces. It is stated that cholera will also remain as a real threat if no improvements are made to the current state of water supply and sanitation.

### **Water resources and supply**

Papua New Guinea receives a high annual rainfall, on average 3000 mm per annum. There are fluctuations in this average from region to region and even province to province. The lowest rainfall measured is 1000 mm for Port Moresby city and the highest at 5000 mm in the Star Mountains of the Western Province while all other regions fall between these two extremes. The mountainous topography and abundant rainfall leaves the country reliant on surface, underground and rainwater catchments as its principal water resource.

When considering access to drinking water, the coverage in Papua New Guinea is estimated at near 60% for urban areas and 30% for rural communities, indicating a low overall coverage with the urban population being better served than the rural. This relates directly to the high mortality and morbidity of diarrhoeal disease in rural health facilities in contrast to those recorded at hospitals, which are located in towns.

In general, water supply systems are not developed throughout the country, except some urban areas and the systems are unreliable in rural communities and many urban centres for a number of reasons, including drought, damage to the supply system, land compensation demands, and water capacity.

Many villages and institutions do not have a drought-proof water supply but there are plans to increase the proportion of rural communities having easy access to safe water from 30% to 50% by 2010.

In PNG, both ground and surface water resources are utilized for domestic purposes. Urban water supplies are usually from surface waters such as rivers.

In the greater number of cases however the lack of safe water supply is not a lack of water resources, but rather unhealthy water supply systems and very low levels of public awareness and community support for safe water supplies particularly where local governments and communities are not responsible for the operation of water supply systems.

In rural areas the Ministry of Health is responsible for the construction, operation and maintenance of supply systems whereas in urban areas the PNG Water Board is responsible. In the capital, Port Moresby, a private water company, Eda Ranu is the responsible body and both Eda Ranu and the Water Board perform quality control and monitoring activities for their systems.

There is no regulatory body for quality monitoring and surveillance activities and no surveillance activities are practiced by an independent authority. In rural areas, the Ministry of Health is responsible for monitoring, but there is little or no regular monitoring.

In some urban areas there are sewerage systems and where there are no such systems septic tanks or pit latrines are used. However, there is insufficient control and auditing over those systems.

Port Moresby and some other town centres have sewerage systems. Eda Ranu is responsible for operation and maintenance of the sewerage system in Port Moresby but it does not cover the squatter areas, Wastewater is disposed to the sea after pre-treatment by means of a lagoon to a marine outfall. In the other urban areas, the Water Board is responsible for construction, operation and maintenance of sewerage and other sanitation systems. The standards for construction of sewerage systems and septic tanks are provided by legislation, however there is insufficient control over the construction and operation of the tanks.



In rural areas, toilet facilities and sanitation systems are not developed and the disposal of solid wastes by irregular dumping is the normal practice.

The main source of contamination of drinking water is bacteriological originating from human and animal wastes, particularly in rural areas where the proportion of rural households having access to safe human waste disposal systems, such as some form of pit latrine, is estimated as to be as low as 15%.

Agriculture is not sufficiently sophisticated that fertilizers and pesticides are used in any great amounts, however their usage has increased in recent years. At some mining sites there is a growing risk of contamination of water resources by heavy metals and although the volume of wastes are higher than any other South Pacific country there is little or no information on the types and quantity of waste.

In urban centres the industrial waste and sewage use the same system and are disposed directly into the sea or rivers without proper treatment. Likewise most mining, agriculture and logging wastes are discharged directly in to the environment usually into a river system or to the sea.

All urban local level governments manage the disposal of solid waste with some undertaking the collection and disposal, while others engage local contractors. Fees are levied on individual residents and businesses and the rates differ from province to province.

Most urban authorities dispose of solid waste in sanitary landfill, however the dumpsites are not maintained and site conditions are poor, with the possibility of seepage into the water sources. Effluent wastes are linked directly into sewage systems and are disposed of with minimal treatment into the sea or rivers. For those provinces that do not have a sewage system, wastes are discharged via septic tanks or soakage pits. In rural communities, wastes are indiscriminately disposed of into the environment. The management of waste generally in the country is poor, and there is a high possibility of underground and surface water contamination from pollutants.

### **Water quality surveillance and monitoring**

The 1984 Public Health (Drinking Water) Regulation was revised following four regional workshops and a consultative meeting with all the technical agencies involved with water quality monitoring. However, due to the number of agencies involved and differences in policies and visions, there remains no clear policy for drinking water quality and safety. The Department of Health has a policy on rural water supplies based on the Healthy Island concept, whereby provinces are responsible for the design, costing and monitoring, while the communities themselves provide labour, site selection, construction and maintenance. The National Health Department facilitates the monitoring process, develops provincial capacity to identify suitable water sources, and develops monitoring guidelines and standards.

Almost all agencies except the National Health Department undertake some form of water quality monitoring; however there is no official exchange of information and results are usually treated as confidential within each respective agency. There are a number of laboratories in the country that undertake water analysis of samples received from various Government agencies and industries and most have the capacity to undertake physical, bacteriological and chemical analysis.

The provinces test for *E.coli* and total coliform on an ad-hoc basis, and for chemical and physical parameters only on request or by complaint.

Eda Ranu samples and tests for biological contamination daily from points in nine suburbs of Port Moresby and takes monthly samples from 60 points in the city, and from five reservoir tanks samples are taken for chemical and physical analysis.



The Water Board samples for physical analysis daily, and takes eight samples for biological testing every two weeks from major urban centres, and three samples every two weeks from smaller centres.

The Goroka LLG takes 10 samples per month from selected sampling points in the town for biological analysis, and five samples every three months for physical analysis. Samples for chemical analysis are done on an ad-hoc basis upon complaints from town residents.

### Needs analysis

Statistics clearly shows that water related diseases, in particular diarrhoeal disease is the commonest cause of mortality and morbidity in all provinces and therefore testing for *E.Coli*, total and faecal coliform are essential for monitoring water quality.

Given large-scale development in the country, particularly in mining, forestry, agriculture and a number of big industries with large volumes of untreated effluent entering the environment, the monitoring of physical and chemical parameters such as alkalinity, pH, pesticides, BOD, TSS, TDS, mercury, copper, arsenic and heavy metals are becoming increasingly necessary and important.

Laboratories do not undertake analysis for all types of parameters, as this would require a major improvement in laboratory capacity and in the effective collection of data and analysis. The provinces do not have the financial capacity to undertake water quality monitoring on regular basis, including the costs for water sampling, transportation and laboratory costs.

Although the country has 350 Environmental Health Officers employed in urban towns and provinces there is insufficient capacity to monitor rural water supplies. Many communities are not linked by road and are isolated, resulting in the difficulties of transportation of samples, and of high costs.

There needs to be a central coordinating mechanism established for monitoring purposes, since there are a number of agencies involved and information is not shared for planning purposes.

A water quality standard was developed in 1984 and revised in 2000, but is not yet fully implemented.

Data needs to be centrally processed and analysed for good decision-making, and a central agency made responsible for collating this information. Currently the sharing of information between relevant agencies is poor.

Treatment with chlorine is used only in urban areas, and public awareness on the benefits of purification tablets, boiling, and filtration needs to be strengthened, particularly in rural areas.

### Reference

1. Country Report Papua New Guinea by Mr Masu William Muru, Principal Adviser, Health Protection, Department of Health, Waigani and, Mr James Teio, Acting Technical Adviser, Water Supply and Sanitation, Department of Health, Waigani. Workshop on Drinking Water Quality Surveillance and Safety 29 October -1 November 200, Nadi, Fiji
2. Development of Drinking Water Quality Monitoring and Surveillance in the Philippines, Papua New Guinea, Tonga and Vanuatu - Report 4 - Papua New Guinea - June 2002 By Hulya Aras, Environmental Engineer



## **Republic of Palau**

### **Background**

The Republic of Palau is the most western island group of the Caroline Islands and is an archipelago consisting of approximately 350 islands located in the south-western Pacific Ocean about 800 km north of the equator and at 7°20" north latitude and 134° 28' east longitude. The nearest neighbouring islands are Guam, the Philippines and Papua New Guinea respectively.

The main archipelago is approximately 160 km in length and 26 km across and includes the seven major islands, all of which are populated. The largest island is Babeldaob with an area of 400 km<sup>2</sup>. Ten of Palau's sixteen states lie on Babeldaob. South of Babeldaob is the island of Koror State. Stretching south of Koror for about 45 km are hundreds of tiny mushroom shaped uninhabited islands known as the "rock islands." At the end of the chain of rock islands are the two inhabited islands of Peleliu and Anguar.

The majority of Palau's population lives in Koror State, which serves as the commercial and business centre of the nation. Koror State is urbanised with modern infrastructure and services, paved roads and traffic. Babeldaob and the other remaining islands are rural and undeveloped. The total population of Palau is around 20,000 of which about 14,000 live in Koror. The largest sectors of the economy are services, tourism, fisheries and agriculture

### **Water resources and supply**

The tropical climate of Palau is warm and humid with an average of about 3800mm. of rainfall per year. Palau has an abundance of surface water streams and rivers on the main island of Babeldaob, which supply the majority of the public drinking water systems. The inland Lake Ngardok is the largest fresh water lake in Micronesia.

A secondary supply source of water for the public water systems is groundwater. Although the potential exists for more groundwater use, it has not been extensively developed because of well maintenance problems, water quality problems (chlorides, iron, manganese and taste and odour) and limited well yields in certain areas.

Groundwater principally comes from two hydrologic units. On the porous limestone islands groundwater is obtained from shallow porous limestone aquifers consisting of basal freshwater lens. Well yields in the shallow limestone aquifers are limited because over pumping will result in saltwater intrusion with a resultant rise in chlorides. On the volcanic islands groundwater is obtained primarily from deeper wells in weathered fractured basalt above the denser basalt formations.

Many of the homes in Palau have their own private individual rainwater catchment systems to provide drinking water. Presently, it is estimated that over 95% of the population of Koror and Airai States and about 80% of the population of the rural states are served by public water systems.

The Palau population centre of Koror is served by the Koror/Airai Public Water System (PWS). The system's service area includes islands in Koror State, as well as the southern region of Airai State. Approximately 95% of the 14,000 people living within the service area are supplied with water from the public system.

The Koror/Airai system is supplied by two surface water sources both of which are located in Airai State in southern Babeldaob. The main source is the 20 million gallon capacity Ngerimel Dam and Reservoir. Water from the dam is supplied to the treatment plant by gravity main. The second source of water is from the Ngerikiil River pump station that can pump water either into



the Ngerimel Dam or directly to the treatment plant through two mains. The watersheds for both the reservoir and the river are largely undeveloped and include only a few residences and small farms. The turbidity of the raw water in the reservoir can fluctuate greatly during heavy rains and some rises in turbidity have been attributed to road construction.

In 1998, the Koror/Airai water treatment plant) was upgraded to a 17 million litres per day conventional filtration plant. Treatment processes at the plant include the chemical addition of alum, soda ash and powder activated carbon, followed by coagulation, flocculation and sedimentation, rapid sand filtration and finally disinfection with hypochlorite solution.

Treated water is pumped from the treatment plant into the distribution system by four pumps, at 15 million litres per day, a high demand for a service area population of only 14,000 people. This high rate of demand is due to leakage, lack of water conservation, and the general misuse and wastage of water. It is subject to service disruptions, water shortages and low pressure caused not only by the high demand, but also by a range of other factors including the need for adequate financing, the need for improved operation, maintenance, management and planning of the system.

There are currently 15 small public water systems serving the rural areas. These public water systems serve populations from 20 to 600 people. Eleven systems obtain their water supply from impoundments of surface water streams and three obtain their water supply from groundwater wells, with one system supplied by both groundwater and a surface stream.

All of the surface water systems are required to treat the raw water by automatic backwashing, gravity fed rapid sand filtration and disinfection by hypochlorite solution while the groundwater supplies are only disinfected with hypochlorite. All systems are equipped with water storage tanks to meet peak demand.

An estimated 80% of the population living in rural communities are served by public water supply systems. The residents primarily use the water supplied by the public systems for bathing and washing, and use their own private water catchments for drinking water. Some islands obtain their water solely from rainwater catchments and will also use very shallow dug wells during drought periods.

Service disruptions and water shortages are common in the rural public water systems. They occur because many systems need to have unserviceable equipment replaced and improved operation and maintenance. Most of the chlorine metering pumps used to disinfect the water are out of order or are not used. The rapid sand filters all need maintenance and have their sand media replaced. Rural public water system financing, management and operator training needs to be improved.

Palau generates approximately 6400 tonnes of solid waste per year and includes sewage sludge from sewage and water treatment plants. Currently almost all solid waste is disposed of in landfills the largest of which is located near the population centre of Koror. The rural States also operate their own solid wastes dumps and operate some kind of solid waste collection system, usually on a weekly basis. Most of the landfills are poorly sited and designed, and are not properly operated and maintained.

Waste is disposed of in dumps that are often located next to mangroves, or dumped down ravines and mostly left un-compacted and uncovered becoming potential sources of storm water runoff pollution and groundwater pollution. At present, chemical contamination of drinking water supplies from wastes has not been a major problem as there is still very little industry, and a low level of development.

Koror is the only State with a centralized wastewater collection and treatment system serving



about 75% of the population. The biggest environmental and public health threat is from improper operation and maintenance of the collection system and treatment plant, resulting in sewage overflows and the discharge of inadequately treated sewage into the lagoon. Another potential problem is cross-contamination of the public water system because lack of a backflow prevention program and regulations. All of the rural States are un-sewered and sewage from homes and businesses is treated by individually owned septic tanks, leach field systems or pit privies, and improperly sited or poorly designed and constructed systems are potential sources of groundwater contamination, especially from nitrogen compounds.

### **Water quality surveillance and monitoring**

The Water Branch, Bureau of Public Utilities, Ministry of Resources and Development, which is a part of the National Government, is the responsible owner and operator of the Koror/Airai public water system.

The Environmental Quality Protection Board (EQPB) is the national regulatory agency responsible for setting drinking water quality standards and the establishment of water treatment and disinfection requirements. The board issues permits to construct, modify and monitor of public water systems for compliance and establishes notification, record keeping, and operator certification requirements.

The Division of Environmental Health and Sanitation, Ministry of Health keeps a record of disease outbreaks and regulates the costs of private water companies. Current water pricing does not raise sufficient revenue to cover the total costs for the Koror/Airai system, which must be subsidized by the National Government and some customers do not pay their water bills but remain connected to the system. Reports estimate that revenue raised was about \$500,000 against operating costs exceeding \$1.5 million.

According to the National Master Development Plan, the national strategy is to provide an adequate supply of safe potable water to meet the needs of the people of Palau, to protect its water supply resources from environmental pollution, and to support sustainable economic development.

In 1993, Palau adopted the EQPB Public Water Supply System Regulations, which regulate public water supply systems in Palau. The Division of Environmental Health, Ministry of Health is also delegated certain regulatory authorities regarding food and health which includes private bottled water companies.

The current EQPB Public Water Supply System Regulations are modelled on the United States drinking water regulations contained in the Code of Federal Regulations issued by the Environmental Protection Agency. However, certain sections of the regulations are not practical or appropriate to conditions in Palau and an assessment needs to be made of the existing drinking water regulations to determine the changes necessary to make them more relevant to Palau, particularly regarding the monitoring requirements for certain inorganic and organic contaminants.

Legislation authorizes the EQPB to issue and enforce primary and secondary drinking water regulations, and other such regulations as are necessary to carry out the purposes of the United States Safe Drinking Water Act. The EQPB is also authorized to establish regulations and a permit system to regulate the discharge of pollutants to the air, land or water, which indirectly acts to protect water supply sources from environmental pollution.

The Capital Improvement Program, Design Engineering Office, Ministry of Resources and Development under the National Government is the agency responsible for constructing the public water systems in the rural states. Once constructed, the systems operation and maintenance is primarily the responsibility of the individual State, which is supported by the



Ministry of Resources and Development. The rural public water systems are primarily subsidized by the National Government and to a lesser extent from the State's individual budget.

The EQPB tests the 20 public water systems on a regular basis for coliform bacteria, chlorine residual, and turbidity. All of the rural water systems regularly test positive for bacteria and only the Koror/Airai water system regularly complies. The majority of the water systems are supplied by surface waters, which are required by regulation to be filtered and disinfected, and currently all of the surface water systems have rapid sand filters, however, some filters are not operational and others are in need of maintenance and repair.

Although most of the public water systems have been provided with chlorination systems, many are used irregularly or are out of service. Only the Koror public water system has been tested for the inorganic, organic, and radionuclide contaminants, which are required under the regulations, adopted by the EQPB.

The drinking water quality standards, implemented and enforced by EQPB, were established by the United States Environmental Protection Agency (EPA), under the authority of the Safe Drinking Water Act (SDWA), and adopted by Palau under the ROP PWSS regulations. Standards have been established for microbiological, inorganic and organic chemicals, herbicides, and radionuclides and for lead and copper testing in the distribution system. The Palau EQPB has the primary enforcement authority for the implementation and enforcement of these regulations in Palau. The PWSS regulations also include treatment requirements. Surface water systems are required to treat the water with filtration and disinfection, and meet turbidity and chlorine performance standards.

Currently all regulatory monitoring of public water systems in Palau is performed by the Palau EQPB. The public water systems are tested on a regular basis for total coliform bacteria, turbidity and chlorine residual. Systems served by a surface water sources are required by regulation to have filtration and chlorination treatment, and are required to test their water on a daily basis for turbidity.

The Koror/Airai system is sampled and tested for coliform bacteria at 13 locations twice a month and chlorine residual measurements are taken at the 13 locations on a daily basis and samples collected from system and tested for lead and copper levels indicate that the water meets the lead and copper requirements. Samples of treated water from the Koror/Airai system were tested twice for a full scan of inorganic, organic (volatile, semi-volatile, pesticide) chemicals, and radionuclides, once in 1994 and once in 2000. None of the Maximum Contaminant Levels (MCLs) were exceeded. Most contaminants were not present, or showed up at levels well below the MCL.

Rural systems are tested once a month for bacteria, turbidity and chlorine residual. In 1995 through 1997, Palau EQPB in conjunction with Ministry of Health and Ministry of Education instituted a program to test for lead content in rainwater catchment systems, as well as the State public water systems. A total of 331 samples collected from school, private, and public water systems had only 8 samples exceeding the Lead MCL of 15 ug/L. Almost all of the samples with high lead levels were from rain catchment systems. The main sources of lead contamination were attributed to lead solder and lead-based paint applied on the catchment systems. None of the rural state water systems have been tested for any other chemical contaminants because there are currently no funds allocated for testing the rural water systems.

Since upgrades to the Koror/Airai WTP were completed and the pre-treatment units went into operation, treated water quality has improved greatly and complies with the *WHO Guidelines for Drinking Water Quality*. Average effluent turbidity levels range from 1 to 3 NTU, Coliform bacteria routinely test negative, and chlorine residual is maintained in the distribution system.



The most common violations at the Koror/Airai PWS are exceedances of the stringent EQPB Drinking Water Regulatory turbidity standard, however violations of the WHO turbidity guideline occur with a much lower frequency.

Rural public water systems are tested on a monthly basis and routinely violate the EQPB turbidity standard and test positive for Coliform bacteria. The filter technology used in the rural systems (rapid sand filters) are unable to provide adequate treatment to meet the turbidity standard, and would need to be supplemented or replaced with slow sand filtration or alternative filtration/treatment technologies to achieve compliance. Most of the coliform violations occur because the chlorine disinfection systems are unserviceable or are not used.

### **Needs analysis**

The recommendations for improvement of drinking water quality are aimed at two main target groups, the water service providers and the EQPB regulatory agency.

Over recent years Palau has been developing rapidly. To support this development adequate infrastructure, including public drinking water systems are needed including implementation of drinking water and wastewater planning. Plans need to define the improvements and upgrades necessary to meet future water demands that comply with water quality standards.

Funding for operation and maintenance has a low priority, and therefore receives inadequate funding. There is an opportunity to combine and restructure public water systems into a self-sustaining independent public utility, which would also serve to improve the management and accountability of these systems. To make this sustainable, legislation and regulations would be required to give authority to extract water, build infrastructure and secure fees for drinking water provision. The fees should be sufficient to cover proper operating and maintenance of the facilities including a process to train operators of water treatment and supply facilities for both public utilities and rural water systems. Some short training courses have been completed focussing on operation and maintenance issues and included a general workshop on water quality. The training covered basic science and math, operation and maintenance of small water treatment and distribution systems, regulations and monitoring leading to operator certification. In addition, the Bureau of Public Utilities awarded a professional services contract, which includes on-the-job training for the Koror/Airai water treatment plant operators and distribution system operators.

The EQPB is an independent agency responsible for regulating public water supply systems and conducting routine water quality monitoring. To strengthen its operations needs to increase the frequency of monitoring of both water quality of supply sources and water quality, and a classification scheme for water sources needs to be implemented. Where there have been water quality violations, improvements in enforcement and corrective actions needs to be taken.

Inter-agency cooperation and coordination should be expanded to include the sharing and management of data and information through professional and regional networking. Training should continue and expand in parallel with public education programs devoted to the health benefits of good quality drinking water, water conservation and the protection of supply sources.

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## **Samoa**

### **Background**

The island state of Samoa is located in the South West Pacific. It is divided into 2 states by the 171st meridian. To the West is Independent Samoa and to the East is the US territory of American Samoa.

Independent Samoa is comprised of two main Islands (Upolu and Savai'i) and two smaller islands (Manono and Apolima). Collectively the islands cover a total land area of 2934km<sup>2</sup>. The capital city of Apia and the majority of commercial activity are based in Upolu. The remaining population lives in Savai'i, which is located 22km by sea from Upolu.

Both Upolu and Savai'i are volcanic, mountainous islands with central water catchment areas covered by tropical rainforest vegetation. The highest points are Mt Fito in Upolu at 1,158m Mt Silisili in Savai'i at 1858m.

Samoa's total estimated population is 161,000. Over a quarter live in the capital city of Apia, with approximately 75,000 living in 200 coastal villages in the island of Upolu. The remainder of the population live in Savai'i (~50,000) and the outer islands. Other than Apia, there are no significant commercial towns and the majority of the population lives in small villages of between 100 to 2000 people, relying on fishing and farming.

### **Water resources and supply**

In the Global Water Supply and Sanitation Assessment in 2000, the coverage of the population in Samoa with access to an improved water supply was estimated at 63% for rural areas and 98% for urban areas.

Samoa is reliant on surface water and groundwater resources. The municipal area of Apia is dependent on surface water collected from a catchment area in the centre of Upolu Island. The remaining smaller villages are currently dependent on groundwater although proposed programmes for both Upolu and Savai'i will attempt to supplement scarce groundwater resources in the West of Upolu with surface water from the centre of the island.

The use of rainwater catchment systems is not common in Samoa. In the early 1990's UNDP promoted the use of rainwater for household consumption. However, in certain parts of the country communities refused to use the subsidised rainwater tanks, saying they disliked the taste of rainwater. In other parts of the country (Savai'i), the European Union (EU) has installed a large number of ferro-cement rainwater tanks, which have been accepted by the communities.

The Management of Samoa's water resources are currently fragmented and no agency has direct responsibility for water resource management. The Ministries involved in Water Resource Management include the Ministry of Agriculture, Forestry, Fisheries and Meteorology who are responsible for watershed management and hydrology, the Department of Health (DoH), responsible for monitoring water quality standards, the Samoa Water Authority (SWA) who are the national water service provider, and the Electric Power Co-operation (EPC) the biggest user of water for hydroelectricity generation.

Due to this fragmentation of responsibility, there is no regulation or control of private groundwater extraction within customary lands, and consequently limited information is available about exact quantities of surface or groundwater resources available.

In an attempt to achieve greater co-ordination, the Department of Lands, Surveys and Environment (DLSE) in collaboration with other key stakeholders, developed a National Water Resources Policy (NWRP) in June 2001. The core focus of this policy was to improve



knowledge of current water resources and to promote greater understanding of the importance of water conservation and water quality at National and community level. The initiative will be further supported by the European Union (EU) through regional workshops.

A part of NWRP is to ensure that deforestation is controlled within the water catchment area. The South Pacific Regional Environment Programme (SPREP) estimates that forest now accounts for only 37% of the land area compared to 57% in 1960. This increased deforestation in the catchment area has caused increased surface water run off, and a depletion of available surface/groundwater resources.

The important issues for the NWRP for water quality include the clearing of forests for agricultural practices resulting in the increased use of pesticides and fertilisers in the catchment area, and the possible nitrate contamination of drinking water and increased turbidity (TSS) caused by soil erosion and the increased surface run off particularly during the rainy season. This change in aesthetic quality of drinking water can result in communities drinking from polluted sources, and impacts on the ability to treat the water.

Currently, the municipal centre of Apia is served by treated surface water through a combination of in-house and yard connections. The surface water is abstracted from the catchment area of the central highlands of Upolu. It is then pumped to treatment plants at Alaoa, Malololelei and Fuluasou where the water passes through three treatment processes; sedimentation, where raw water from reservoirs is pumped into sedimentation tanks with a retention time of 4 hours to reduce turbidity and TSS. It is then filtered through a roughing filter and slow sand filters to remove microbial contamination. However, the filtered material is removed by hand from the slow sand filters and dumped under uncontrolled conditions due to lack of funds. Finally the water is disinfected by UV light. In July 2001, SWA added chlorination with calcium hypochlorite as a final treatment phase before distribution.

The distribution network for the town has been designed to deliver 240 litres per capita, however some households consume more than 900 litres per person per day (lppd) and in some cases consumption rates reached more than 1900 lppd implying major losses through mains leakage or in-house wastage. A project began in 1999 to equip households with water meters and some 13,000 households of the 18,000 in Apia have been equipped with such meters resulting in a reduction in consumption from greater than 900 lppd to less than 350 lppd.

There are two major limitations facing the Apia distribution system, the ineffective treatment during rains due to increased deforestation in the catchment area resulting in high particle loadings, and the high consumption rates with the increased demand for water for rural water supply programmes, reducing the water available for Apia.

Rural areas of Samoa are primarily dependent on groundwater resources, abstracted from boreholes at below 80m by electric submersible pumps. In the west of Upolu, these groundwater resources are scarce and to supplement supply, the European Union is currently funding a program to divert surface water from the central catchment area to these rural villages.

The second island of Savai'i relies on groundwater extracted from boreholes, pumped into a reticulation system by submersible electric pumps and distributed by gravity through in-house connections. The SWA has proposed developing surface water resources on the island to supplement the groundwater supply.

In rural areas that are not served by a piped water supply, unprotected springs or river intakes are used as the principal drinking water source. It was noted that in Apia, customers who do not receive regular water supply often supplement their town supply with unprotected spring water.



Over the last 5 years there has been an increase in the number of households buying bottled water. There are currently 5 private companies bottling water (4 on Upolu and 1 in Savai'i) with one company estimating that they are supplying the equivalent of 20litres per family per month. Some limited water quality regulation of these companies is in place.

The present levels of coverage do not guarantee 100% reliability of service with households in low-pressure zones having intermittent supply with some households being without water for up to 12 hours. Where the supply is intermittent, piped water is often supplemented by untreated spring water by individual households. Households at end points of the distribution system receive low pressure, and treated water has until recently been diluted with raw water to boost supply.

In rural areas, the operation and maintenance of village reticulation systems is not well defined but SWA will assume greater responsibility for rural areas in the near future. Currently, there is little community involvement and supply and repair is intermittent, and where water is unavailable it has to be transported by local authorities in 200 litre drums.

SWA have recently initiated a cost recovery system in Apia and since the installation of water meters consumers have been paying approximately US\$3.5 per capita per month, equivalent to less than US\$0.03 per litre. Because of this low level of cost recovery, SWA does not generate sufficient revenue to cover system development or operation and maintenance. Many of the rural areas are dependent on piped water supply and bulk metering at the village level has been considered, however these voluntary contributions are currently minimal.

Samoa, like its neighbouring pacific islands, has a very low level of industrial and agricultural activity, but concerns remain over the potential effects of some chemical and biological pollutants in drinking water.

A survey to identify and quantify the volume of unwanted Persistent Organic Pollutants (POP's) and associated environmental contamination in Samoa identified that the level of chemical contamination is comparatively low and that chemical pollutants in drinking water are of less concern than microbial contamination associated with unsafe sanitation practices.

Sanitation practices in Samoa include on-site household faecal disposal that include pour flush, septic tank systems and pit latrines. The SWA has identified that sewerage is necessary for the 18,000 households of Apia due to presence of black and grey water overspill from septic tanks running into watercourses and recreational waters, and there are indications of eutrophication occurring in lagoons around Apia.

Currently, there is no standard septic tank design in Samoa. They are not lined to prevent subsurface pollution, and are not monitored by the EHU to ensure regular desludging. The tanks are emptied by private-public co-operation, which includes the Department of Lands Survey and Environment (DLSE) and the Ministry of Public Works, however the enforcement of quality control standards for emptying by the EHU is lacking. De-sludging often occurs prior to sludge maturity, and in some cases the holding capacity of septic tanks is insufficient and emptying is required daily.

The sludge is disposed of in two unlined pits at Tafa'igata 10km to the south west of Apia upstream of a number of production boreholes and testing for microbiological contamination, nitrate and nitrite levels in these boreholes are conducted on a regular basis. The estimated 740mt of nitrogen-based sludge produced annually is not being disposed of under controlled conditions and in areas outside of Apia sludge is removed manually and dumped in forested areas.



A waste characterisation study recorded that Samoa has a relatively low waste generation rate of 0.52kg/person/day with a bulk density of 350kg/m<sup>3</sup> of which 59% were biodegradable materials and the remaining 41% predominantly paper, metal and plastic. The Department of Land Survey and Environment (DLSE) in partnership with a number of private sector groups, collect waste at household level, which is then disposed at the landfill site in Tafa'igata which began operation in 1993, is unlined, with limited covering activities.

A program has begun aimed at raising awareness of the importance of solid waste management as a major source of pollution, promoting household sorting and recycling of organic products and the drilling of a number of inspection boreholes close to the present landfill site to monitor COD/BOD and conductivity.

The uncontrolled dumping of solid waste raises concerns of possible chemical pollution of drinking water particularly from the leachate contamination of groundwater and surface water resources from the unlined landfill sites.

A high percentage of cultivated land in Samoa is used to grow subsistence crops such as taro, yams, bananas, pawpaws and breadfruit with coconut products being the only agricultural export accounting for 70% of exports. Despite this low level of export-driven agriculture the use of pesticides remains a concern, and the Ministry of Agriculture maintains a register of pesticides aimed at controlling the importation of both agricultural and household pesticides.

There is limited industrial activity in Samoa and the food and brewing industry accounts for a third of all industrial discharge, the remainder including printing, photo developing, cigarette manufacturing, fuels, gasses, lubricants and shoe manufacturers.

The wastewater discharged from Vialima Breweries is the major industrial waste discharge however the brewery has installed a treatment facility and adheres to the Coca-Cola standard for wastewater discharge.

Currently there is no effective form of medical waste disposal at Apia Hospital and of the 30 bins of medical waste collected per day, 25 are taken to Tafa'igata. The hospital incinerator is currently being re-habilitated. Medical waste in rural areas is buried and burnt, and an incinerator is currently being built for Savai'i hospital.

Unsafe faecal and waste disposal has resulted in an increase in water borne diseases with morbidity data from the Department of Health suggesting that there is an increasing trend in water borne diseases, particularly diarrhoeal diseases, gastro-enteritis, unclassified and infantile diarrhoea. Typhoid has also increased and is now endemic in certain areas of the country. The Preventive Health Department are currently investigating the cause of these typhoid outbreaks using questionnaires to establish the principal drinking water source and food sources 30 days prior to illness, however, to date, there is no conclusive evidence as to cause. Dengue Fever is also evident in Samoa.

Although mortality rates associated with waste related disease remains relatively low, rates of morbidity continue to remain high and the Department of Health have formed a Committee of Communicable Diseases with typhoid prevention as the primary issue.

### **Water quality surveillance and monitoring**

An inter-Ministerial panel compiled the *Samoa Drinking Water Standards* with a final draft published in 1999 the objective being to raise awareness of the importance of water quality and to create a set of standards applicable to physical conditions in Samoa.

These Samoa Drinking Water Standards are significantly different from the WHO Guidelines for Drinking Water Quality in the requirements for indicator bacteria for microbiological



parameters. The reason for the difference is related to realistic levels of service provision and the perceived immunity of Samoans. It was noted that SWA and EHU stated that increased levels of *E.coli* was of limited concern due to the higher immunity of Samoans through long exposure to bacterial infections, however, acceptable levels of contamination are not dependent on immunity. There are other deviations in chemical standards outlined in the Samoan guidelines including a limited number of pesticides and arsenic.

Although the final draft of the Standards was written in 1999, to date the Cabinet has not legally mandated the Standards and they are considered as "Intermediate" standards and WHO Guidelines continue to be used.

The agencies responsible for water supply at the national (urban and rural) level include the Samoa Water Authority Environmental Business Unit (EBU) responsible for capital works systems, rehabilitation, operation and maintenance, management and cost recovery, and water quality. The Environmental Health Unit (EHU) of the Department of Preventative Health, Ministry of Health are responsible for water quality health education. The Ministry of Agriculture, Forestry, Fisheries and Meteorology are responsible for watershed management boreholes and siting. Policy is the responsibility of the Department of Lands Survey and Environment (DLSE) and private bottling companies (including Le Vai, Vailele and Vai Lata) are responsible for bottled water supply. A number of NGO's and United Nations Departments are also active in Samoa focussed on health education programmes.

There are currently two official drinking water quality monitoring programmes in Samoa. One operated by Samoa Water Authority (SWA) and the second by the Environmental Health Unit (EHU). There is also an independent Chemist who collaborates with both SWA and the EHU in the sampling and analysing of water from Le Vai Bottled Water Company.

Prior to formation of SWA in the mid 1990's, the EHU were responsible for the majority of sampling and water quality testing in Samoa. With the creation of SWA, it was verbally agreed that SWA as the service provider should monitor the water they are providing and the EHU should act as a surveillance agency that undertake random sampling to cross check results.

Following the publication of the first draft of the *Samoa Drinking Water Standards Manual* in March 1999, it was noted that sampling and monitoring laboratories will be approved and regulated, as necessary, by the Department of Health and that should a supplier fail to comply with the standards it must contact the Director General of Health within 24 hours of receiving results. Notifying the public of the unsafe water source is then the responsibility of the Ministry of Health.

The SWA has a team of water quality monitors that make up the Environmental Business Unit (EBU), a semi autonomous unit within SWA. They primarily collect samples from the Apia urban distribution system but also test selected boreholes in Savai'i and recently have begun to take samples from the private bottling companies and are promoting themselves as an independent unit that can also test private supplies. Currently they have been concerned only with collection and analyses of samples, both in the field and in a central laboratory.

Irregular and regular results are recorded and discussed with Managers and Engineers on a monthly basis. These results are then used by SWA to locate and improve potential areas of contamination within the distribution system, however no form of sanitary survey, health education or community development is undertaken by the EBU. The diagnosis of points of contamination and remedial action is the responsibility of the Engineering Works Department of SWA with the EBU having the sole responsibility for monitoring water quality.



The monthly report is discussed at the monthly Water Quality Committee meeting attended by all the key stakeholders in water quality and the SWA Board Meeting attended by Board Members including the Director General of Health, and other Departments

The Chief Health Inspector leads the Environmental Health Unit (EHU) within the Division of the Preventative Health Service. He manages a team of 17 people who are divided into five Programmes; Environmental Sanitation, Vector Control and Quarantine, Water/Food Safety and Quality Control, Occupational Health and Chemical Control and Rural Health in Savai'i

Currently, the EHU is doing a limited amount of work in the area of water quality surveillance with a greater focus being paid to food safety and quality control. Due to limited physical resources and lack of motivation house-to-house surveys are being done on an irregular basis and focus on a household level analysis such as condition of food preparation areas and general house condition. Standard sanitary survey forms for water supply are not used but a limited number of sanitary inspections are conducted at the household level. Water samples are taken on an irregular basis and results are questionable due to condition of testing facilities.

The major supplier of bottled water in Apia (Le Vai) has contracted an independent chemist to test their water quality at varied points of treatment on a weekly basis. Impartiality is maintained by crosschecking with the EBU and SWA. Results from this water quality testing are fed into the operation and maintenance of the treatment and bottling facility.

The major focus of the EBU of the Samoa Water Authority is on the Apia distribution system where it is currently taking approximately 50 samples per week from 10 fixed points in the distribution system, and testing for a number of microbiological, physical and chemical parameters.

A combination of field and laboratory testing is used depending on the parameter to be tested. For the physical parameters of conductivity, TDS, turbidity, pH and residual chlorine, field-testing equipment is used with samples returned to the laboratory to reconfirm turbidity, salinity, pH and iron. Equipment is available for BOD and COD testing but arsenic has not been tested.

The Department of Health has been testing water quality since 1949. It is scheduled to collect 10 samples per week but due to limited resources, often fewer samples are collected. For these samples, the EHU are responsible for collecting the samples and, in collaboration with laboratory technicians, undertake analysis of the samples. Over the last 5 to 10 years however, there has been a reduction in the number of samples collected due to restructuring in the sector with greater responsibility being passed to the SWA. Due to these limitations, it is estimated that the EHU is currently sampling a maximum of less than 10 samples per month and despite the presence of new field-testing kits, it is understood that a large number of samples are transported to the laboratory under uncontrolled conditions. In the rural areas, the EHU appear to have a systematic method of testing for samples, some are taken randomly and some at fixed points. The collection rate is less than that agreed in the *Samoa Drinking Water-Standards Manual 1999*.

There are three laboratories in Samoa that are undertaking drinking water quality testing. The Department of Health Laboratory is located in the Central Hospital in Apia. It was established in 1929 and is in need of rehabilitation. The Public Health Laboratory (which undertakes water quality testing) is a shared facility with the clinical laboratory and it has been noted that due to the poor sanitary conditions of the laboratory it is recommended that laboratory services be suspended. The staff are experienced but the laboratory itself was in an unsanitary condition and it was very difficult to locate equipment, media and data.

Samoa Water Authority Laboratory is located in the Environmental Business Unit of Samoa



Water Authority set up in 1996 when the Samoa Water Authority was formed. The laboratory has the capacity to undertake a range of biological, chemical and physical tests.

The EBU laboratory follows the US Environment Protection Agency (USEPA) approved standard operation procedures (SOP's) for all tests and a copy of these SOP's was available. The laboratory staff are highly efficient and motivated and their data is organised and recorded in the laboratory computer.

A small private laboratory is located in Le Vai Bottled Water Plant established in 1998 for in-house water quality monitoring and has the facility to conduct a limited number of microbiological, physical and chemical tests. The laboratory is well organised and attention to detail is paid in calibration of equipment.

No systematic form of sanitary surveys is currently being used, although the EHU undertakes house-to-house surveys with greater attention paid to food preparation and less to water sources. The SWA does not conduct any form of sanitary survey and water quality monitoring is done in isolation with results provided to assist engineers in improving facilities. As a result the effectiveness of the sampling without sanitary surveys is questionable.

The largest challenge facing Samoa in the sector of Water Quality surveillance is institutional. Currently, the service provider (Samoa Water Authority) is also the regulator. In order to maintain equilibrium between service provision and control, there is a need for an independent surveillance agency.

During meetings held with the various actors in the sector, there was an acknowledgement that an independent surveillance agency is required. As part of Samoa Water Board's master plan, the Environmental Business Unit (EBU) will, in time, become self-funded entity acting autonomously from SWA as a regulator. The first step to becoming independent is income generation and EBU currently advertise their services to carry out water quality testing for private consumers. The fees associated with these tests are to maintain the service.

However, the Department of Health is obligated to maintain standards of service provision in order to reduce the risk to public health and there is an argument for the Environmental Health Unit (EHU) of the DoH to become a more active regulator of the service provider, however they are unable to this with their current human and physical resources.

Furthermore, the Department of Land, Survey and Environment (DLSE) is proposing through the National Water Resource Policy to maintain appropriate water quality. To achieve this, greater co-ordination is required between the water catchment unit of the MoA, the service provider (SWA), the consumer (including EPC) and the water quality surveillance body. This will ensure that over-intensive agriculture is not depleting or polluting water resources.

### **Needs analysis**

An independent water quality surveillance agency should be created that should be an agency that is not a service provider, but rather a monitor of service provision.

Following the recommendations of WHO a new management position should be created as Manager of the Environmental Health Service, who in collaboration with the Head of Preventative Health Services would be responsible for restructuring the EHU. It is recommended that new Job Descriptions be composed for all members of EHU and that performance be reviewed on a monthly basis with particular attention paid to laboratory staff.

It is important to maintain the current dynamism in the EBU by dividing responsibility for sampling and testing between the EBU and EHU. This could be done by zoning with high risk



areas with limited access to basic service provision covered by the EHU, and private customers with the ability pay covered by the EBU.

The creation of National Water Resource Policy (NWRP) by the Department of Lands, Survey and Environment should form a basis for future inter-departmental co-ordination in Integrated Water Resource Management whereby a full and comprehensive survey of water resources is conducted regarding quantity, quality, and coverage of water supply. It is recommended that all key players in the water sector should participate in the assessment to enable them to understand the linkages. With regard to the linkage of water quality and health statistics the establishment of a monthly Water Quality Committee meeting is the first step to information dissemination.

Current laboratory resources in the Department of Health are inadequate and it is proposed that in the interim that the EHU focus on field-testing rather than laboratory testing.

It is also recommended that legislation be followed up in Drinking Water Standards as since the publication of the final draft of the Samoa Drinking Water Standards no progress has been made to legally mandate them. The Public Health Act needs to be reviewed as to its applicability in relation to water quality surveillance as the mandating of the Drinking Water Standards and of the Public Health Act affords a legal backing to an independent water quality surveillance agency once formed.

Legislation towards the standardisation of septic tank design is required to avoid further surface and groundwater pollution and should be enforced by the EHU. A review of desludging practices in Apia is recommended, particularly in reference to collection and disposal. It is recommended that the pits be relocated and redesigned with adequate water quality monitoring facilities to measure levels of groundwater contamination from wastewater.

Training is required in the area of sanitary surveys and health education and their importance for water quality monitoring. This should be directed at the EHU, EBU and any agency involved in community health care

Laboratory testing procedures should be standardised to ensure uniformity of results and it is recommended that a committee be formed to compile a *DRAFT* Standard Operation Procedures Manual to accompany the Drinking Water Guidelines. It is recommended that a format for water quality testing is designed and used by all testing water.

It was recommended in the Pacific Water Association Meeting in 2000, that a regional laboratory is needed to test for chemical parameters that cannot be tested in each Island state. This would provide a more effective procedure for chemical analysis for the island States.

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## **Solomon Islands**

### **Background**

The Solomon Islands are a widely scattered archipelago of mountainous islands and low lying coral atolls geographically located in the South West Pacific between longitudes 155° 30' West and 170° 30' East and between latitudes 5° 10' North and 12° 45' South. It consists of 6 main islands and more than 300 smaller islands and islets. The total land area is approximately 28,369 km<sup>2</sup> covering a total sea area of 1,632,964 km<sup>2</sup>. The capital and principal economic centre Honiara is located on the main and largest island of the group, which is Guadalcanal.

The climate is equatorial with an average daytime temperature of 28°C with a high humidity ranging from 60% to 90%. The annual rainfall averages 3000mm to 5000mm while the monthly average of about 200mm varies greatly with location. The wettest time of year is usually from November to April.

The country is divided into nine (9) Provinces for political and administration at the provincial level. They are Central, Choiseul, Guadalcanal, Isabel, Makira, Malaita, Renbell, Temotu and Western.

The most recent census puts the population around 420,000 people making it the third most populated in the region after Papua New Guinea and the Fiji islands. Estimates suggest that less than 20% of the population live in towns, whilst the majority live in rural areas. The Solomon Islands has an average population growth of 3.5% per annum. Population density based on individuals per unit land area identifies Malaita as the most populated province in the country.

The country's economy is agriculturally based, with 90% of families practicing subsistence farming methods. The average earning capacity of individuals is relatively modest in comparison to some regional countries.

### **Water resources and supply**

Due to its geographical location the Solomon Islands enjoys a tropical weather pattern with the monsoon experienced during November to April, though less severe as other parts of the globe. Long dry spells are infrequent but may last for a few months resulting in adverse effects on water supplies to most rural and urban water supply systems.

Almost all of the larger islands in the Solomons group are mountainous and volcanic with rugged terrain, and except for a small coastal plain areas on a few of the bigger islands the rough terrain provides abundant fresh water springs.

According to the 1999 census 60% of the population has access to water supplied by the Solomon Islands Water Authority (SIWA) in urban areas, or the Rural Water Supply and Sanitation project (RWSS). About 69% of the rural population has access to what is termed "clean water" in the form of "gravity feed" supplies. Some households have rain water tanks. There is no form of water treatment in rural areas and the protection of water sources from animals, people and land "run off" is all that are feasible at present.

In small islands the main source of water is from wells and from rainwater captured in water tanks. This figure matches closely a 1999 census figure of about 62% having received piped water supply. In recognition of the close link between good water supply and good health, the Government has approved the expansion of the current National Water and Sanitation Project that includes training for women in water and sanitation issues.



A UNICEF primary schools water and sanitation programme has seen the instalment of systems in 25 schools in three pilot provinces over the period 1995 to 2000. This has included school educational programmes on the health aspects of safe water and proper waste disposal. The 1999 Census, drawing on individuals' responses to a question on toilet facilities, produced a figure of 23% of the total population who have access to "modern" or "improved" toilet facilities. This has been seen as an improvement in light of an earlier estimate that only 19% of the rural population had access to improved toilet facilities. Most urban households have access to toilet facilities, either septic systems, or pour flush. In peripheral urban areas, septic systems, pour flush, squat type or VIP (ventilated improved pit latrines) are available.

The most common source of water utilised for water supply systems in the country is surface water supplied to consumers using gravity feed systems from the rivers, streams and springs. For the smaller outlying islands and coral atolls, a combination of underground sources and rain catchment methods are exploited.

Overall, the surface water and gravity feed systems supply 80% of drinking water needs, rainwater catchments 15% and the remainder from underground water sources. Most of the towns and urban centres in the country are well served and have an existing infrastructure for water supply. However, there has been a steadily growing trend of landowners claiming rights to existing and potential sources. This trend has caused disruption to water supplies and is having an effect on the rehabilitation and improvement of older systems, resulting in town residents experiencing inconsistent and sometimes unreliable water supplies.

A large majority (93%) of urban dwellers have access to an improved water supply, but this represents only 16% of the total population while 75% of the rural population has access. The remainder may still have to access water from remote locations, and some urban dwellers have to rely on illegal connections or share standpipes with others who do have access.

The urban water supply in Honiara and some of the provincial capitals is the responsibility of the Solomon Islands Water Authority (SIWA) who collect a water supply levy. Provincial governments are free to choose the SIWA as a supply authority or to operate their own provincial water organisations that charge their own levies.

The Ministry of Health and Medical Services, Environmental Health Division (EHD) through its Rural Water Supply and Sanitation Program (RWSS) is the responsible agent for water supply projects in many other parts of the country.

For Honiara, the greater percentage of the water is extracted from surface sources with a substantial portion acquired from underground sources while roof catchments and rainwater tanks are the responsibility of private property owners. The reticulation system for Honiara is generally old except for newly developed properties on the fringes of the town.

Currently drinking water treatment practices and technologies are mostly primary. Centralized treatment done by SIWA for Honiara is by chlorination, and boiling of water by consumers is encouraged.

Pollution sources affecting water quality in the urban areas are varied and the greatest concern is the direct impact of human activities in and around the fringes of catchment areas. Housing developments near both surface and underground catchments pose a real threat but commercial and industrial activities are not considered a threat at this time, as they are far removed from present catchment and water source locations.

Sanitation in Honiara and other provincial capitals are managed and operated by SIWA as separate systems independent of the water supply. Wastewater and sewerage are linked into a



common network that pumps waste and effluent directly into the ocean and poses less of a threat to water quality.

Due to the naturally rugged topography of the islands, it is not readily possible to link all homes to the sewerage system and so remote properties rely on septic tanks that are pumped out whenever necessary by the Honiara Town Council, or by contractors delegated by them.

There is a designated refuse site for dumping solid waste that is also the responsibility of the Town Council and garbage collectors are contracted to be responsible for areas within defined boundaries. These designated solid waste dumping sites are also removed from all catchment areas and water sources.

A potential pollution source may be private developers infringing on and within catchment areas of the surface and underground water sources, and the water quality of urban centres, particularly Honiara, is largely dependent on the degree to which such developments are allowed. The greater the population growth, the greater the risk of this population encroaching on water catchments with an adverse effect on water quality.

Of specific relevance to water-borne diseases was the first quarter of 2000 when the national incidence rate of diarrhoea amongst children under the age of one was markedly high. That period, which was also at the height of the civil disturbances, occurred at a time of massive displacement of people throughout the nation. The high incidence rate may have been caused by shock related stress in the younger children in that age group, or may have been due to other causes.

Water-borne diseases found in the Solomon Islands include, diarrhoea, hepatitis, influenza, cholera, and typhoid.

### **Water quality surveillance and monitoring**

The Solomon Islands does have a legislative provision for Water Quality and Safety Standards, but does not have explicitly written standards to safeguard Water Quality and Safety and resorts to World Health Organisations (WHO) guidelines and relevant sections of the Australian Drinking water Quality Standards.

There is a legislative provision in the Solomon Islands under its Food Hygiene Regulations Act 2000, for drinking water quality and safety standards. Unfortunately these strategies, and approaches for implementing policies are all too frequently ignored, and there has been political unwillingness to introduce the idea of quality and safety of drinking water.

The issue has become politicised, and while the issue of constructing water supply systems for rural communities in their respective constituencies has support, the introduction of the idea of quality and safety of drinking water does not. This lack of political will has resulted in less emphasis on drinking water and is compounded by the lack of support for funding awareness programs

There has been a slow but steady increase in the number of technically qualified locals, who mostly graduate from institutions abroad, and there are also growing numbers of engineers and laboratory analysts.

There are three laboratory facilities all operating at the national level that are responsible for monitoring water quality and safety. They are establishments under the Ministries of Health and Medical Services, Public Health Laboratory (PHL), Energy and Mines, Water Resources Division (WR) and the Solomon Islands Water Authority (SIWA), Water Quality Laboratory.



The Solomon Islands Water Authority (SIWA), Water Quality and Safety Laboratory is located in Honiara the capital of the Solomon Islands, and it is managed and operated by SIWA. It is the only one of its kind operated by the Authority in the entire country.

SIWA has two monitoring programs for ensuring water quality and safety is maintained. There is system monitoring including assessment of the quality of water in the distribution system by testing for chlorine residual and physical characteristics which occurs twice a week for micro-organisms and monthly for chemical characteristics. The data obtained is used for compliance with guidelines, and for corrective actions to improve water quality. Secondly there is operational monitoring, to check that the processes, water quality equipment and treatment facilities are in proper working order.

The Ministry of Health and Medical Services, Public Health Laboratory (PHL) is located in Honiara within the Malaria Research Centre Building and is looked after by staff of the Ministry of Health and Medical Services. It too is the only laboratory engaged in public health (water quality and safety) related analysis in the country.

The Ministry of Energy and Mines, Water Resources Division Laboratory is also located in Honiara at the Ministry compound. It is concerned with analysis of water samples both for commercial and domestic use. Verification tests are carried out to determine heavy metal contamination of a particular natural river system, when the Gold Ridge mining company was operating prior to the height of the social problems in the country. The water resources laboratory would collaborate with SIWA and sometimes also with the PHL to perform verification checks on suspected contaminated water sources.

Of these three laboratory facilities, the Water Resources Division deals mainly with chemical analysis of water for commercial use, and the sampling and analysis of water and assuring safety for consumption is not their main concern despite the fact that they have the means and capacity to perform such tests. However, SIWA and PHL are concerned with monitoring water quality and safety for consumption.

The Public Health Laboratory monitors turbidity to ensure that drinking water is as free as possible from microscopic suspended particles that cause cloudiness. They monitor odour and where possible determine the cause, and give advice to consumers on precautionary measures to be taken. Several other physical parameters such as temperature, hardness, alkalinity and acidity are also monitored, except where equipment used to conduct tests is broken. The PHL is currently unable to conduct chemical tests, mainly due to aging equipment, and does not cater for conducting radiological tests.

SIWA Water Quality Laboratory conducts tests for bacteriological contamination in the form of total coliform and *E.coli* to ensure quality and safety of drinking water is maintained and sampling from strategic points throughout the system are conducted on a weekly basis. Random sampling at other points in the system, and testing of such samples are also conducted whenever the need arises.

SIWA has in its laboratory a spectrophotometer that can analyse up to 200 different kinds of water characteristics, however, due to a shortage of reagents, it can only analyse for nitrate/nitrite, potassium, manganese, calcium, hardness, copper, arsenic, ammonia, zinc, silver and iron. SIWA is also capable of monitoring alkalinity, acidity, calcium and chemical oxygen demand (COD).

The frequency of sampling and testing for chemical parameters is irregular and infrequent compared to bacteriological samples, but the frequency of sampling and testing may be increased under suspicious and abnormal circumstances such as occurred at the height of the civil unrest in the country, when the Honiara Water System was rumoured to be chemically



poisoned, at which time the SIWA laboratory conducted chemical analysis on an almost hourly basis. Generally chemical parameters are monitored to enable identification of any fluctuation or accumulation of a particular chemical or a number of chemicals that may become a threat to, or detrimental to, general public health.

SIWA also monitors the following physical parameters: turbidity, hardness, true colour, total dissolved solids, pH, temperature, taste and odour, and dissolved oxygen. The physical parameters are monitored to determine the physical quality of water so that preventive measures may be taken to ensure quality and safety is maintained. These parameters are generally not of direct public health concern, but they do affect the aesthetic quality of water and this determines whether or not people will choose to drink it. If water appears to be of poor quality, then even though it may be safe to drink, the consumer may seek alternative water sources, which may not be as safe.

### **Needs analysis**

The SIWA Laboratory is housed within one of the main office buildings of the Authority and the present state of the laboratory is poor. The room is too small and crowded with equipment creating an unfavourable work environment. While there is equipment capable of carrying out most analyses for monitoring water quality and safety to a high standard of acceptability, there is only a single staff member managing the entire operation.

The Ministry of Health and Medical Services, Public Health Laboratory (PHL) is housed within the Malaria Research Centre building in Honiara. Its present condition is not suitable for conducting water quality and safety analysis tests although the equipment is still functional and the lab has three trained technical officers.

The Ministry of Energy and Mines, Water Resources Division Laboratory (WR) is housed within the Ministry compound and while its condition is adequate for carrying out water quality and safety analysis it is not primarily concerned with analysis for public health reasons. However, they are willing to cooperate with SIWA and the PHL in dealing with specific health related contamination events. Their staff are university qualified and are capable of performing water quality and safety analysis.

The National Vision, Strategy, and Position of Drinking Water stakeholders (The Water Resources Division of the Ministry of Energy and Mines, The Solomon Islands Water Authority (SIWA), The Rural Water Supplies and Sanitation Program (RWSS), and local water bottling enterprises around Honiara) recommended the establishment of a taskforce to consider formulating a National Policy guideline leading to the creation of a national water quality and safety standard, based on WHO criterion and Guidelines which would be appropriate to local conditions.

They also recommended establishing a data/information management system that controls flow and exchange of data and information between stakeholders, Government Ministries and corresponding Divisions and Units.

Suitable laboratory sites need to be identified and buildings to be specifically constructed for the purpose of water quality monitoring and be fully equipped and appropriately staffed. Currently all three laboratories are situated in or near Honiara, and are not suitably equipped or staffed to provide reliable and accurate data

Development and improvement is required in terms of political commitment, and legislative tools for monitoring, including the protection and control of sources and modification of current legislation regarding customary land ownership and their associated rivers, streams, springs and or underground water sources within those areas is needed.



Water Authorities and Agencies to be kept well informed of the extent and limit to their legal rights when conducting water supply related activities on customary land and be empowered to exercise by-laws for the protection and control of watersheds and catchment areas in the vicinity of water sources, both surface and sub-surface.

There is a need for the provision of portable water quality testing field kits that are weather proof, robust and suitable for the remote locations around the country with indigenous staff being further trained for specific areas related to public health and water quality and safety.

Priority issues identified are that there should be a Drinking Water Quality and Safety Standard that makes it easier to determine water safety and makes provision for easier communication using measurements and guideline values rather than classifying water as “safe” or “not safe” for drinking. This will enable measures of performance and decisions to be made on trends in water quality.

Power should be legislated for Water Authorities and Agents to ensure the best management practices for protection and control of water sources and catchment areas. It will allow for stakeholders to have access to water quality and safety related data of concern to them, particularly in light of recent events experienced in the country. It will legislate to allow activities associated with protection, control and management of water supply sources and supplies and for trespassers to be penalized for unacceptable conduct.

Creation of proper facilities and training for technical staff is needed to allow for upgrades of building infrastructure purposely designed for laboratory activities with a corresponding upgrade of equipment capability/capacity. It should include appropriate training for technical staff dealing with specific and relevant areas of concern in regards to water quality and safety.

There has never been a revision of the *Food Hygiene Act 2000*, which would impact any changes on the formulation of a national drinking water standard. There are a number of problems affecting the implementation of such drinking water standards such as a lack of initiative to establish, organize and coordinate a team of relevantly qualified individuals (locals and expatriate advisers) to examine the matter.

There is a current lack of management procedures and programs that needs to be addressed to coordinate the flow of data/information to the proper government offices and agencies. At present water monitoring data are noted, entered and filed and then passed on to the Environmental Health Division in hard-copy format making analysis difficult.

The Ministry of Health oversees all matters relating to public health and therefore other drinking water quality stakeholder organisations and agencies are answerable to the Ministry if and when general public health may be at risk because of the action or inaction on their part.

Public awareness campaigns while actively pursued by SIWA and the Rural Water Supply and Sanitation (RWSS) are insufficient to publicize the issue of protection and conservation, and a broadening in methodology is needed to reinforce the message.

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## **Tonga**

### **Background**

The Kingdom of Tonga is a Polynesian Country located in the South West Pacific between Fiji, Western Samoa, and New Zealand. It is a Monarchical State situated approximately on a North-South line at Longitude 177°W and between 15°S and 23°S. Latitude.

The Kingdom of Tonga is comprised of 176 Islands of which 35 are inhabited. These islands fall into five major groups. They are Tongatapu, Ha'apai, Vava'u, and the Niuas.

In 1996, Tonga had an estimated population of 100,000 people dispersed throughout the six island groups. Of the total population recorded, 98% had access to water supply in urban areas but only 63% had access in rural areas. As noted in the WHO Guidelines for Drinking Water Quality Volume 3, access to water supply is of paramount importance and can be defined by factors such as, the population served, the reliability of the supply, and the cost of the water to the consumer.

Tonga receives a relatively high annual rainfall of 1700mm to 2300 mm that recharges the groundwater resources. On the majority of the islands, this groundwater resource is located in shallow and highly porous coral limestone aquifers. In years of low rainfall, droughts are common on many of the islands and no obvious emergency preparedness is in place.

### **Water resources and supply**

The use of groundwater resources presents a common problem throughout the islands due to the saline intrusion. In the main island of Tongatapu the groundwater is as little as 0.6 metres above sea level. Consequently, the water supply for the capital Nuku'alofa is from 31 boreholes to the south west of the town. These boreholes are spaced at 150m intervals and have a controlled flow rate of 3 l/s, a conservative estimate to limit saline intrusion.

Where groundwater abstraction has been monitored, increased levels of salinity have been noted. In 1990, the Neiafu area of the second largest island of VaVa'u indicated an increased level of salinity to 1,750 µs/cm.

On the island of Hapai and Nomuka, surface water resources have been used. In Hapai infiltration galleries filter out surface water run off from mountain streams but during heavy rains this has proved ineffective resulting in highly turbid water.

In 1992, the US Army installed two Reverse Osmosis (RO) Desalination Plants on the small island of Nomuka to produce potable water from a hyper-saline central lake. Operation of the RO plant was recorded as being hampered by the excessive contamination of the pre-filters with organic material from the lake.

The main drinking water source in urban areas in Tonga is groundwater and for rural areas rainwater, with some utilisation of surface river water. Due to the hardness of the groundwater, Tongans supplement their supply with rainwater from catchment systems and purchased filtered groundwater.

The rainwater catchment systems are mainly based on corrugated iron roof catchments, which collect water in ferro-cement rainwater tanks. The majority of tanks are equipped with an inspection hatch and soak-away facility, however none were noted as having first-flush systems.

The rainwater tanks provide the principle source of drinking water. However, 10% of Tonga's population were recorded as living in thatched roof dwellings during the 1996 census and in



these households, rainwater catchment is not possible due to the low roofing and the materials used.

Although the National Health Plan 2000-2004 indicates that 100% of the population has access to safe water, and that there has been no serious outbreak of waterborne infectious diseases the water supply and quality monitoring systems are generally not well developed and remain a subject of concern, particularly in rural and some urban areas. Data from the Ministry of Health suggests that there has been an increase in water related diseases since 1996. Cases of diarrhoea and gastro-enteritis have increased from 2281 to 3667 (almost a 30% increase in reported cases) over a 4-year period.

Additionally since 1996, 92 cases of typhoid have been recorded and of the 11 cases recorded in 2000, 10 were recorded in the Central Hospital. Although reported as not water-borne typhoid, these figures indicate an alarming number of water and hygiene related diseases.

Conflicting information gained from different sources suggest that the last typhoid outbreak was either in 2000 or 1996. This was resolved by ensuring all households had access to safe water and sanitation. However, typhoid is endemic in one particular village in Tongatapu where outbreaks are common and improvements in access to water and sanitation have not reduced numbers of recorded cases. No recorded cases of cholera, rotavirus, or shigella were noted.

The National Health Plan also states that 86% of Tonga has adequate sanitary facilities. However, there is no sewerage system and on-site sanitation consists of septic tanks or pit latrines. There are no detailed regulations governing the construction and operation of these facilities and there are no inspections or other control mechanisms over their use. The poor septic tank design results in the overflowing of tanks during the wet season leading to surface flows of black water into small streams and the sea. Fifteen composting latrines were built in Hapai to reduce possible contamination of shallow groundwater resources, but community opposition to them prevented further latrines being constructed. As a result, the most common source of contamination of drinking water is from these domestic sources. There are no wastewater treatment facilities on Tonga and the effluents are commonly discharged into the ocean, the lagoon, or nearby stormwater drains.

Solid waste collection and management is a problem throughout Tonga and poses a threat of contamination of recreational and groundwater sources. In the Nuku'alofa area the collected waste is dumped in a landfill site to the east of the city, near to the sea and 1 km from the Lagoon. In 1996, WHO funded the establishment of a designated landfill site to prevent unauthorised dumping of solid waste. By 1999, this site was recorded as being poorly managed, and solid waste was being dumped at 1m above ground level. In rural areas, no public collection of solid waste is practised and disposal is by burning, burial and composting.

The few industrial activities that are carried out in Tonga are unlikely to be a source of contamination, but the increasing use of agricultural chemicals and fertilisers may pose a risk in the future. Geology suggests that there are no naturally occurring contaminants other than salinity from the intrusion of seawater into the freshwater "lens" underlying the islands.

Responsibility for water supply, distribution, operation, and maintenance in urban areas is that of the Tonga Water Board, and of village committees in rural areas. Monitoring is carried out by the Board in urban areas and by the Ministry of Health in rural areas, although both monitoring and surveillance activities are generally poor.

The urban areas that are the responsibility of the Tonga Water Board include Nuku'alofa the capital on Tongatapu Island, Pangai, on Ha'apai Island, Neiafu, on Vava'u Island and Ohonua, on Eua Island. In these urban areas groundwater is the normal supply, together with the sale of rainwater, which is rarely inspected or monitored.



Town water supply for the capital Nuku'alofa comes from 31 boreholes in the Mataki'Eua and Tongami well fields to the south-west of the City where it is pumped from the bores and collected in large concrete tanks from where it is gravity fed into in house connections throughout the city. The only treatment that it receives is chlorination, however the automatic dosing system using calcium hypochlorite, is often broken down and chlorination is applied manually, often resulting in complaints from overdosing. The treatment plant is often unmanned. Consumption of water is high and a program of installing water meters in urban areas is underway to help reduce usage.

In rural areas, groundwater from dug wells and collected rainwater provide the normal water supply with some areas also utilising river water. Most households have their own rainwater collection system, although in some villages, common collectors, water storage tanks, and piping systems are used. The construction, operation, maintenance, and collection of fees are the responsibility of the village water committee with the Ministry of Health providing technical assistance in design and construction, and some additional funding.

### **Water quality surveillance and monitoring**

There is no national drinking water quality standard in Tonga and regulations are governed by The Law of Tonga - Water Supply Regulations of 1963 which lays down the general rules and regulations for the utilisation of water sources and formation of village committees, and the Act to Deal With Public Health Services in Tonga - Water Supply Control, 1992. This second act provides general rules for the examination of water sources by authorised officers of the Ministry of Health to carry out routine water quality sampling, issue potable water certificates, advise on the prevention of contamination and operational aspects to the village water committees. A third Act To Reconstitute and Empower The Tonga Water Board and For Related Purposes — Water Supply, 2001 states the formation, functions and powers of the Tonga Water Board but defines no responsibilities for the Board to maintain or monitor the quality of the water supply.

In urban Nuku'alofa, the Tonga Water Board conducts monthly water quality analysis from fixed sampling points at wells, water tanks, and fixed points in the distribution system, and analyses samples from other urban areas. All samples in the capital and these other urban centres are tested for salinity, total and faecal coliform, and residual chlorine in the distribution system. Reports indicate that residual chlorine levels are nearly always below the value recommended in the WHO guidelines to maintain the safety of water.

Bacteriological analysis is normally satisfactory in urban areas except for Eua where the total coliform, and at times faecal coliform, markedly exceed the WHO standards, attributed to a poorly developed water supply system. However, no remedial action is taken and it appears that problems with sampling and analysis require addressing to maintain adequate water quality. Results are reported to the Manager of the Board, the Board of Directors, and annually to the Prime Minister.

The Environmental Health Unit (EHU) of the Ministry of Health (MoH) is responsible for water quality surveillance in urban areas, and for monitoring in rural areas, and the unit performs sanitary inspections weekly at a single point. Sanitary inspection is purely observational and includes monitoring potential saline intrusion, engine leakage into boreholes and drop off in flow rates due to leakage. Twelve health inspectors are responsible for the inspections of which only one is responsible for water supply. The process of "sanitary inspection" involves the Health Inspectors visiting individual households, inspecting their water supply, sanitation, and cooking facilities. If these do not meet the Health Inspectors standards, Section 14 of the 1992 public health act is invoked. Under this section, households are given a defined time to improve their facilities or face legal proceedings.



Although ten sampling points have been defined, only half are analysed because of limited laboratory capacity. Often only one bacteriological analysis for total and faecal coliform is performed, and in the case of a positive result, the Tonga Water Board is alerted for remedial action. Residual chlorine is not measured, and as the sampling points used by the agencies differ there is no opportunity for crosschecking or comparison of results.

Despite the Director of Health of MoH being a member of the Board of Directors at the Tonga Water Board, there is a lack of information exchange, reporting, or collaboration between the agencies, and there is no overall evaluation and supervision of water quality and monitoring.

In rural areas, the Environmental Health Unit of the Ministry of Health is responsible for water quality monitoring, advising on remedial actions, and for disinfection where necessary. Monitoring is performed on a quarterly basis, with samples collected from villages once every three months and transferred to the Ministry laboratory for bacteriological analysis. However, the MoH laboratory currently, only has the capacity to test up to six samples per week. This is very low and is not sufficient samples to have a representative view of water quality in a given area. Rural water samples from Tongatapu Island are sent annually to Australia for chemical analysis to determine possible contamination from agricultural activities. Analysis is normally for nitrogen compounds, ammonia, phosphate, organo-chlorine and organo-phosphorus pesticides. To date there appears to be no significant contamination by these chemicals.

The Tonga Water Board has a single laboratory in Nuku'alofa for the analysis of all water samples, operated by two technicians. The laboratory is poorly equipped and maintained. Total and faecal coliform, residual chlorine, and salinity are measured, but the bacteriological analyses are performed by a non-standard method according to WHO guidelines. Residual chlorine is measured on-site and there is currently no capacity for the measurement of pH, turbidity, and other physical-chemical parameters.

The Ministry of Health laboratory is located at Vaiola Hospital on Tongatapu and is responsible for all hospital, food, and water analysis, resulting in an excessive workload on the limited number of staff. Water quality analysis has a lower priority, which restricts the number of samples analysed. Another limitation is a lack of testing equipment for bacteriological analysis, and like the Tonga Water Board laboratory, there is no capacity for measuring pH, turbidity and physical-chemical parameters. The portable kits provided by WHO for on-site testing by health inspectors are no longer functioning.

### **Needs analysis**

As there is no defined water quality monitoring and surveillance scheme in Tonga, this has resulted in an unsupervised system characterised by limited water analysis, intermittent sanitary inspections, and a lack of review and evaluation. Information exchange is limited, as is co-operation and collaboration between the main agencies. There are no national standards for drinking water quality, and therefore no identification of the parameters to be monitored, or acceptable levels for them.

To improve the situation a closer collaboration between the Ministry of Health and the Tonga Water Board should be established which could review the results of water analyses, and complaints about water quality. This would assist in identifying sources of contamination, remedial actions that can be taken, and the establishment of an effective quality assured monitoring scheme. The Tonga Water Board has the technical capacity to take the responsibility as the service provider, and quality control the responsibility of the Ministry of Health.

This might take the form of an independent legislative body created to monitor quality of service provision from Tonga Water Board and Ministry of Health. This could monitor the quality of the water provided by the Water Board in the urban areas, and assist in capacity building of water committees to monitor water in rural areas.



The minimum number of parameters to be monitored should be defined based on an evaluation of potential contaminants of the water supply system. These parameters can form the basis of national drinking water standards that are capable of being enforced. The results of the chemical analyses undertaken overseas should be reviewed to help evaluate the parameters that need to be measured. The location and number of sampling points and sampling frequencies should be reviewed, and a monitoring scheme established which includes the duties of both major agencies, exchange of information, and common reporting methods.

Where chlorination is used for disinfection, equipment should be maintained, with adequate dosing to ensure efficient disinfection with sufficient residual chlorine content. To estimate the appropriate dosages of chlorine, pH and turbidity are the essential parameters to test.

Currently, water quality sampling is focussing on groundwater supplies even though a large percentage of the population use rainwater as their principal drinking water source. The inclusion of rainwater in a Water Quality Surveillance programme (as the primary source) is essential. Additionally, random sampling should be incorporated into water quality programmes. Sampling should not only be done at fixed points (i.e. water source/outlet) but also at the household level.

The sampling collection system should also be reviewed to ensure that the points used are indicative of the most vulnerable points of the system, and are analysed regularly. There should be a sampling point immediately after the chlorination unit. Analysis of duplicate samples by both agencies should be conducted ensure measurements are comparable.

Laboratories that are currently poorly equipped and maintained should be improved to enable standard methods of bacteriological analysis and simple physical-chemical methods such as pH, turbidity, and those parameters that have been identified by a risk management evaluation. There should be a sufficient number of suitably trained personnel available to analyse for these critical parameters, and enough equipment and reagents for bacteriological analysis.

Field test kits should be maintained to enable simple on-site analyses to be made. This would minimise transportation costs, and reduce the workloads of the two testing laboratories in Nuku'alofa. It will also encourage greater community participation in sampling and testing their water supplies on-site particularly if supported by technical assistance from the surveillance agency. It will build capacity in the village water committees and allow them to measure the deterioration or improvement of their water supply and participate in hygiene promotion programs, particularly in schools.

Computer and data analysis facilities should be available for the storage and evaluation of monitoring results and analysis.

In order to understand rainwater and groundwater usage in Tonga, it is important to undertake an inventory of groundwater and rainwater sources for drinking water. This information will provide direction in planning the location and frequency of sampling of future water quality surveillance.

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## **Tuvalu**

### **Background**

Tuvalu with 10,000 people is one of the smallest Pacific Island states comprising nine low lying atolls with a total land area of only 25.3 km<sup>2</sup>. It lies to the west of the international dateline and 1,000 km north of Fiji in the Central Pacific. Tuvalu is scattered over an ocean area of 754 987 km<sup>2</sup>. With an estimated population of about 10 000 people, Tuvalu has a very high population density (398 persons per km<sup>2</sup>).

Tuvalu has a tropical climate with an average temperature of 30° C, and a rainfall of 3000 mm annually.

Tuvalu's main resource is considered to be its ocean. With an Exclusive Economic Zone of approximately 754 987 km<sup>2</sup>, Tuvalu will need vast financial resources, technology and manpower to tap this resource. The extremely poor, arid and sandy non-agricultural soil does not allow growing of any vegetable or fruit, and there is no industry, including tourism, thus Tuvalu has been labelled as one of the "least developed countries".

The dispersed population, isolation and limited natural resources severely limit prospects for economic growth and development. Nonetheless, Tuvalu has an excellent record of meeting its people's basic needs since Independence in 1978, with nearly universal access to basic health services and formal education. Life expectancies are on a par with some middle income countries. Despite a high dependence on one sector (government), the economy has performed satisfactorily.

Slow population growth and declining dependency ratios provide opportunities for improvements in quality of services rather than just quantitative expansion. However, the creation of cash income opportunities has been low, the capacity of the public service is extremely limited; health services struggle to meet demands of changing lifestyles, educational services are focused more on knowledge and skills needed for overseas employment than on sustainable livelihoods within Tuvalu, and rapid urbanisation is beginning to stress the physical and social fabric of Funafuti.

There is a high degree of vulnerability to external economic and environmental events and Tuvalu is among those countries expected to suffer the greatest impact of climate change, including disappearance in the worst-case scenario. To some extent offsetting these problems, Tuvalu has the advantages of a strong and resilient culture, a reasonably egalitarian society, strong democratic principles, and a record of prudent fiscal management.

Tuvalu's atolls are among the planet's harshest environments: flat ribbons of sand, with limited fresh water; supporting a very narrow range of vegetation; with geographic fragmentation making transport and communications, both internal and international, costly and difficult.

### **Water resources and supply**

Rainwater is the main source of fresh water in Tuvalu, and any period of drought poses very serious consequences to the health and well being of the people of Tuvalu.

Generally, all Tuvaluans have access to potable water although it often requires boiling. Ground water from wells is very limited and is brackish and there are no rivers or lakes. Water is usually obtained from roofs by catching rainwater (85% of households have private water tanks). Although rainfall is heavy, averaging 3m annually overall and 3.8m in Funafuti, households often run out of water even during normal weather because of poorly maintained systems and



tanks. According to the Tuvalu Trust Fund Advisory Committee (April 2002), “rain is not collected, stored and distributed in accordance with any coherent strategy”

The issue of water supply on Funafuti needs to be given a high profile and dealt with comprehensively if real improvements are to be made. The position appears to be somewhat better on other islands, but there too the situation needs assessment and planning for improvement. A single planning and management structure, accountable to the Government and Parliament, is needed.

The main source of drinking water is rainwater, on the grounds of quality and safety. Ground water from wells is used only in times of drought for washing, bathing and domestic needs. Also used in times of drought is a desalinator, which is also only used during droughts, but is currently out of commission.

Rainwater catchments to harvest rainwater, are common on government buildings and households, and consist of water tank, water cistern, or green plastic tank catchments.

The Public Works Department (PWD) responsible for the distribution of drinking water to households at a cost of \$15.00 per 500 gallons.

The Waste Management Unit deals with pollution and contamination of water sources and their inspectors are responsible for monitoring and advice for problems raised by the public.

In 1998, the South Pacific Regional Environment Programme (SPREP) surveyed Tuvalu for sites containing unwanted Persistent Organic Pollutants (POPs), hazardous organic chemicals which remain in the environment for a long time, accumulate in living tissue, and can cause serious health problems. Polychlorinated biphenyls (PCBs) from old power transformers, for example, can cause cancers. Four POP-contaminated sites were found on Funafuti; the Power Station, PWD depot, Agriculture Department and the Hospital. It is not known how much of this has been removed or treated, or whether additional POPs resulted from recent road upgrading. There is no legislation to ban imports of hazardous wastes or control their disposal. Medical and other hazardous wastes are burned in the open. Household and small business waste production has become a significant problem in Funafuti, with solid waste collected from about half of Funafuti households and much waste simply dumped at various sites with no controlled land filling.

An innovative and comprehensive three-year waste management project at the Government of Tuvalu Environment Unit has educated the public on waste issues, established a dedicated landfill, has begun composting vegetable waste, and plans to control piggery and medical wastes. However, it is approaching completion with no firm agreement on future institutional responsibility for waste management.

Most households in Funafuti, and increasing numbers of households in outer islands employ improved privies rather than the beach as in the past. The impact of these on the water quality of lagoons is unknown, although anecdotal reports describe the waters near the hospital as being unsafe. Many of the improved privies are water-sealed, limiting their effectiveness in times of drought. It is not known what other designs might be appropriate in Tuvalu, such as the dry ventilated improved privy.

Diseases identified as resulting from contaminated drinking water include, typhoid fever, ringworm, scabies, worms, diarrhoea, vomiting, tinea, and cholera.



## **Water quality surveillance and monitoring**

The Public Health Act in Tuvalu is very old and needs to be revised in order to safeguard the work of the Inspector. The Health Inspectors are responsible for vector control, food safety and control, drinking water quality and safety, and quarantine of incoming vessels.

Monitoring of drinking water quality and safety is carried out by the Senior Health Inspector and his assistant, however a lack of water testing equipment has been partially offset by public awareness programs. These programs instruct the public on the prevention of contamination of water supplies by means of community level workshops, and a radio program that explains the importance of keeping water catchments clean, to boil drinking water, and to cook food well. Water used for making ice must also be boiled.

## **Needs analysis**

There is only one laboratory, but it is not involved in drinking water monitoring, except in the case of disease outbreaks.

There is no water-sampling program, and no test kits.

The Public Health Act needs to be reviewed.

## **Reference**

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2. WPRO web site
3. United Nations Common Country Assessment Tuvalu Final Draft: 30 April 2002 Office of the United Nations Resident Coordinator Suva, Fiji April 2002



## **Vanuatu**

### **Background**

The Republic of Vanuatu is located in the western Pacific. Vanuatu is one of the groups of countries known as Melanesia, and is surrounded by Melanesian neighbours: the Solomon Islands to the northwest, Fiji to the east and New Caledonia to the southwest. The archipelago that constitutes the republic contains over 80 islands and runs roughly north-south in a Y-shaped chain, spanning nearly 1100 km. from the Banks and Torres group to the barren Matthew and Hunter islands. The total land area is just 12,189 km<sup>2</sup>, less than the other nations in Melanesia but large compared to countries in Polynesia and Micronesia. Although the land area is small, the sea area is extensive, over 680,000 km<sup>2</sup> including Vanuatu's Exclusive Economic Zone.

Sixty-five of the islands are inhabited and the total population of the country was about 187,000 in the 1999 census of which 30,000 are living in the capital Port Vila. Shefa is the most populous province with 29.2% of the total followed by Sanma and Malampa provinces with 19.3% and 17.5% respectively. The population percentages of the other provinces are Tafea with 15.6%, Penama 14.3%, and Torba 4.2%.

The majority of the people (78.5%) live in rural areas, and the only urban centres are the capital Port Vila, on Efate Island and Luganville on Santo Island. 15.7% of the total population reside in Port Vila and 5.8% in Luganville. Although the majority of the population is concentrated on the coastal zones, the interiors of some islands are also quite densely populated.

The economy is based mainly on agricultural products especially fruits, cocoa, coffee and copra with fishing and forestry as the other basic economic activities, with tourism following agricultural products as the major sources of revenue for the country.

### **Water resources and supply**

In Vanuatu, both ground and surface water resources are utilised for domestic purposes. In urban areas the main water resource is groundwater whereas in rural areas, various sources such as wells, springs, rivers and rainwater are used. However, at most places other than the main urban settlements, water supply systems are either quite poor, or do not exist. The quantity of water is inadequate in many cases, and water sources are subject to contamination. In the hot and dry seasons in particular it is common to have insufficient amounts of safe drinking water in the rural areas.

Local governments are not responsible for the operation of supply and distribution systems. In Port Vila, the body responsible for water supply is a private company UNELCO. In Luganville, it is Department of Public Works, part of the Ministry of Infrastructure and Public Utilities.

In rural areas, village water committees are responsible for the operation of water supply systems where they occur. Water quality monitoring and surveillance activities are poor even in urban areas. UNELCO conducts the quality control and monitoring activities in Port Vila and there are some water monitoring activities by Department of Public Works in Luganville, and also by the Department of Geology and Mines in rural areas. No surveillance activities are practiced and public awareness on the safety and quality of water is generally at quite low levels.

The major urban centres of Port Vila and Luganville are primarily dependent on surface water collected from nearby catchments. The supply of water in these two cities was privatised in December 1993, but remains expensive for urban dwellers.



In rural areas most water supplies are obtained from surface water, rainwater and groundwater and is of some concern particularly in small islands during period of drought and seasonal rainfall fluctuations.

About 88% of the total population has access to some form of potable water supply. Most of these sources are reliable while others whose source is rainfall are less reliable especially on the small islands during the dry seasons.

The provision of safe water has become a national issue and access to safe water was reported by UNICEF (1998) to be 74%, and the percentage of rural areas with installed water has almost tripled in the last fifteen years to about 53% of the population (ESCAP/POC, 1995). By 1999 the main sources of drinking water in rural areas are from rivers, springs and wells (26.0%), shared piped water (19.3%), community water tanks (18.5%) and household water tanks (15.9%).

Sanitation ranges from pits and septic tank to flush toilets. National levels of adequate sanitation are estimated to be 45% for rural areas. Nevertheless, a survey by the Vanuatu National Council of Women in 1995 shows that sanitation problems in urban areas include water pollution through human waste, and the inadequate disposal of household rubbish. There are poor sanitation facilities in the hastily erected and overcrowded squatter settlements and in some areas up to twenty families share the communal standpipes, making the potential for the transmission of communicable diseases in these communities very high. In the small islands the water table is elevated and the underground water is very susceptible to contamination from latrines.

Animal and human excreta are the main sources of pollution of water supplies in Vanuatu and much of the surface water is exposed to animal and human wastes and other contaminants. This is due to a lack of source protection, and from wastewater runoff during floods or heavy rainfall.

Vanuatu is not an industrialized country and agriculture is currently not at a level that fertilizers and pesticides are used in large amounts and contamination of drinking water is predominantly bacteriological. In urban areas, there is no sanitary sewerage system. Domestic wastewater is collected in septic tanks and there is no control mechanism on the tanks to check whether they are appropriately built and operated. In rural areas, water sources are open to bacteriological contamination originating from human or animal sources. Due to the volcanic nature of the islands, naturally occurring chemical substances may also be a source of chemical contamination.

Town planning in Port Vila has been deficient, and water pollution in Port Vila Harbour and the nearby Erakor/ Ekasuvat/ Emten lagoon system is serious due to the overall lack of a domestic sewerage system, and poor management of many individual septic tank systems, which empty into the lagoon.

This pollution of the Erakor lagoon near Port Vila is now widely considered to be Vanuatu's most serious urban environmental problem, and requires early attention for reasons of health and tourism development. At present, uncontrolled nutrient discharges; nitrates and phosphates from sewage, septic outflows, siltation, industrial waste, etc. combined with poor natural flushing of the lagoon are even more serious than bacterial contamination, which is reaching the limits of world standards (World Bank, 2000).

In Port Vila management of solid waste is undertaken by Port Vila Municipality who ensures that dumping sites do not pose a risk to public health and the environment. The Port Vila Hospital Sewage Treatment Plant is monitored by UNELCO and the effluent is treated before being discharged into the sea (lagoon). Nevertheless, solid waste management is a serious problem in both main urban centres.



The safe disposal of solid waste is a significant problem for many communities. In north-Ambae for example much of the waste is disposed of in a coastal lake where water is drawn for the community, and also damages the environment. Addressing these solid waste disposal issues is becoming a high priority for many islands as ongoing health hazards from wastes is a growing concern, and there already exists the issue of timber wastes (sawing mills and timber factories), the waste oil from power generation plants, and landfills. (SPREP, 2000).

A lack of land use planning is leading to potential future problems such as forest clearing for cattle rather than rejuvenation of old pastures, and soil erosion, which is serious in logged parts of Tanna, Tongoa, Pentecost and Paama.

Another growing issue is the alarming acceleration in the number and the size of squatter settlements in Port Vila that has brought a corresponding decrease in the capacity of health and sanitation facilities to provide even minimal facilities for these families. It is common for up to eight people share one room, and the rents for one room without water and electricity, but with access to a shared pit latrine, are frequently equivalent to 50% of the family income. Income inequalities are therefore, and poverty and vulnerability are evident in an increasing underclass of landless urban poor.

Records of water related diseases show that diarrhoea and gastroenteritis remain important sources of morbidity.

### **Water quality surveillance and monitoring**

Water quality monitoring activities are quite poor in Vanuatu. There is no defined quality monitoring system or corresponding responsibility, and no overall review and evaluation of data quality. Quality standards do not exist leaving no basis for evaluation of the analytical results. No surveillance authority has been appointed and currently the Ministry of Health does not have an involvement in water supply, monitoring or surveillance sectors. However, the Ministry has put forward some rules and legislation with respect to water safety, its quality and towards the development of a surveillance system.

The Vanuatu government is dedicated to the provision and access to a safe water supply for all of its population, with a vision to ensure that all citizens have water that is protected, accessible, adequate and safe. Providing this water supply is one of the priority areas for the government with an allocation of funds from the National Government to the Department of Water Resources to oversee development of the water supply.

The country also receives donor aid (especially from the New Zealand Government) towards the development of water supplies in the country and the Vanuatu government also supports non-government organizations in helping to improve water supply systems.

The Ministry of Health has developed new policies covering the area of Environmental Health which also covers water issues, and the policy was due to go before the council of Ministers in early 2002.

The Public Health Act of 1994 ensures that water intended for human consumption must be protected from contamination; however, enforcement measures for the Act are yet to be put in place. There are currently no drinking water quality guidelines for Vanuatu although the Public Health Act includes provisions for regulations under the Act for standards, quality and adequacy of water for domestic purposes.

The Department of Water Resources also has in draft a Water Resources Management Act but it is not yet clear when this Act will go to parliament. In Port Vila a water protection zone has



been established around the Port Vila Water Supply Catchment Area to ensure the water supply is protected from possible contamination.

In rural areas the water supplies to communities is often poorly monitored due to inadequate human resources.

Agencies involved in water supply in Vanuatu include the Public Health Department who is responsible for water quality monitoring and health and hygiene education for both urban and rural communities. The Department of Geology, Mines and Rural Water Supply is responsible for the construction of new water systems, borehole drilling and monitoring in rural and urban coastal areas. In urban areas the Operational and Maintenance Management are the responsibilities of the Public Works Department in Luganville and of UNELCO Vanuatu Ltd in Port Vila, while non-government organisations are responsible for construction of new water supply systems in rural areas.

UNELCO Vanuatu Limited is a private French company that operates the water supply system in Port Vila, which is considered to be 100% reliable and safe for human consumption. The company undertakes water quality testing weekly and samples are also sent to New Caledonia and New Zealand for crosschecking.

At present there is no clear organizational chart identifying the different roles and responsibilities of the various water agencies in Vanuatu. Each organization has its own way of dealing with water related problems.

The Public Health Department has about seven Environmental Health Officers stationed throughout the country that oversee water safety and one water quality analyst based at the Public Health laboratory at the Port Vila Hospital. UNELCO has two full time Water Quality Officers regularly undertaking monitoring in Port Vila and the Department of Geology and Water Resources also has two staff that oversee water quality.

With respect to analytical facilities, the National Water Quality Laboratory is a newly established laboratory set up with assistance from the New Zealand Government and it is attached to the Department of Geology, Mines and Water Resources. The UNELCO Laboratory is owned by the French company who are responsible for the Port Vila water supply. It is a very advanced laboratory and has two trained technicians who operate the laboratory. The Public Health Laboratory only conducts microbiological tests.

Bacteriological and biological tests are carried out in Port Vila every week and chlorine residual is done daily. This is important as Port Vila water sources are not well protected and if there is a possibility of contamination, many people will be affected. In rural areas bacteriological tests are carried-out only when there is an outbreak of disease or when there are complaints from the public concerning the quality of water.

In Vanuatu some islands are prone to volcanic activity and testing for pH and some physical parameters are always done whenever there is an eruption. The UNELCO laboratory also tests for most of the physical parameters to ensure they comply with WHO standards. Chemical analysis is done only when there is known chemical pollution of the water supply and no radiological parameters are measured.

### **Needs analysis**

There is a lack of legislation, rules and standards in the water sector and the responsibilities and powers of the authorities are not clearly defined.



The Ministry of Health, normally the surveillance agency, has no involvement or powers in the water sector and currently does not conduct any surveillance activity, inspection or sampling activities.

There is little or no co-operation, collaboration or exchange of information between relevant authorities.

It is recommended that the Government should appoint The Ministry of Health as the National Surveillance Agency giving them the necessary administrative power to perform surveillance activities. Once the Public Health Act comes into force, the legislative basis will be provided and meetings of all relevant agencies should establish a monitoring and surveillance scheme to which all of the authorities agree.

The Ministry should perform periodical surveillance activities with sanitary inspections and water sampling-analysis in urban and rural areas through their Provincial Health Offices with the initial priority for urban systems.

The Environmental Health Unit (EHU) should be the responsible unit for surveillance activities and the overall supervision of water quality aspects, and should develop a monitoring scheme for the short term including the critical parameters to be monitored, sampling frequencies and inspection regimes.

National Drinking Water Quality Standards are required; this will include bacteriological, physical, and chemical quality parameters and their acceptable levels in drinking water. Standardised sampling methods, sampling frequencies and analysis methods, should be derived through inter-agency studies.

## **Reference**

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2. Country Report, Vanuatu, By, Mr Viran Tovu, Senior Environmental Health Officer, Public Health Department, Ministry Of Health, Port Vila, And, Ms Rosette Kalmet, Hydro-Geologist, Department Of Geology, Mines And Water Resources, Port Vila Workshop on Drinking Water Quality Surveillance and Safety 29 October - 1 November 2001, Nadi, Fiji
3. Development of Drinking Water Quality Monitoring and Surveillance in the Philippines, Papua New Guinea, Tonga And Vanuatu - Report 2- Vanuatu May-October 2002 by Hulya Aras Environmental Engineer



## **Appendix B – Non-reporting countries**

### **Northern Mariana Islands**

The Commonwealth of the Northern Mariana Islands (CNMI) are located in the North Pacific Ocean, and is situated about 5300 km west of Hawaii and 2300 km due south of Japan at 15° 12' North and 145° 45 East, consist of 16 islands (all the Mariana group except the United States Territory of Guam) including Saipan, Rota, and Tinian and are a dependency of the United States.

The land area totals 477 km<sup>2</sup> and the islands are of two distinct types, the northern volcanic islands (with active volcanos on Pagan and Agrihan, and the southern islands of limestone with level terraces and fringing coral reefs. The climate is tropical marine with little seasonal temperature variation and which is moderated by the northeast trade winds. The two main seasons are the dry season from December to June and the rainy season from July to October.

The population of 78,000 is primarily employed by the tourist industry, which accounts for over half of employment and a quarter of the GDP. Agriculture and garment manufacture account for the rest of the labour market. The economy as a whole benefits substantially from financial assistance from the United States.

Environmentally, contamination of groundwater on Saipan has been identified as contribute to disease, and waste disposal in landfills is a problem.

### **Pitcairn Island**

Pitcairn is an isolated dependency of Great Britain, located in the South Pacific Ocean, about midway between Peru and New Zealand at 25° 04' South, 130° 06' West.

Only the largest of the four islands of Pitcairn is inhabited and the population has progressively diminished over the last 70 years from over 200 to less than 50 today. The inhabited island has a land area of just 47 km<sup>2</sup>, is volcanic in origin, with a rugged rocky coastline with cliffs that make landing difficult. The climate is tropical, hot and humid although modified by southeast trade winds with a rainy season between November and March

The inhabitants live by subsistence farming of fruits and vegetables with all other essentials having to be imported from overseas and delivered by passing ships. The only natural resource are Miro trees used to make handicrafts, which together with sale of postage stamps are the only cash earning component of the economy.

Drinking water is harvested from the collection of rainwater

### **Tokelau**

Tokelau is located in the central Pacific Ocean at 9° 00' South, 172° 00' West, about 480 km north of Samoa its nearest neighbour. The territory consists of three low-lying coral atolls enclosing large lagoons with a total area of 12 km<sup>2</sup>, while the sea area covers 300,000 km<sup>2</sup>. The climate is tropical and moderated by the trade winds from April to November.

The islands have very limited natural resources, and are overcrowded, resulting in many inhabitants emigrating, mainly to New Zealand. The current population is about 1400

Because of its small size (three villages), isolation, and lack of resources economic development is constrained and agriculture is confined to the subsistence level. The country relies on aid from New Zealand to maintain public services, with annual aid being substantially greater than



GDP. The principal sources of revenue come from sales of copra, postage stamps, souvenir coins, and handicrafts and from money remitted from overseas.

## **Wallis and Futuna Islands**

The Wallis and Futuna Islands are a French overseas territory isolated in the South Pacific Ocean at 13° 18' South and 176° 12' West. The islands are small, of volcanic origin with low hills and fringing reefs, and a land area in Wallis of 95 km<sup>2</sup> and in Futuna of 50 km<sup>2</sup>. The population is estimated at around 15,000 inhabitants.

The climate is tropical with a hot rainy season from November to April and a cool, dry season from May to October. The mean temperature is 26.6°C with 80% humidity and rainfall averages 2,500-3,000 mm per year.

The economy is limited to traditional subsistence agriculture and fishing with about 4% of the population employed in government. The cost of living is high and the country depends totally on assistance from France, from the licensing of fishing rights to Japan and South Korea, import taxes, and remittances from expatriates.

Heavy deforestation has resulted from the continued use of wood as the main fuel source with the mountainous terrain of Futuna being particularly prone to erosion. There are no permanent settlements on Alofi because of the lack of natural fresh water resources, and the pollution of ground water in Wallis and the absence of generalized purification of water particularly in Wallis are possible sources of ill health.

