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Summary and Country Reports of French-speaking Territories also included in French

TOPIC REVIEW No. 16

COASTAL AND INLAND WATER QUALITY IN THE SOUTH PACIFIC

A review of existing information, monitoring programmes, monitoring facilities and legislation

South Pacific Commission
Noumea, New Caledonia
December 1984

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SOUTH PACIFIC REGIONAL ENVIRONMENT PROGRAMME

Noumea, New Caledonia

TOPIC REVIEW

COASTAL AND INLAND WATER QUALITY IN THE SOUTH PACIFIC

A REVIEW OF EXISTING INFORMATION, MONITORING PROGRAMMES, MONITORING FACILITIES AND LEGISLATION

J. E. Brodie
R. J. Morrison

South Pacific Commission
Noumea, New Caledonia
December 1984

PREFACE

Twelve years ago, the United Nations Conference on the Human Environment (Stockholm, 5-16 June 1972) adopted the Action Plan for the Human Environment, including the General Principles for Assessment and Control of Marine Pollution. In the light of the results of the Stockholm Conference, the United Nations General Assembly decided to establish the United Nations Environment Programme (UNEP) to "serve as a focal point for environmental action and co-ordination within the United Nations system" (General Assembly resolution XXVII of 15 December 1972). The organizations of the United Nations system were invited "to adopt the measures that may be required to undertake concerted and co-ordinated programmes with regard to international environmental problems", and the "intergovernmental and non-governmental organizations that have an interest in the field of the environment" were also invited "to lend their full support and collaboration to the United Nations with a view to achieving the largest possible degree of co-operation and co-ordination". Subsequently, the Governing Council of UNEP chose "Oceans" as one of the priority areas in which it would focus efforts to fulfil its catalytic and co-ordinating role.

The Regional Seas Programme was initiated by UNEP in 1974. Since then the Governing Council of UNEP has repeatedly endorsed a regional approach to the control of marine pollution and the management of marine and coastal resources and has requested the development of regional action plans.

The Regional Seas Programme at present includes eleven regions (1) and has over 120 coastal States participating in it. It is conceived as an action-oriented programme having concern not only for the consequences but also for the causes of environmental degradation and encompassing a comprehensive approach to combating environmental problems through the management of marine and coastal areas. Each regional action plan is formulated according to the needs of the region as perceived by the Governments concerned. It is designed to link assessment of the quality of the marine environment and the causes of its deterioration with activities for the management and development of the marine and coastal environment. The action plans promote the parallel development of regional legal agreeements and of action-oriented programme activities (2).

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(1) Mediterranean, Kuwait Action Plan Region, West and Central Africa, Wider Caribbean, East Asian Seas, South-East Pacific, South Pacific, Red Sea and Gulf of Aden, East Africa, South-West Atlantic and South Asian Seas.

(2) UNEP: Achievements and planned development of UNEP's Regional Seas Programme and comparable programmes sponsored by other bodies. UNEP Regional Seas Reports and Studies No.1, UNEP, 1982.

The idea for a regional South Pacific environment management programme came from the South Pacific Commission (SPC) in 1974. Consultations between SPC and UNEP led, in 1975, to the suggestion of organizing a South Pacific Conference on the Human Environment. The South Pacific Bureau for Economic Co-operation (SPEC) and the Economic and Social Commission for Asia and the Pacific (ESCAP) soon joined SPC's initiative and UNEP supported the development of what became known as the South Pacific Regional Environment Programme (SPREP) as part of its Regional Seas Programme.

A Co-ordinating Group, consisting of representatives from SPC, SPEC, ESCAP and UNEP was established in 1980 to co-ordinate the preparations for the Conference.

The Conference on the Human Environment in the South Pacific was convened in Rarotonga (8-11 March 1982). It adopted: the South Pacific Declaration on Natural Resources and Environment of the South Pacific Region; and agreed on the administrative and financial arrangements needed to support the implementation of the Action Plan and on the workplan for the next phase of SPREP (3).

To facilitate the Action Plan, close co-operation has been developed between Research and Training Institutions in the South Pacific Region and SPREP. This report was produced by Mr J.E. Brodie and Dr R.J. Morrison, Institute of Natural Resources, University of the South Pacific, Suva, Fiji. The sponsors of the study would like to express their gratitude to both the authors and their institution.

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(3) SPC/SPEC/ESCAP/UNEP: Action Plan for Managing the Natural Resources and Environment of the South Pacific Region. UNEP Regional Seas Reports and Studies No.29, UNEP, 1983.

C O N T E N T S

ACRONYMS USED IN THIS REPORT

SPREP	- South Pacific Regional Environment Programme
SPC	- South Pacific Commission
SPEC	- South Pacific Bureau for Economic Cooperation
USP	- University of the South Pacific
INR	- Institute of Natural Resources, USP
IMR	- Institute of Marine Resources, USP
SNR	- School of Natural Resources, USP
UPNG	- University of Papua New Guinea
UNITECH	- University of Technology, Lae, Papua New Guinea
NAL	- National Analysis Laboratory, UNITECH
UOG	- University of Guam
WERI	- Water and Energy Research Institute of the Western Pacific, UOG - formerly known as the Water Resources Research Center
GEPA	- Guam Environmental Protection Agency
TTPI	- Trust Territories of the Pacific Islands
TTEPB	- Trust Territories Environmental Protection Board
USEPA	- United States Environmental Protection Agency
UNDP	- United Nations Development Programme
ADAB	- Australian Development Assistance Bureau
CNEXO	- Centre National pour L'Exploitation des Oceans
ORSTOM	- Office de la Recherche Scientifique et Technique Outre Mer
LESE	- Laboratoire d'Etude et de Surveillance de l'Environment
NZDSIR	- New Zealand Department of Scientific and Industrial Research
CCOP-SOPAC	- Coordinating Committee for Offshore Prospecting, South Pacific
FAO	- Food and Agriculture Organization of the United Nations
AAS	- Atomic Absorption Spectrophotometer or Spectrophotometry
HGA	- Heated Graphite Atomizer for AAS
GLC	- Gas Liquid Chromatograph or Chromatography
HPLC	- High Performance Liquid Chromatograph or Chromatography
UV-VIS	- Ultraviolet-Visible Spectrophotometer or Spectrophotometry
MF	- Membrane Filtration

SUMMARY

The small size of most Pacific countries and the limited inland and coastal water resources make water a major limitation to development in many countries. Increasing populations and the demand for better living conditions have placed considerable stress on these water resources and it is essential that the quality of the resources be carefully monitored.

This paper reviews information available on coastal and inland water quality in the South Pacific. A number of problems have been encountered in attempting to make such a review. These include, a lack of information in many situations, variability in the quality of the available data and poor reporting of experimental procedures. The information available has been reviewed in terms of the different types of water bodies, the different uses of water and the influence of human activities on water quality. Areas where major information gaps occur have been identified.

This is followed by a review of the legislation, monitoring activity and facilities available for water quality study and control in the region. There is considerable variation with some countries having comprehensive legislation, others have old inadequate legislation while a few countries have effectively no legislation. Some monitoring of water quality takes place in almost every country but while drinking water is usually monitored, the extent of monitoring of other inland and coastal water is poor. As a consequence it is difficult to establish baseline situations for many natural water bodies in the region. Facilities for water quality investigation need to be upgraded in almost every country. This includes the provision of equipment and the training of staff.

The report finishes with a set of recommendations for future activity. These include provision for training and education schemes, increased monitoring, upgraded laboratory facilities, information coordination and dissemination, advisory services and better coordination of laboratory activities.

LA QUALITE DES EAUX COTIERES ET DES EAUX INTERIEURES DANS LE PACIFIQUE SUD

ELEMENTS D'INFORMATION, PROGRAMMES ET MOYENS DE CONTROLE, LEGISLATION

R E S U M E

Un des grands obstacles au développement de bien des pays du Pacifique est l'exiguïté de leur territoire et de leurs ressources en eau. L'expansion démographique et l'amélioration des conditions de vie opèrent de très lourdes fonctions sur ces ressources en eau, dont la qualité doit absolument être contrôlée avec soin.

Le présent document fait le point des renseignements disponibles sur la qualité des eaux côtières et des eaux intérieures dans le Pacifique Sud ; tâche rendue difficile par un certain nombre de problèmes : manque d'information dans bien des cas, qualité variable des renseignements disponibles et insuffisance des rapports sur les opérations expérimentales. On a classé les renseignements disponibles selon les divers types de masses d'eau, les différentes utilisations de l'eau et l'influence des activités humaines sur la qualité des eaux. On a identifié les grands domaines dans lesquels l'information fait particulièrement défaut.

Cette partie de l'ouvrage est suivie d'une étude de la législation, des activités de surveillance et des moyens d'étude et de contrôle de la qualité des eaux dont dispose la région. La situation diffère beaucoup d'un pays à l'autre, certains ayant une législation très complète, d'autres une législation ancienne et insuffisante, et quelques-uns n'ayant aucune réglementation. Le contrôle de la qualité des eaux est pratiqué dans une plus ou moins grande mesure dans presque tous les pays, mais si l'on surveille généralement les eaux de boisson, la surveillance des autres eaux intérieures et côtières laisse beaucoup à désirer. Il est donc difficile de faire un bilan en ce qui concerne de nombreuses masses d'eau naturelles de la région. Dans presque tous les pays, les moyens d'étude de la qualité des eaux demandent à être modernisés au niveau du matériel et de la formation du personnel.

Le rapport se termine par une série de recommandations portant sur la mise en place de programmes de formation et d'instruction, l'intensification de la surveillance des eaux, la modernisation des laboratoires et des moyens dont ils disposent, la coordination et la diffusion de l'information, la mise en place de services de conseils et une meilleure coordination des travaux des différents laboratoires.

BACKGROUND

The SPREP Action Plan which was launched at the Conference on the Human Environment in the South Pacific in March 1982 has the following specific objectives:

> Further assessment of the state of the environment in the region including the impacts of man's activities on land, fresh water, lagoons, reefs and ocean, the effects of these on the quality of man's environment, and the human conditions which have led to these impacts.
>
> The development of management methods suited to the environment of the region which will maintain or enhance environmental quality while utilizing resources on a sustainable basis.
>
> The improvement of national legislation and the development of regional agreements to provide for responsible and effective management of the environment.
>
> The strengthening of national and regional capabilities, institutional arrangements and financial support which will enable the Action Plan to be put into effect efficiently and economically. (SPREP Action Plan, para. 4).

In accordance with the Action Plan and the 1983 SPREP Work Plan which was approved by the South Pacific Forum and the South Pacific Conference, the first Consultative Meeting of Research and Training Institutions in the South Pacific Region was held in Suva in April 1983. At that meeting the SPREP Research and Monitoring Network was established. During 1983 the Network initiated eight projects, one of which was the Coastal and Inland Water Quality Project. The USP Institute of Natural Resources was asked as the nominated lead institution to prepare a report which:

(a) reviewed the existing information, survey and monitoring work on water quality in government and non-governmental organizations of the region;
(b) identified the major water quality problems and their sources;
(c) defined the parameters for suitable programmes of monitoring and identifies the national, sub-regional and regional requirements for implementation of the project; and,
(d) proposed a detailed work programme for implementation of the project in 1984-85.

METHOD OF SURVEY

The information reviewed in this report was obtained in three ways:

1. Bibliographic/Library Searches

   Searches were made of the collection of the USP Library, the SPC Library, and the Pacific Information Centre arranged for a literature search to be carried out using the computer facilities of the National Library of Australia in Canberra.

2. Personal Visits

   Mr Jon Brodie visited the Marshall Islands, Federated States of Micronesia, Guam, Northern Mariannas, Palau, Papua New Guinea, and the Solomon Islands in August-September 1983 using funds provided by SPREP. Dr J. Morrison visited UPNG and UNITECH (in May 1983) and Western Samoa (in January 1984) using funds obtained from other sources. Within the past 2 years one or other of the authors also visited New Caledonia, Kiribati, Nauru and Tuvalu. These visits facilitated a survey of the laboratories working on water quality in the region, the establishment of personal contacts with appropriate staff and a review of the literature and problems encountered by local scientists working in the area.

3. Questionnaires

   Questionnaires (2) were sent to each country not visited by one of the authors in the period July-December 1983. Copies of the questionnaires are given in Appendix I. A list of respondents is given in Appendix II.

When preparing this draft the authors found that it was impossible to avoid duplication of material already prepared under the SPREP umbrella. It was thus felt that, unless necessary for purposes of discussion in this document, material which would be a duplication would be omitted. This report should therefore be read in conjunction with the following SPREP publications.

1. South Pacific Regional Environment Programme. Country Reports 1-19. Noumea, SPC 1980-2

2. South Pacific Regional Environment Programme. Topic Reviews 1-13. Noumea, SPC, 1981

INTRODUCTION

Water is an enigma. This apparently simple and ubiquitous molecule, having unique properties which are not yet fully understood, is the most abundant compound at the Earth's surface, yet human beings and other animals suffer and ultimately die in many places because of either an absolute absence of water or an inadequate supply of water of suitable quality. This paradox is nowhere more apparent than in the South Pacific where the countries consist of relatively small land masses scattered over a substantial portion of the major water body on Earth, yet coastal and inland water resources represent a major constraint to the development of many of these countries. Dahl and Baumgart (1983) in a review of environment problems in the South Pacific state that 60% of the countries report some problem of water shortage.

Water resources have played an important role in the development of the South Pacific and will continue to do so. The quality of coastal and inland water is an important parameter in assessing the progress of development as this will determine to a significant extent the health and well-being of the populations, the improvement of which is the ultimate goal of development.

The "quality" of water bodies is determined by the interaction of atmospheric, biological, chemical, geographic, geologic (hydrologic) and physical factors. It is difficult to objectively evaluate water quality partly because the effect of water composition on various ecological processes is little understood and partly because of the difficulty in defining what is meant by "good quality". Previously used water quality criteria such as the concentration of dissolved oxygen or the behaviour of indicator organisms are no longer sufficient because many "pollutants" have no effect on dissolved oxygen and many of the indicator organisms have only limited applicability.

In the South Pacific, where water plays such a vital part in the lives of the inhabitants - in drinking, cooking and other domestic uses, as a source of food (fish, shellfish, etc.) in industry (both directly and indirectly in power provision) and as a recreational facility, "good quality water" would be defined as that able to sustain the local population and (temporary) visitors without adverse effects on the health and activities of the community.

The islands of the South Pacific vary considerably from the low-lying coral atolls to the rugged mountainous "high" islands. As a consequence of the considerable variation in size, geology, topography and climate there are a number of different types of coastal and inland water resources. These include rainwater, freshwater lakes, rivers and streams, standing groundwater (both on atolls and high islands), lagoons where mixing with the ocean is limited, estuaries, bays almost enclosed by barrier reefs, other shallow-water coastal areas and open ocean waters.

Problems associated with the quality and utilization of such resources therefore vary considerably. Some countries, entirely

dependent on groundwater (and roof catchments), have problems because of unreliable rainfall while others, that have reliable adequate rainfall, face problems because of inadequate or unsuitable storage and reticulation facilities. The demands placed on the often limited water resources are ever increasing and becoming more diverse. In the past water resources were primarily required to meet domestic demands for cooking and waste disposal but increasing development has changed this situation. Greater industrialization, more tourism and the associated problems of population drift and urbanization have created a new dimension in the difficulties of maintaining or improving water quality. The demands for increased supplies (frequently of higher quality) together with the necessity of disposing of the increased wastes (both human and industrial) have placed a great strain on the water resources available. This, together with the lack of willingness* to pay for improvements to water supply systems, has led to a marked deterioration in water quality in many areas.

These problems are by no means limited to the South Pacific+ and there are problems of water quality common to many of the countries of the region. Dunn (1981) has highlighted a number of them.

1. Excessive extraction of groundwater causing saltwater intrusion of the groundwater lens, soil subsidence and salinity.
2. The treatment of water supplies with chemicals that may produce harmful reaction by-products.
3. The removal of vegetation during engineering projects causing erosion, degradation and siltation.
4. Excessive extraction of water from water-courses for irrigation causing harmful ecological downstream effects.
5. The poor construction and design of water supply systems (dams, tanks, etc.) that lead to breeding grounds for disease vectors.
6. The inefficient use of agricultural chemicals causing pollution of potable water sources.
7. The pollution of groundwater through badly sited waste-stabilization ponds.

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*As Pfeiffer (pers. comm.) has observed, many Pacific islanders (particularly rural dwellers) are more inclined to use a polluted water supply which is free, than part with hard-earned cash in water taxes, when they see little of the benefits.

+One problem found elsewhere which is not of major significance because of the small size of many of the countries is that of time 'wasted' in fetching water.

Three other problems observed by the authors of this paper are

1. A lack of appreciation, in some quarters, of the economic significance of good water quality. The loss of revenue and working hours due to illness caused by poor water supplies and the influence of polluted water on industrial processes have not always been recognized. As a consequence insufficient resources are delegated to the provision of adequate water supplies of good quality.

2. Considerable funds have been spent on water supply and waste disposal, but expenditure on water conservation has been considerably less. Good management of the water resources would considerably diminish a number of the problems discussed elsewhere in this paper.

3. As noted by Dale (1981) there appears to be a lack of coordination in the studies of water resources and use in the region. This lack of coordination is found between aid agencies (national and international), between countries of the region and outside having similar problems and even within some of the larger countries of the region. Dale himself is attempting to remedy the situation somewhat by coordinating a series of satellite discussions and publications on the water resources of Pacific island countries (Dale pers. comm.).

Unless adequate resources (both of finance and manpower) are delegated to the management of water resources and a coordinated programme of monitoring these resources adequately is established, coastal and inland water quality may become a significantly greater limitation to development in the South Pacific than it already is.

REVIEW OF THE EXISTING INFORMATION

On first inspection it would appear that there is a reasonable body of data on coastal and inland water quality in the South Pacific. However, a closer examination of the information indicates that a number of problems exist both with the actual information itself and with the interpretation of the data available.

1. The major problem is related to the most common monitoring activity in the region - the assessment of drinking water quality. Most countries in the region have an active programme of monitoring drinking water quality (at least for simple bacteriological and chemical parameters) but it is difficult to obtain published data on the actual results. Much of the data is summarised in the annual reports of the health or water supply departments in the form of summary statements indicating the number of samples analysed. Often the origin of samples, the number outside the required limits and the extent to which they exceed those limits are not detailed. This makes an assessment of the quality of the data difficult.

2. There have been few long-term monitoring programmes in the region. Frequently a batch of samples is tested as a one-off exercise. While this may be useful in the short term, it does not allow an assessment of the variability of the quality of the water e.g. effects of climate variation, tidal effects or the effects of environmental change.

3. A number of publications providing data do not give details of sampling time, sampling procedures or methods of analysis. Assessment of data in these publications is therefore difficult.

4. In a number of publications it is clearly stated that the samples (particularly those from more isolated areas) have been stored for some time before analysis (e.g. the time required for the samples to be sent from the sampling point to a metropolitan laboratory for analysis). As many of the authors of such papers have noted this storage will have a profound effect on the values obtained for some of the parameters determined. This presents a problem of interpretation, which is further exacerbated in a few papers where details of storage/transit time are not supplied.

5. In many situations, new water sources (e.g. boreholes) are added to the supply system without any comprehensive chemical analyses. No baseline data therefore exist against which to measure changes.

6. For one or two countries the information is voluminous and it is difficult for one who has not worked closely with the projects to make an adequate review of all the existing information. This would apply to the data available for

Guam, Papua New Guinea (particularly the Ok Tedi and Bouganville mining impacts) and for the impact of mining in New Caledonia.

For these reasons the authors have decided to concentrate on a number of situations where the water quality of the various categories of coastal and inland situations has been studied to give an indication of the sorts of problems that may occur elsewhere in the region.

Water can be categorised in a number of useful ways for environmental assessment. Three useful systems are based on:

1. Geography - thus one has rainwater, groundwater, surface water (lakes, rivers and streams), lagoon water, bay water, estuarine water, other coastal water and open ocean water. Some of these categories of course overlap.
2. Usage - including drinking water, recreational water, industrial process water, mariculture water, irrigation water and natural marine nursery water.
3. Quality - including water bodies close to urban areas, industrial estates, harbours, mining activities, lightly inhabited areas and uninhabited areas. The keynote here is divergence from an original 'unpolluted' state free from human impact.

Examples of information on a number of these categories will be reviewed from a selection of the countries involved in SPREP.

1. RAINWATER

Rainwater usually has a pH of less than 7 (due to dissolved carbon dioxide) and a total dissolved material of 5-10 mg dm^{-3}. Very little work on rainwater analysis has been published from the Pacific Island states. The data from the analyses show that rainwaters are relatively pollution free; the data are similar to predictions assuming the influence of ocean spray with the occasional presence of relatively high Ca^{2+} and SO_4^{2-} levels probably from cement collecting tanks. Downes[4] (1981) discusses rainwater collected from roof catchments from Tokelau, Tonga and Niue but the water quality has obviously been affected by the roofing material (as discussed in the paper) as shown by the high absorbances at 270 nm (>0.1, due to organic matter) and the high total organic nitrogen. The source of the organic matter was the wooden materials used for roofing.

It is unlikely that industrial air pollution has significant effects on rainwater composition in the South Pacific. The only large scale producers of such emissions are the nickel smelter in New Caledonia and the Bouganivlle copper operation in Papua New Guinea. Due to the prevailing south-

easterly and easterly winds the stack gases are quickly carried over the sea. Emissions from power stations, cement works and smaller metallurgical operations such as the Vatukoula gold mine in Fiji are of such small scale as to have insignificant effects except in areas very close to the point of emission.

This is confirmed by data recently obtained in a study of South Pacific aerosol components being coordinated by Prof. J.M. Prospero of the University of Miami. The data (see Table 1 below) show that there is a uniformly low concentration of nitrate in the aerosol (half to one third the values measured in the North Pacific) and non sea-salt (NSS) sulphate values are low compared to those for the North Pacific (J.M. Prospero, pers. comm.).

TABLE I

Mean (Standard Deviation) of Constituent Concentration ($\mu g\ m^{-3}$) of Aerosols at SEASPAN Stations

Station	Period (1983)	n	NO_3^-	NSS $SO_4^=$
Amer. Samoa	Mar-Aug	20	0.088(0.036)	0.318(0.112)
Funafuti (Tuvalu)	Apr-Aug	17	0.101(0.053)	-
Nauru	Apr-July	8	0.087(0.032)	-
Norfolk Is.	May-July	8	0.090(0.035)	0.215(0.114)
Rarotonga (Cook Is.)	Mar-July	11	0.101(0.033)	-

2. GROUNDWATER

If sufficient rainfall occurs water will infiltrate the ground surface and move to groundwater or run off as streams or small rivers. As the water moves through the soil the carbon dioxide content usually increases as the soil atmosphere commonly contains much more of this gas than the atmosphere due to the processes of respiration and decay of organic matter. Water then percolates the substratum and various reactions may occur depending on the nature of the substratum. In the Pacific Islands the substratum is usually composed of reef derived carbonate material, basalts or andesites and the weathered derivatives, or sediments derived from these components.

Groundwater tends to contain more dissolved material than surface waters because of the more intimate and longer contact with the host materials (dissolved material may be

Guam, Papua New Guinea (particularly the Ok Tedi and Bouganville mining impacts) and for the impact of mining in New Caledonia.

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Groundwater tends to contain more dissolved material than surface waters because of the more intimate and longer contact with the host materials (dissolved material may be

up to 1000 mg dm^{-3}). Groundwaters are generally less well mixed than surface waters. Often there is a fairly direct relationship between the composition of a given groundwater and the host rock but this does not always hold true. Other important factors include the porosity and permeability of the host rock, the amount of organic matter in the host rock and the redox conditions prevailing.

A significant body of data is available from many countries but in only a limited number of cases has a continuous monitoring programme been implemented and the results published. In many instances only partial analysis of the samples has been completed; thus interpretation of the results is extremely difficult. Groundwater is of prime importance for those island states with no mountains or with highly permeable soils and substrata and hence no surface runoff e.g. the atolls and raised coral islands, parts of Western Samoa. Such water is often hard (through contact with limestone), very susceptible to salt water intrusion from over-pumping and easily contaminated from the surface since the aquifers are unconfined.

One of the most detailed groundwater studies was initiated in Guam in 1979 as part of a complete evaluation of limestone aquifers in the northern part of the island (GEPA, 1982b). This northern lens represents a major natural resource with the total recharge being estimated at about 112 million gallons per day. The sustainable yield is estimated at 59 million gallons per day. During the evaluation programme water samples from 10 wells were sampled and analysed for 114 organic compounds, 17 metals and asbestos fibres. Groundwater in northern Guam was shown to be essentially free of measurable contamination. All contaminant concentrations, except for selenium in one well are below formally designated or presumed harmful levels. No explanation was found for the high selenium level (13 µg dm^{-3}) in the A-17 well.

Natural chemical characteristics of the groundwater depend on whether it is basal (freshwater floating on seawater) or para-basal (lying directly on the impermeable basement). Para-basal groundwater always has a salinity of less than 30 mg dm^{-3} while basal groundwater normally has a salinity in excess of 70 mg dm^{-3} although in the complete absence of seawater intrusion it may resemble parabasal water. A chloride content exceeding about 150 mg dm^{-3} implies upconing due to over-pumping. The limestone groundwater has hardness of 170-320 mg dm^{-3} and conductivity of 365-625 micromhos per cm.

The groundwater in the northern lens is of excellent quality and generally free of pollution as indicated by an investigation of primary pollutants. Although the groundwater is of high quality, there are certain land use practices which have the potential for contributing to future degradation of the

aquifers. These include on-site wastewater disposal systems, livestock waste disposal, industrial waste disposal, and the application of pesticides and herbicides. A programme of sampling and analysis at 10 sites has been instituted to monitor the priority pollutants.

Another situation where a considerable amount of work has been done is in Tarawa in Kiribati (see e.g. Mather, 1973; Department of Housing and Construction, 1981). Tarawa is a low atoll with the southern portion having a high population density (in 1980 it was estimated that about 20,000 people occupied a land area of less than 20 km^2). The main sources of water for this high population are rainwater (roof catchments) and groundwater. As droughts are common the groundwater represents a major resource.

As expected for groundwaters in contact with a carbonate substratum all the samples tested had a high total hardness with the content of sodium and chloride increasing with depth as salt water intrusion into the freshwater lens becomes important. Levels of magnesium are quite high which may reflect a relatively high level of this element in the host rock. There has been relatively high water extraction from some parts of the freshwater lens with the consequence that brackish water only is now supplied from some wells. Bacteriological contamination is relatively high particularly in the areas of high population density (values in excess of 500 coliforms/100 cm^3 are common) and the use of contaminated waters is considered to represent a comparative health risk. The restriction of use of groundwater in the contaminated areas has been recommended with water being taken from relatively clean parts of the lens and pumped to storage tanks in the highly populated areas to fill the gap.

There is a dearth of data on groundwaters in basalt host rocks in the South Pacific. Limited information is available from Fiji (Taveuni), Western Samoa and New Caledonia but in almost all cases the range of analyses carried out was not sufficient to determine whether or not the groundwaters were in equilibrium with the host rocks. Data on the detailed chemistry of the host rocks is frequently unavailable and the samples have been "one-off" collections. Little regular sampling and detailed analysis work seems to have been attempted.

3. LAKES

Lakes are not common on Pacific islands and those that occur tend to be relatively small and shallow e.g. Lake Tagimucia in Fiji and the marine lakes of Palau. A number of artificial lakes have been constructed in recent years for water supply or hydropower generation in Fiji, New Caledonia, PNG and Western Samoa while others are planned for Fiji, PNG and the Solomon Islands. A feature of the construction of many of

these dams has been the lack of adequate environmental assessment (Raj, U. et al., 1977).

The only state in the SPREP region with large significant natural lakes is PNG. A considerable amount of research data is available on some of these lakes especially from work done by personnel of UPNG. A particularly interesting study is that of Kyle and others into the high mercury levels in the fish of Lake Murray (Kyle and Ghani, 1982; Reynolds and Price, 1974; Sorentino, 1979; Lamb, 1977 and Petr, 1979).

Fish from Lake Murray - most importantly the giant perch (Lates calcarifer) and catfish (Hexanematichthys latirostris) were found to have levels of mercury close to or above the World Health Organisation recommended limit of 0.5 µg/g wet weight for total mercury. No source for this elevated mercury level has been located although it is assumed to be a natural geochemical phenomenon as this area of PNG lacks any industrial or agricultural development which could account for the presence of mercury. Methylmercury levels in the hair of the Lake Murray population are also elevated compared to neighbouring populations (Kyle, 1981; Kyle and Ghani, 1982) and a high incidence of albuminuria has also been found (Kyle and Mackenzie, 1982) although this has not been definitely correlated to the elevated environmental mercury levels.

These studies have used a large number of samples and, most importantly in this type of trace element work, inter-calibration exercises with the Bouganville Copper Mine Laboratory. The intercalibration exercise was carried out using samples of shark tissue. Intercalibration checks should be built into all SPREP trace analysis projects from an early stage.

There exists a number of small lakes on some of the smaller Pacific Islands. These small lakes vary considerably in quality but virtually all are brackish to some extent. The salt content varies with rainfall and extent of evaporation and some (e.g. Christmas Island in Kiribati) have recorded salinities above that of seawater. These lakes have limited potential use for non-consumption purposes e.g. washing, cleaning. Examples of this type of lake can be found in Kiribati, Cook Islands, Niue, Nauru and Fiji.

Results of a study on one of the man-made freshwater lakes in Fiji (Monasavu) are now being compiled by INR. Preliminary environmental investigations of the reservoir area by INR teams took place in 1977 (U. Raj et al.) and 1979/1980 (P. Ryan et al.) and since 1982 limited scale monitoring of the limnology of the reservoir, the effects of the dam outflow on the Wailoa River downstream from the power station and the fisheries potential of the reservoir have continued.

The reservoir is normally anoxic at depths greater than 5 metres and appears to be polymictic, turning over occasionally in limited areas especially after heavy rains and sharp temperature drops. The normal temperature variation from the surface to 40 metre depths and deeper is less than 5°C and often in winter only 2°C. Some effects of the discharge of bottom water through the Wailoa power station into the Wailoa River are now evident. Reservoir bottom water (the outflow is from a depth of about 45 m) is anoxic and high in dissolved iron, manganese and sulphides. On discharge through the jets onto the turbine blades the water is quickly aerated and on discharge into the river hydrogen sulphide is released and can be smelt. Iron and manganese are oxidized and the oxide/hydroxide products coat the rocks for up to 1 km downstream. However, normal river conditions seem to be re-established by a point 8 km downstream from the discharge point where the first downstream village is situated. Effects on fishing in the river further downstream have not been investigated. A large population of Tilapia (Tilapia mossambica) has been established in the reservoir and considerable fishing activity is taking place providing a valuable protein supplement to the remote inland villages (INR unpublished data, 1984).

4. RIVERS

Only the larger high islands have extensive river systems - Viti Levu in Fiji and the main island of Papua. Small rivers are present in W. Samoa, Vanua Levu in Fiji, New Caledonia, Solomon Islands, Vanuatu, Guam and the other islands of PNG. The small high islands in Tonga, Cook Islands, Micronesia and French Polynesia also have intermittent streams.

Studies on rivers have normally accompanied planning for hydro-power, mining or water supply schemes. Irrigation using river-water has not been widespread but since the 1983 Pacific-wide drought more consideration is being given to the use of this technology.

To focus on one water quality study of a river system the environmental impact study for the Namosi copper project in Viti Levu, Fiji has been chosen (Amax Exploration Incorporation, 1977, 1978; Greenbaum, D., 1979). The copper deposit covers a large area in the headwaters of the Waidina River. This river is one of the major tributaries of the Rewa River which enters the sea near Suva. The mining company (Amax Exploration Inc.) carried out an extensive study of the catchment streams, upper Waidina River and a number of boreholes in 1977 and 1978. The Fiji Mineral Resources Division studied the Waidina and Rewa Rivers downstream from the prospecting area in 1978.

In the Amax study area eleven surface water stations and 4 groundwater stations (some in the mineralized zone and some outside) were sampled once a month. A large range of analyses

was performed. The surface water was low in acidity and alkalinity (< 50 mg $CaCO_3$ dm^{-3}), quite soft (< 50 mg $CaCO_3$ dm^{-3}) and low in suspended solids (< 20 mg dm^{-3}) except after periods of heavy rain. Values of up to 2000 mg dm^{-3} were then obtained (Namosi has an average yearly rainfall in excess of 5000 mm). The water had an extremely low content of most measured species. The bore waters showed somewhat higher values for hardness and alkalinity. In the mineralized zone hardness averaged 366 mg $CaCO_3$ dm^{-3} while in the non-mineralized zone the average was 81 mg $CaCO_3$ dm^{-3}. Low values of copper and zinc in all waters shows that these metals in the ore body are not mobile in the neutral to slightly alkaline percolation water.

Greenbaum's study downstream of the prospect showed similar water properties with low values of hardness, alkalinity and total dissolved solids. These values are as expected for a river system flowing through an area dominated by old volcanic rocks and sediments derived from them. River waters generally have relatively low values of total dissolved solids (100-150 mg dm^{-3}) unless they move through a significant area of more soluble material. This is clearly illustrated by data for the Purari river system in PNG where the total dissolved material in the limestone draining rivers was about twice that of the rivers draining other catchments (Petr, 1980).

The ionic content of the Waidina and Purari rivers with Ca > Mg > Na > K and HCO_3 > SO_4 > Cl is similar to rivers worldwide (Garrels and Mackenzie, 1971). This indicates that the quality of these rivers is controlled by normal chemical and biological processes until they are altered by human activities in the lower reaches (see Sections 10 and 11). It is likely that other river systems in the Pacific Islands will follow the same pattern.

5. LAGOONS

The definition of a lagoon is not completely fixed. In this review lagoons will be considered to be large bodies of water substantially enclosed by coral reefs or coral reefs and land masses. Thus are included lagoons such as Tarawa, Truk, the Papuan coastal lagoon and Laucala Bay, Fiji. Obviously some of these lagoons are also bays and estuaries and thus Laucala Bay will be considered under the category of bays and estuaries. Although a large amount of research has taken place on lagoons in French Polynesia and TTPI much of the data has not been published since the work was carried out in association with nuclear bomb testing. Investigations of the Tarawa lagoon pollution and coastal lagoons in PNG and Fiji have also been made.

The construction of the new extended airport on Moen Island in the Truk lagoon required a water quality monitoring programme, the results of which have been published by Clayshulte et al. (1979, 1982) and Amesbury et al. (1978, 1981). The monitoring programme extended for over three years and a large amount of data was collected. The observed effects on the lagoon water quality near the construction site were an increase in turbidity levels (from below 1 NTU initially to above 10 NTU during construction periods) and some possible smaller temporary changes in pH, dissolved oxygen, salinity, total phosphorus and total Kjeldhal nitrogen. A Post-construction Monitoring Programme will follow the completion of construction.

In French Polynesia extensive monitoring has taken place in connection with the proposed expansion of the Papeete port. The impact of this expansion on the Taunoa lagoon (a coastal lagoon) and the wider area of Tahiti and Moorea has been investigated. Audic and Fraizier (1981) give data for mercury levels in seawater, primary producers (mainly algae), primary consumers (algal grazers), secondary consumers (carnivores) and filter feeders (mainly bivalves) from sites in the Taunoa lagoon. They show clearly the concentration effects with increasing trophic levels and changes in average mercury content with increasing distance from the landmass e.g. litoral algae, 7 ng g^{-1}; fringing reef algae, 4.2 ng g^{-1}; barrier reef algae, 2.9 ng g^{-1}. Values are compared to those from other studies particularly in the Pacific region. Secchi and Fraizier (1981) published data on levels of iron, copper, cadmium and lead in the coastal waters of Moorea and north-western Tahiti. The levels found suggest that the South Pacific may be enriched in cadmium and lead relative to other oceans possibly due to the volcanic nature of the islands. While considerable variation in levels of iron, copper and lead at different sites could be linked to land influence the relative constancy of the cadmium levels suggests an oceanic influence. De Nardi, Raymond and Richard (1983) monitored metals, pesticides, bacteria and nutrients in the Taunoa lagoon during 1980/81. Nutrient levels were not high and faecal bacteria numbers moderate for Pacific island lagoons in urban areas (20-300 per 100 ml). Considering the almost complete lack of pesticide monitoring in the Pacific the residue level results showing aldrin in seven of the ten sampling sites (in concentrations up to 170 ng g^{-1}) and heptachlor, endosulfan and captan at others was significant.

The impact of human activities on Tarawa Lagoon has been studied by Johannes et al. (1979). The study was prompted by the rapid urbanization of South Tarawa. This allied with inadequate sewage and garbage disposal facilities and the closure of inter-island passages by road causeways leading to reduced circulation in the lagoon has led to increasing degradation of the lagoon. The results of the study highlighted

the high levels of faecal bacteria present in the lagoon water and in shellfish which are a popular diet item. Faecal coliform counts in bivalves ranged up to 180,000 per 100g and were generally above 1000 per 100g near all heavily populated areas. International standards for faecal coliforms in shellfish are generally less than 300 per 100g. The chemical status of the lagoon was found to be more satisfactory with adequate dilution and flushing of nutrient and organic inputs.

The ecology of Fanga'uta Lagoon, Tongatapu has been studied by Zann et al. (1984). The Tonga Fisheries Division and the Ministry of Lands and Surveys has been concerned by two decades of declining fish catches and reported environmental changes in the lagoon. The lagoon is under pressure from commercial fisheries, land reclamation and sand mining for construction purposes and the study assessed the impact of these activities. The results suggest that although the lagoon has been subjected to considerable overfishing and degradation due to removal of mangroves and reclamation of land it is still extremely productive. No evidence of pollution was found from the water chemistry data although the groundwater in the surrounding land areas showed high levels of nitrate and silica. Effective stripping of nutrients in the groundwater before entry to the lagoon was suggested to account for this.

6. BAYS AND ESTUARIES

Many bays in the tropical Pacific have their water movement characteristics strongly affected by offshore coral reefs and have shorelines dominated by fringing coral reefs or mangroves. Bays which are the estuaries of significant rivers may have the offshore reefs broken by large gaps due to the inhibitary effect of cold, fresh, silt-laden water on coral growth. A number of bays which are used as major harbours or as disposal sites for urban and industrial wastewater and sewage have been studied. These include Vila Harbour (Carter, 1983), Pago Pago (Soule and Oguri, 1983), Port Moresby (Moore, 1982), Laucala Bay, Suva (Caldwell Connell Engineers, 1982) and Apra Harbour, Guam (GEPA, 1982a). As an example of a well run, fairly comprehensive monitoring study the Laucala Bay work will be discussed.

Suva, the capital city of Fiji, has at present a greater city area population of about 150,000 persons and it is estimated that by the year 2000 this will reach 300,000. Up until early 1983 the main Suva sewage works at Kinoya treated sewage from a contributory population of about 12,000 but during 1983 the scheme was expanded to receive sewage from a population of 33,000. Further developments to increase the capacity to cater for sewage from a population of 63,000 and later to 120,000 are now being designed. The effluent from the Kinoya plant and a smaller plant at Raiwaqa all flows into Laucala Bay (see Figure 1), a bay which forms part of the

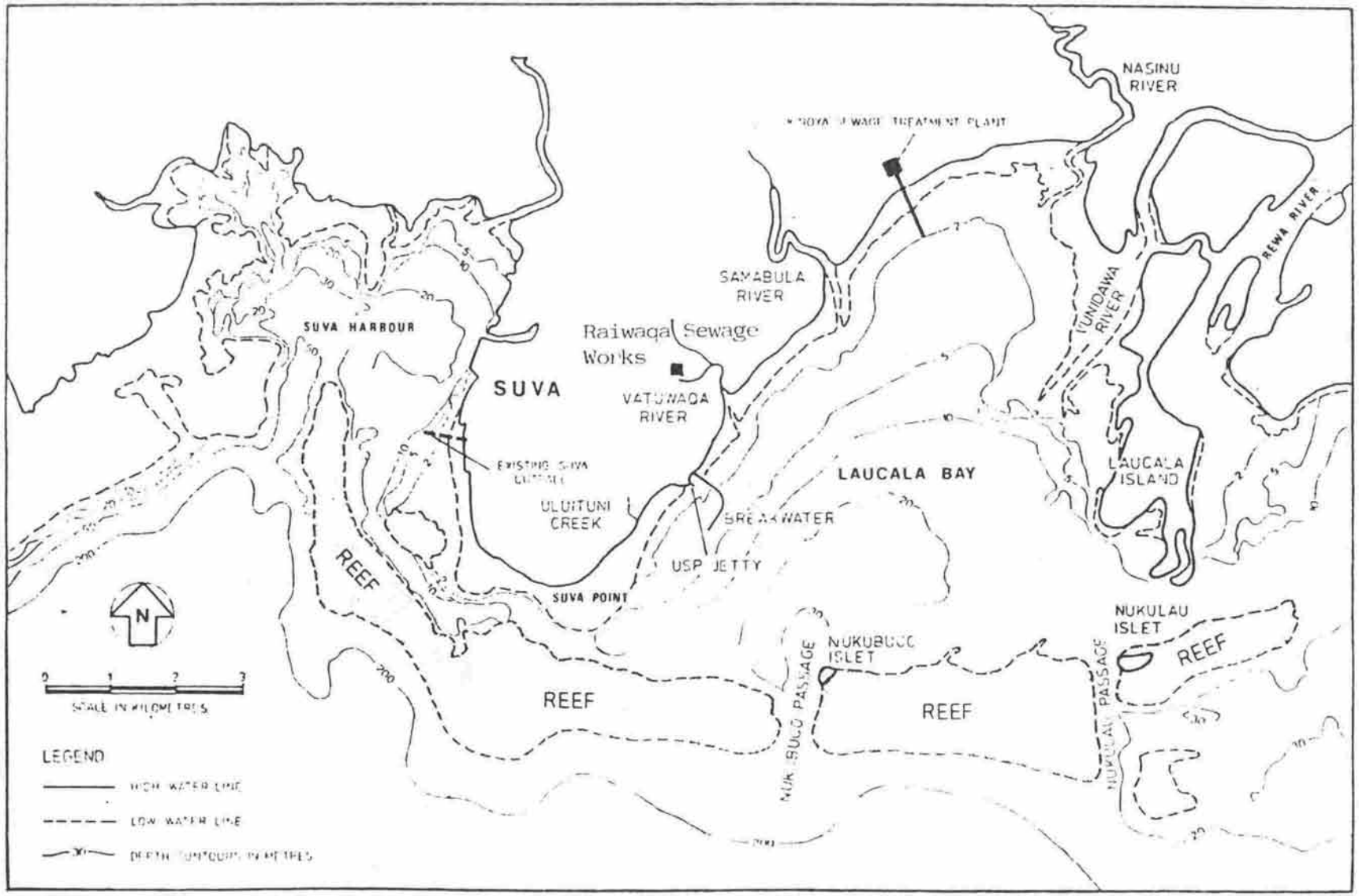
NASINU RIVER
SAMABULA RIVER
Raiwaqa Sewage Works
SUVA HARBOUR
SUVA
VATUWAQA RIVER
TUNIDAWA RIVER
REWA RIVER
EXISTING SUVA OUTFALL
ULUITUNI CREEK
LAUCALA BAY
LAUCALA ISLAND
BREAKWATER
USP JETTY
REEF
SUVA POINT
NUKULAU ISLET
NUKUBUCO ISLET
NUKUBUCO PASSAGE
NUKULAU PASSAGE
N
SCALE IN KILOMETRES
LEGEND
HIGH WATER LINE
LOW WATER LINE

Fig. 1

estuary of the Rewa River and has an offshore barrier reef. To assess the probable effects on Laucala Bay of the increased effluent flow a long term monitoring programme was begun in 1979. Organizations involved in the study included the consulting engineers - Caldwell Connell Engineers (funded by ADAB), the Fiji Public Works Department, the Hydrographic Unit of the Fiji Navy, Ministry of Agriculture and Fisheries - Fisheries Division, the Fiji Mineral Resources Department, the Colonial War Memorial Hospital and the USP Institute of Natural Resources. A major collection of data was made between 1979 and 1982, with smaller scale monitoring continuing since 1982.

Results so far interpreted show the growth of algae in the bay to be phosphorus limited - a relatively unusual situation. It is believed, however, that the amount of phosphorus entering the bay from the sewage scheme will not cause blooms as even by the year 2005 Kinoya discharges will only provide a 50% increase in phosphorus loading in the bay and growth will still be phosphorus limited. At present N/P ratios for the bay average 180 with average nitrogen levels of 3.3 mg/l and average phosphorus of 0.018 mg/l. Recent bacteriological studies on water and shellfish from the bay (INR, unpublished data) have indicated the possibility of serious problems and it is hoped to continue some of these studies in future SPREP activities.

7. DEEP OCEAN WATER

The quality of deep ocean water is considered beyond the scope of this review and will be considered in the SPREP Monitoring Network Report on Oceanography.

8. DRINKING WATER

It is almost impossible to compare drinking water supplies and quality in the Pacific since the variation in supply, treatment, reticulation, quality and expectations is so great. This can be seen if the examples of published material in three localities are compared - Guam (GEPA, 1982a & b); Niue (Downes, 1981; Waterhouse, 1981; Brodie et al., 1983) and Savo Island, Solomon Islands (Brodie et al., 1983).

In Guam continuous, extensive, comprehensive monitoring of drinking water occurs. Violations of the quality standards (USEPA) are immediately investigated and the public is notified. Since GEPA was established in 1973 the number of violations has declined while the bacterial quality of drinking water has improved dramatically. The groundwater has been extensively studied (GEPA, 1982b and see Section 2).

In Niue there have been a number of studies of the groundwater which have examined a considerable range of water quality

parameters and in recent years included a continuous check on salinity and bacterial levels. The water is quite hard (100-300 mg/l $CaCO_3$) and often contains considerable quantities of iron (0.5-4.0 mg/l). During the droughts of 1977 and 1983 pumping was severely restricted to prevent saltwater intrusion (Downes, 1981; Waterhouse, 1981; Brodie et al., 1983).

Savo Island is a small, high volcanic island near Guadalcanal with a population of approximately 2,500. The volcano is still semi-active, venting steam and gases into the three major streams thus causing them to be unusable as drinking water sources. The principal sources of drinking water are the numerous open wells just above the high water mark. During heavy seas (particularly in cyclone Bernie, 1982) many of the wells are contaminated with salt water or even buried by coral rubble and sand. Pigs are common on the island and often roam freely near the wells which do not always have raised sides. The water quality of the wells is abysmal. There is always coliform contamination - often in excess of 1000 organisms/ 100 cm^3 (total coliform) and the salinity of many wells is high (chloride levels > 500 mg/l). If the well water has always had these levels of salt (some up to 10% of seawater) the population must be of considerable interest from a medical point of view as to the physiological effects of a continual natural high salt intake. It is hoped to provide the people of Savo with roof catchment water in the not too distant future (Brodie et al., 1983).

The influence of roofing materials and storage construction materials on the quality of roof catchment water has received little investigation in the region. Downes (1981) noted high organic content in water from the Tokelau Islands and linked this to leaching from wooden roofing components. The organic content of the water contributes to an unacceptable taste and odour. Small amounts of zinc were also found in rain water collected from galvanized rooves in the Tokelaus and Niue but levels were well within WHO guidelines. Recent analysis of so called 'lead free' paint from Tonga used to paint catchment rooves showed levels of 0.6% lead (INR unpublished data, 1984) but no follow-up studies of the water lead content or blood lead contents have occurred.

9. MARINE NURSERY AREAS

One of the most serious effects of coastal water pollution is the reduction in the productivity of inshore areas used as breeding and nursery grounds for marine animals and particularly food animals. The possible effects of loss of mangrove areas is well documented. Mangroves provide attachment sites for oysters and small snails, prevent erosion of foreshores (in fact they are land extenders) and provide a basis for the food chain of organisms such as fiddler crabs, bivalves and larval

fishes (Stillberger and Rowley, 1980). Mangrove conservation in most Pacific states is very weak and reclamation of mangrove areas for uses such as bus depots (Fiji Times, 29 December, 1983) especially near the larger cities proceeds apace.

An interesting study of the effects of an oil spill in Apra Harbour, Guam on a mangrove community has been published by GEPA (Stillberger and Rowley, 1980). The oil came from a leaking buried pipe carrying marine diesel fuel. 13,579 mangrove trees died in the area along with large numbers of fiddler crabs, fish, Portunid crabs and bivalves. The final estimate of the volume of the spill was 10,000 U.S. gallons and this destroyed an immediate area of approximately 18,000 square metres (4 acres). Further damage to a larger area was expected. Since 1980 the offending company has been required to clean up and restore the affected areas. The successful replanting took place between June and August, 1981 and by September, 1982 over 2,500 new mangrove trees were growing in the restored areas (Rowley and Strong, 1983).

10. URBAN AREA WATER

It is now recognised in developed countries that stringent controls are needed to protect water from pollution in urban and industrial areas. With increasing urbanization and industrialization in the Pacific the same controls must be enforced. Streamwater, riverwater, groundwater, rainwater and coastal water are likely to be affected. Since many of the Pacific island cities lack both adequate sewage systems and water reticulation systems the problems are compounded.

In Lae, PNG, the Bumbu River flows through a number of villages and city suburbs. The Taraka sewage works effluent also discharges into the river. Two self-help settlements which lie on the Bumbu River have been examined by personnel from UNITECH (Mallard and Mahoney, 1983) to estimate water quality, water usage and the effect on public health. Taraka Self-Help Settlement has access to the town water supply and city rubbish collection while Bumbu does not. The Bumbu River and adjacent streams were shown to be highly polluted with faecal coliforms and in most areas not even safe for bathing (46% of samples contained > 2000 faecal coliforms/ml). Statistical analysis showed that the occurrence of diarrhoea, ear and eye infections was higher in Bumbu than in Taraka. 72% of people in Bumbu versus 48% of people in Taraka reported diarrhoea while in Bumbu 29% had ear infections and 36% eye infections and in Taraka the corresponding figures were 16% and 20%. Obvious contamination of wells by pit toilets and of small streams and springs by household rubbish was noticed in Bumbu.

11. INDUSTRIAL WASTEWATER

Very few studies have been made into the composition and effects on industrial (non-mining) wastewater discharge in Pacific island states. Examples have included: fish processing wastes in Pago Pago, American Samoa (Soule and Oguri, 1983), edible oil plant waste in Suva, Fiji and sugar mill effluent in Labasa, Fiji (Lee, 1979, 1981). The Samoan study prepared for the USEPA investigated the fate of the wastes and public health implications from the two canneries in Pago Pago in early 1982. One of the canneries is now being forced to improve waste disposal while the other had already voluntarily installed anti-pollution measures.

In Fiji the edible oil plant investigation was carried out by INR on the request of the harbourmaster. The Qawa river problem (smell, high BOD values) was found to be a consequence not just of the actual dumping of industrial effluent but also of the nature of the river at the discharge point. The river is slow moving and meandering at this point and it has been found that there is a depression in the river bottom close to the discharge point. Thus the high density, organic rich effluents sink into this depression, deoxygenating the river at that point and creating a problem for the local inhabitants particularly during the "dry" season when the river flow is particularly sluggish.

12. MINING ACTIVITIES

Many of the larger mining projects in the region have had extensive environmental impact assessments made and those that have gone ahead have continuing monitoring schemes. Examples are Bouganville Copper (PNG), Ok Tedi (PNG), the Vatukoula gold mine (Fiji) and the proposed Namosi copper mine (Fiji).

Mines such as Bouganville Copper have produced vast environmental effects on streams, rivers and the coastal lagoons but the economic benefits of the mine were estimated to far outweigh these detrimental effects. Information on the effects is often politically sensitive and is therefore not always easily accessible. In both PNG and Fiji the control of mining wastes is one of the strongest areas of wastewater legislation and all such projects must have a detailed environmental impact statement. This is not the case with many other types of industrial activity. The control of environmental degradation in mining projects in areas of rough terrain and high rainfall substantially adds to the cost of the project and may even be a bar to the entire profitability of the project. Recent problems with the slow collapse of the tailings dams area at Ok Tedi (January, 1984) have seriously affected that project. Subsequent discharge of cyanide from the treatment plant with extensive aquatic biota mortality downstream and the loss of approximately 200 tonnes of cyanide from a capsized barge

in the river have added to the problems. The problem of disposal of wastes from the Namosi copper prospect along with falling world copper prices were major factors in the mothballing of the project.

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COUNTRY REPORTS ON

MONITORING FACILITIES, LEGISLATION

AND MONITORING ACTIVITIES

1. AMERICAN SAMOA

Laboratory Facilities

The Water Quality Laboratory of American Samoa is involved in the analysis of drinking water, natural waters and waste waters. The laboratory is staffed by a Supervisor (Master of Public Health graduate) and 4 laboratory technicians who have attended basic training courses on water analysis. A need has been identified for an expanded environmental laboratory to complement the Coastal Zone Management Plan and the Quality of Life Plan. The laboratory is equipped to carry out basic water quality tests. Some samples are sent overseas (US) annually for more detailed analyses.

Legislation

American Samoa is covered by US federal environmental legislation and has four pieces of territorial legislation dealing with water and waste water - The Environmental Quality Act, The Safe Drinking Water Rules of American Samoa, Water Quality Drinking Standards of American Samoa and the Individual Sewer System Rules of American Samoa. These acts are monitored by the Environmental Quality Commission. Coastal pollution is controlled under the Coastal Zone Management Act.

Monitoring Activity

Drinking water samples (rainwater systems) are analysed at a frequency of 27 per month for the American Samoa Government System and 30 per month for individual village systems. These samples are analysed for total and faecal coliforms, turbidity and (if appropriate) residual chlorine. Natural water samples from streams (20 per month) and beaches (20 per month) are analysed for faecal coliforms. Samples from the main harbour (48 per quarter) and adjacent streams (4 per quarter) are analysed for turbidity, total suspended solids, dissolved oxygen and (for the streams) oil and grease.

Needs

- Availability of closer facilities for complete water testing
- Training of technicians and public health analysts

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2. COOK ISLANDS

Laboratory Facilities

Drinking water analysis is carried out in the hospital laboratory which is equipped to do bacterial and basic chemical tests. The laboratory has a HACH field monitoring kit. Two staff are involved in water analyses, 1 senior laboratory technician and 1 laboratory assistant.

Legislation

The Public Health Act and Ordinances control contamination of water while water catchments and resources are controlled by the Conservation Act of 1975. Local acts such as the Rarotonga Waterworks Ordinance (1960) and the Housing Improvement Scheme No. 4 Subsection 2 of the Cook Islands Amendment Act (1960) control local water supplies. The Harbour Control Act 1971 prohibits pollution of harbours.

Monitoring Activity

Apart from drinking water little monitoring is carried out. Monthly inspections of all major water intakes and analysis of samples for basic microbiological and chemical parameters occur. Several batches of samples have been analysed in New Zealand over the past 15 years.

Needs

- Better instrument maintenance
- Training of technicians and public health officers
- More rigorous and continuous monitoring
- More basic equipment for water analysis

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3. FEDERATED STATES OF MICRONESIA (FSM)

Laboratory Facilities

As FSM was part of the Trust Territories of the Pacific Islands (TTPI) drinking water quality was regulated by the Trust Territories Environmental Protection Board ((TTEPB). Thus in common with Palau and the Marshalls the main centres were equipped with a water and waste water laboratory. In FSM these are located in Ponape, Yap, Truk and Kosrae i.e. one in each state centre. Each laboratory should be equipped with the following major items to meet TTEPB requirements.

- o membrane filtration (MF) bacteria testing kit
- o 2 incubators
- o turbidimeter
- o pH meter
- o autoclave
- o refrigerator
- o chloride and residual chlorine Hach test kits

With this equipment bacterial and simple chemical parameters can be monitored while once a year samples are also sent to mainland USA for complete water analysis to USEPA standards.

At present much of the equipment available in FSM, Palau and Marshall Islands is quite old and due to lack of maintenance some items are not working. This problem is compounded by the sanitarians lack of training in routine maintenance of the equipment.

Legislation

At present FSM is still covered by the TTEPB regulations in particular Chapter 13 of Title 63 (Air, Land and Water Pollution) of the T.T. Public Law 4C-78. These regulations were developed in close cooperation with the USEPA so they also comply with the US Federal Water Pollution Control Act. FSM is now drafting its own Environmental Quality act which is available in draft form. The T.T. Environmental Quality Protection Act will also remain in force.

Monitoring Activity

Town water supplies are regularly monitored. Problems have arisen due to the age of the water reticulation system and subsequent heavy leakage and contamination combined with the inadequate training of many of the water system staff and the

sanitarians. The cholera outbreaks and continuing dysentry problems on Truk are well known.

Needs

- Better instrument maintenance
- Training of public health analysts
- Availability of closer facilities for complete water testing

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4. FIJI

Laboratory Facilities

A number of government and university laboratories are involved in or have facilities for water analysis.

A. Koronivia Research Station (Ministry of Primary Industry)

This laboratory has sections devoted to agriculture, food and forensic analyses, and has a staff of 3 chemists and 8 technicians. It is equipped with an Atomic Absorption Spectrophotometer (AAS), Gas-Liquid Chromatographs (GLC), UV-Visible Spectrophotometers (UV-VIS) and a wide range of basic laboratory instruments and facilities. The laboratory analyses water for chemical parameters for the Health Department on request.

B. Colonial War Memorial Hospital Laboratory (Suva)

This laboratory analyses water samples from the Central, Northern and Eastern Divisions of Fiji on a regular basis for bacterial quality for the Health Department. The testing is done with facilities shared with the normal hospital diagnostic test programme. Lautoka Hospital Laboratory performs a similar service in the Western Division.

C. Kinoya Sewage Treatment Plant Laboratory, Suva (Public Works Department) carries out bacterial and basic chemical tests on water from sewage outfalls and surrounding areas.

D. Institute of Natural Resources (University of the South Pacific) Laboratory

This laboratory with a staff of 3 chemists and 5 technicians is equipped with AAS, GLC, UV-VIS, Fluorimeter, MF bacterial test equipment and a wide range of basic laboratory instruments and facilities. It analyses water regularly for the Fiji Public Works Department, hotels, fisheries projects and the Tonga Water Board.

E. School of Natural Resources (University of the South Pacific)

The school is equipped with AAS, GLC, UV-VIS etc. but priority must be given to teaching functions. The equipment can be used as a backup for the Institute laboratory.

F. Geological Survey (Ministry of Energy and Mineral Resources Laboratory)

This laboratory is equipped with AAS and other facilities and does some routine water analysis for the Fiji PWD.

G. At present the Fiji Government is planning to upgrade water analysis facilities at Koronivia and the Colonial War Memorial Hospital with possible funding from UNDP and at Kinoya with possible funding from ADAB.

Legislation

The following acts and regulations control water quality and waste water discharge - Public Health Act and Regulations, Chapter 111; Pure Food Act, Chapter 116; Pure Food Regulation, Chapter 97. All these are very old acts e.g. the Public Health Act dates from 1937 and are at present under review. The Water Supply Ordinance 1955 controls water catchments while the Land Conservation Board established under the Land Conservation and Improvement Ordinance 1955 has the responsibility of conserving and improving water resources. The Mining Act and Regulations 1966 control mining close to water supplies. The Harbour Act 1974 and the Continental Shelf Act protect some coastal areas from pollution.

Monitoring Activity

Drinking water supplies are tested regularly for bacterial quality. There is no regular monitoring of waste water and industrial discharges except when complaints are received. No regular monitoring of shellfish from urban and industrial foreshores takes place. These problems are compounded by a shortage of health inspectors and the wide scope of their responsibilities. There is no regular requirement that environmental impacts be examined before large development projects are begun.

Needs

- Better liaison between laboratories within Fiji
- Better use of existing facilities
- More effective legislation which will require a continuous monitoring programme in urban areas
- A diploma course for Health Inspectors
- To provide a complete service to the region the INR laboratory needs staff and equipment

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5. FRENCH POLYNESIA

Laboratory Facilities

A. Service d'hygiène et de salubrité

B. Syndicat pour la promotion des communes de Polynésie française

These two organizations function in the routine surveillance of drinking water supplies in a similar way to Service mobile d'hygiène and Bureau d'hygiène municipale in New Caledonia.

C. Office de la recherche scientifique et technique outre-mer (ORSTOM)

ORSTOM has good laboratory facilities but its main water related research interests are in oceanography, the lagoonal environment and island hydrology. 15 research staff plus support staff are employed.

D. Etablissement pour la valorisation des activités aquacoles et maritimes (EVAAM)

This marine biology institution is active in research into fish stocks, aquaculture, both of fish and invertebrates and fish and shellfish disease. Eleven scientists plus support staff are employed.

E. Laboratoire d'étude et de surveillance de l'environnement (LESE)

This laboratory is active in the monitoring of the coastal marine environment in particular the monitoring of heavy metals and pesticide residues.

F. Centre national pour l'exploitation des océans (CNEXO)

This laboratory is equipped with an autoanalyser and other equipment. However, its basic research aims are in the area of aquaculture. 18 research staff plus support staff are employed.

Legislation

Water supply management is a responsibility of the communes which are charged by the territorial authority with providing water to their populations. According to existing legislation, water resources management is a responsibility of the territorial authority. With respect to monitoring French legislation on drinking water supply is not applicable to French Polynesia and local regulations have not been developed.

Monitoring

The Service d'hygiène et de salubrité monitors water supply especially in urban areas but as their paper at the Water Resources of Small Islands Workshop (Suva, Fiji, 27 June - 9 July 1984) states "No water delivered for consumption meets the sanitary requirements on bacteriological quality". Monitoring of outer island supplies is extremely limited - as is the case in all Pacific island countries.

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6. GUAM

Environmental and water quality matters are very well monitored and controlled in Guam since the territory has an active EPA which is part of the USEPA.

Laboratory Facilities

A. Guam Environment Protection Agency (GEPA)

This laboratory is fully equipped with AAS, GLC, US-VIS and MF-bacterial testing equipment. It employs a large staff to operate its Safe Drinking Water Programme, Community Wastewater Programme, Individual Wastewater Programme, Water Quality Management Plan and Monitoring Services Division as well as non-water related programmes.

B. Water and Energy Research Institute of the Pacific Islands (WERI), University of Guam

This laboratory is equipped with AAS-HGA (Heated graphite atomizer), UV-VIS and MF-bacterial testing equipment. It has carried out a large number of investigations into water related environmental matters in Guam and TTPI (also see bibliographies of TTPI states).

C. University of Guam Marine Laboratory

This laboratory has also carried out large scale investigations of coastal environmental matters but with emphasis more on biological aspects.

D. University of Guam Chemistry Department

This department is equipped with AAS, GLC, UV-VIS etc. but priority must be given to teaching functions. It can serve as a back-up for the WERI and Marine Laboratory.

E. Guam Community College

Although not having extensive laboratory facilities this college runs an active programme of training public utilities workers to which TTPI people could be sent for training.

Legislation

Title LXI, Government Code of Guam (Environmental Protection) gives legal authority to the GEPA. Those sections involving water include Chapter II (Water Resources), Chapter III (Water Pollution Control), Chapter IV (Sewage Disposal), Chapter VI (Pesticides), Chapter X (Operators Certification, Chapter XIII (Safe Drinking Water).

Monitoring Activity

GEPA has a very active monitoring programme covering drinking water supplies, wastewater and coastal and inland surface waters. WERI is involved in monitoring of special studies such as urban runoff composition while UOG Marine Laboratory has carried out a number of special studies into the Coastal environment.

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7. KIRIBATI

Laboratory Facilities

A. Tarawa Hospital Laboratory. This laboratory tests the basic chemical composition and bacterial content of reticulated water on South Tarawa on a regular basis.

B. Atoll Research Unit (University of the South Pacific). This laboratory is equipped with a colorimeter, a salinometer and sampling equipment and could in future be involved in coastal water monitoring.

C. Veterinary Laboratory (Ministry of Natural Resource Development). This laboratory also has basic chemical equipment including pH meters and Kjeldhal nitrogen analysis apparatus and in future could be involved in water monitoring.

Legislation

Drinking water quality and testing and waste water disposal are covered by the Public Health Ordinance (Chapter 80) while pollution of water reserves and water supplies is also specifically covered by the Public Utilities Ordinance (Chapter 83). Pollution of coastal areas except harbours is not specifically mentioned but is covered by general clauses and inference. Harbours are protected by the Harbours Ordinance 1957.

Monitoring Activity

Water supplied via the Tarawa reticulation system is analysed weekly from a number of taps systematically chosen to cover the whole system. As well the salinity level of the supply the residual chlorine level of the reticulated water is checked daily. At present there is no check on coastal (lagoon) pollution from sewage outfall or other causes.

Needs

- Regular lagoon and wastewater monitoring
- Outer island water supply monitoring

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8. MARSHALL ISLANDS

Laboratory Facilities

Facilities are similar to FSM in that they derive from TTPI requirements. There are water laboratories on Majuro and Ebye. As in FSM much of the equipment is aging and needs replacement. A new hospital is being built on Majuro which will incorporate a larger laboratory. The Marshalls also sends drinking water to mainland USA yearly for complete analysis.

Legislation

Environmental matters are still covered by the TTEPB Acts but at present a new act to provide for establishment of their own EPB is being drafted (c.f. FSM).

Monitoring Activity

On Majuro the reticulation system is regularly monitored for bacterial levels and residual chlorine. The Majuro lagoon is monitored at 6 sites for bacterial levels monthly. Reticulated water on Ebye is also regularly monitored. There is no monitoring of any other islands.

Needs

As for FSM

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9. NAURU

Laboratory Facilities

A. Hospital Laboratory

The Nauru hospital has facilities for bacteriological testing and some basic chemical testing of water samples. There are a number of technicians who have overseas training.

B. Nauru Phosphate Company Laboratory

This laboratory is quite well equipped with AAS and UV-VIS as well as basic laboratory equipment. It has one professional chemist and 4 locally trained technicians. This laboratory does test imported water samples for inorganic materials. This laboratory could assist with more work in this area in the future.

Legislation

Nauru's water is obtained from roof catchments and from supplies shipped from overseas. Imported samples are checked on arrival and chlorinated as necessary. No formal legislation covers the quality of water or discharge activity, but the Director of Health and Medical Services can request that water supplies be tested if he feels that a potential problem exists.

Monitoring Activity

Apart from imported water which is analysed on arrival, little monitoring activity has been reported.

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10. NEW CALEDONIA

Laboratory Facilities

A. Service mobile d'hygiène

This is a small mobile unit serviced by 1 doctor and 1 medical technician which can operate anywhere in the territory. The unit has a spectrophotometer and membrane filtration equipment and can analyse water samples for coliforms, suspended solids and some basic chemical parameters.

B. Bureau d'hygiène municipale (Nouméa)

This unit has 1 doctor and 15 technical staff and is charged with the general surveillance of drinking water supplies and vector problems and the prevention of water-borne disease epidemics. The unit analyses samples for microbiological contamination, suspended solids, BOD and basic chemical parameters.

C. Institut Pasteur

A legal investigating laboratory with special interest in bacteriology and parasitology.

D. Service des Mines

A legal investigating laboratory with special interest in the impact of mining on the chemical and physical properties of water resources.

E. Office de la recherche scientifique et technique outre-mer (ORSTOM)

This has very good analytical facilities but does not carry out water analyses for health or pollution studies.

Legislation

The water resources and pollution law (No.105 of 1968) controls discharges of pollutants into surface, underground or coastal waters. Marine pollution is specifically prohibited by law No.73-447 of 1973 (hydrocarbon pollution) and No.76-599 of 1976 (dumping from ships and aircraft). No legislation is being drafted for inland and potable water quality. Two new organizations have recently been instituted to monitor this area. One is the Comité technique de l'eau (CTE) established in March 1982 with responsibilities for the evaluation, management, conservation and protection of water resources. The second is the Comité technique de l'assainissement established in December 1982 with responsibilities for the control of health improvement activities related to water use. These committees are charged with the integration of the activities of the various groups involved in the control and use of water resources.

Monitoring

A rigorous systematic monitoring programme is carried out in the Noumea area. In rural areas there are 17 communal centres where samples are tested by doctors for bacteriological contamination, but this is not in a systematic programme.

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11. NIUE

Laboratory Facilities

Drinking water analysis is carried out in the hospital laboratory which is equipped to do bacterial and salinity tests.

Legislation

An act controls drinking water quality but at present there is no legislation covering waste water disposal, coastal water quality or water pollution in general.

Monitoring Activity

16 bores on Niue which provide drinking water are sampled and analysed 4 times yearly for bacterial levels and salinity.

Needs

- Training of public health workers
- Instrument maintenance

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12. NORTHERN MARIANAS

Laboratory Facilities

Saipan Environmental Health Laboratory (Dr Torres Hospital)

This laboratory has a well equipped microbiological section and chemical section capable of all wet chemical methods.

Legislation

The Commonwealth is covered by U.S. Federal environmental legislation and has its own laws on drinking water (Public Law 1-8) and marine and fresh water quality (Public Law 3-23).

Monitoring Activity

Drinking water is monitored regularly for bacterial and chemical quality. A proposal for an extensive Marine Water Monitoring system is now to be implemented to continuously check the quality of Saipan (and perhaps later other islands) coastal areas in view of the increase in tourist development.

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13. PALAU

Laboratory Facilities

A. The water laboratory in Colonia is set up to meet TTPI requirements (see FSM entry) and has the same problems.

B. Palau Marine Research Institute (Colonia). This institute is involved in mariculture but could be in the future interested in coastal monitoring.

Legislation

Palau is also covered by TTPI environmental legislation and is now in the process of considering its own regulations (c.f. FSM and Marshall Islands).

Monitoring Activity

Drinking water is regularly monitored for bacterial levels and residual chlorine.

Needs

As for FSM and Marshall Islands.

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14. PAPUA NEW GUINEA

Laboratory Facilities

A. National Analysis Laboratory (University of Technology, Lae)

This laboratory employs 2 analysts and a number of technicians and is well equipped with basic laboratory apparatus, AAS, UV-VIS and pathology equipment. The laboratory carries out water analyses for the northern provinces of PNG on request by the health authorities.

B. Department of Chemical Technology (University of Technology, Lae)

This laboratory is equipped with AAS, GLC, UV-VIS etc. but priority must be given to teaching functions. It can act as a back-up facility to the National Analysis laboratory (which is a sub-unit of the department). Staff of this department have carried out a number of investigations around Lae of water quality and its environmental and public health implications.

C. University of PNG Chemistry Department, Port Moresby

This laboratory employs 3 full-time technical staff and utilizes academic staff from the chemistry and biology departments. It is equipped with AAS, GLC, HPLC, UV-VIS etc. but priority has to be given to departmental teaching functions. The laboratory has a severe space shortage. Personnel from the departments have carried out many water quality surveys and investigations particularly around Port Moresby and on the inland lake systems. Pathology facilities exist in the biology department.

D. Central Public Health Laboratory (Port Moresby Hospital)

This laboratory employs one chemist and a number of technicians and is capable of doing all basic chemical and bacteriological water analysis. It is equipped with pH-ion meters, turbidimeter, dissolved oxygen meter, colorimeters etc. and tests water supplies and some surface waters from around Port Moresby. Approximately 70 samples are examined for bacterial levels per week. Samples for more complete analysis are sent to Australia.

E. The Bureau of Water Resources use the Mines Division Laboratory in Port Moresby. The Bureau controls permits for water supplies throughout PNG. The laboratory employs 2 chemists and a number of technicians and is equipped with AAS and all basic laboratory equipment.

Legislation

Drinking water quality is controlled under the Public Health Act and Permit system. General environmental matters are controlled by the Environmental Planning Act (No. 45 of 1978). Also proposed but not passed is the Environmental Contaminants Act (No. 55 of 1978). Marine pollution is controlled by the Merchant Shipping Act.

Monitoring Activity

Drinking water supplies are tested regularly for bacterial and chemical quality at the National Analysis Laboratory or the Central Public Health Laboratory. Coastal water samples from a number of Port Moresby beaches are also checked for bacterial levels. There is no regular monitoring of waste water and industrial discharges. All major projects have to inform the Office of Conservation and Environment of their plans and they may also be required to submit an environmental impact assessment.

Needs

- Water analysis laboratories seem particularly isolated from each other even when physically close together. There is no overall coordination of water analysis activities and personnel from the different laboratories are not in contact. This problem has been noted previously by Professor L. Smythe (Univ. of New South Wales, Australia) who investigated the activities of PNG government laboratories in the late 1970's and at present by Associate Professor R.J. McKenna (University of Technology, Lae) who is carrying out a similar survey.

- To participate in the coastal and inland water quality project the National Analysis Laboratory needs staff and equipment while the UPNG needs staff, equipment and possibly more laboratory space.

- Laboratory technician training and Public Health engineering training were also seen as particular needs. The Civil Engineering Department of the University of Technology at present runs courses in environmental engineering and could be involved in such training.

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15. PITCAIRN ISLAND

As all water supplies for domestic use come from roof catchments, and as there is effectively no trouble with waste disposal because of the low population, water quality is not a problem on Pitcairn.

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16. SOLOMON ISLANDS

Laboratory Facilities

A. Honiara Hospital Laboratory

This laboratory is equipped with a Flame Photometer, pH-ionmeter, UV-VIS and bacteriological testing equipment but at present only carries out bacterial tests on water. There are tentative plans to build a Public Health Laboratory with Japanese aid.

B. Mineral Resources Laboratory (Honiara)

This laboratory is equipped with AAS and basic analytical instrumentation and does occasional water testing.

C. Department of Agriculture Laboratory (Dodo Creek)

This laboratory is equipped with a Flame Photometer, UV-VIS and pH meters and carries out some water analysis for agricultural purposes.

Legislation

The Environmental Health Act (1980), in particular, Part XI Sections 93 and 94 has provisions relating to waste water disposal and pollution of rivers, lakes, estuaries and coastal areas. Part VIII, Sections 43-49 deals with the provision, protection and quality control of drinking water. Regulations for the testing of source and delivered water in urban sanitary districts are included.

The Mining Act (1968/1969) controls mining activity close to water supplies. Catchment areas are also protected by the Forests and Timber Act (1969/1977).

Monitoring Activity

The Honiara drinking water supply and reticulation system is regularly monitored for bacterial quality. The monitoring of residual chlorine in tap water is to be commenced in 1984. No other regular monitoring is done.

Needs

- Better utilisation of present facilities is possible and the proposed Public Health laboratory is most desirable.
- Outer island monitoring needs to be increased.
- Technician and public health training are required.

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17. TOKELAU

Residents of the three atolls (total population approximately 1,500) rely on roof catchments, small tanks and galleries for all water supplies. Well water is reported as generally poor due to ineffective filtration systems at the bottom of the wells and none of the supplies is treated (Dale, 1981).

Effectively no regular monitoring is carried out and testing facilities are extremely limited.

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18. TONGA

Laboratory Facilities and Monitoring Activity

Drinking water monitoring is controlled by the Ministry of Health. A staff of 4 on Tongatapu tests drinking water for bacterial quality. 204 samples were tested in 1983. Portable membrane filtration equipment is used in Ha'apai and Vava'u.

Legislation

Sanitary Superintendance Regulations cover sewage disposal (Chapter 48 of Section 50 - 1976) while discharge of pollutants in ports is covered by the Quarantine Regulations (Chapter 51 of Section 61(c). The Public Health Act gives limited protection to water supplies while the Forest Act can be used to protect water catchments.

Needs

- o More basic chemical monitoring equipment
- o Technician training

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19. TUVALU

Laboratory Facilities and Monitoring Activity

Water for most uses is obtained by pumping from groundwater resources and held in large storage tanks. A number of roof catchments are used for household use. According to Dale (1981) water is generally untreated but is usually boiled before consumption.

Bacteriological testing of drinking water is carried out at the Pathology Laboratory of the Princess Margaret Hospital, Funafuti.

Legislation

The Public Health Act controls waste disposal and water supply pollution while the Water Supply Act controls pollution of water supplies and water reserves. The Harbours Act prohibits discharge of sewage or oil into harbours without permission.

Needs

- Facilities for more basic chemical tests
- Better use of existing facilities
- Testing of water supplies on other islands besides Funafuti
- Training of health workers

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20. VANUATU

Laboratory Facilities

A. Central Hospital Laboratory, Port Vila

This laboratory analyses drinking water samples for bacterial quality - (about 20 samples per year are analysed). The laboratory has good basic facilities and 6 staff, 4 of whom have overseas training.

B. Department of Geology, Mines and Rural Water Supplies

This laboratory has the facilities to carry out basic inorganic water analyses. However, little water work is done as the main function of the laboratory is in analysing rock samples in the mineral reconnaissance survey. The staff consists of 1 applied geologist and one laboratory technician, both with limited water analysis experience.

Legislation

No general legislation exists to control water pollution and water supplies. Local ordinances such as the Joint Regulations 6 of 1931 to control sanitation in Vila and the Joint Forestry Regulation No. 30 of 1964 do affect water supplies. The Decentralisation Act 1980 empowers local governments to construct and maintain water supplies. A programme to develop appropriate legislation has recently been initiated.

Monitoring Activity

The Vila drinking water supply and reticulation system is regularly monitored for bacterial quality. No other regular monitoring is done.

Needs

- Increased monitoring programme
- Technician and public health training
- More equipment for basic water analyses

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21. WALLIS AND FUTUNA

Water is obtained either by pumping groundwater resources or from stream and roof catchments. Minimal or no treatment of supplies occurs. Very little water quality checking is carried out apart from occasional bacteriological tests.

Bibliography

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22. WESTERN SAMOA

Laboratory Facilities and Monitoring Activity

A. The Apia hospital laboratory carries out bacteriological examination of drinking water in Apia for the Public Health Department.

B. School of Agriculture (University of the South Pacific), Apia.

This laboratory is equipped with AAS flame photometer etc. but its primary role is to carry out analyses for agricultural purposes and only a few water samples are analysed annually.

C. The Observatory undertakes physical water measurements to estimate water resources for public use and hydro-electricity generation. Attempts are being made to establish a system for the routine analysis of water samples for basic chemical parameters.

Legislation

Water supply is controlled by the Water Act of 1965 which established a Water Supply Committee to monitor water pollution. Water catchments are controlled under the Takings of Land Act of 1964.

Needs

- Instrument maintenance and replacement
- Technician training

Selected Bibliography

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POLYNESIE FRANCAISE

Laboratoires

A. Service d'hygiène et de salubrité

B. Syndicat pour la promotion des communes de Polynésie Française

Ces deux organismes assurent le contrôle systématique des eaux de boisson de la même façon que le service mobile d'hygiène et Bureau d'Hygiène Municipale en Nouvelle-Calédonie.

C. Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM).

L'ORSTOM a des laboratoires bien équipés mais, en ce qui concerne les eaux, ses travaux de recherche portent surtout sur l'océanographie, le milieu lagonaire et l'hydrologie des îles.
L'Office a un effectif de 15 chercheurs complété par des services d'appoint.

D. Etablissement pour la valorisation des activités aquacoles et maritimes (EVAAM).

Organisme spécialisé dans la recherche en océanographie biologique : stocks de poissons, aquaculture des poissons et invertébrés et maladie des poissons, mollusques et coquillages. Effectif de 11 scientifiques complété par des services d'appoint.

E. Laboratoire d'étude et de surveillance de l'environnement (LESE).

Le LESE assure activement la surveillance de l'environnement marin côtier, particulièrement en ce qui concerne les résidus de métaux lourds et de pesticides.

F. Centre National pour l'Exploitation des Océans (CNEXO).

Le Laboratoire du CNEXO est équipé, entre autres, d'un auto-analyseur. Mais ses travaux de recherche portent surtout sur l'aquaculture. Effectif de 18 chercheurs complété par des services d'appoint.

Législation

La gestion des approvisionnements en eau incombe aux communes que l'autorité territoriale charge d'assurer ce service public. D'après la législation actuelle, la gestion des ressources hydrologiques est la responsabilité du gouvernement territorial. En ce qui concerne le contrôle, la législation française sur les eaux de boisson n'est pas applicable en Polynésie Française et aucune réglementation locale n'a été élaborée.

Le Contrôle

Le Service d'Hygiène et de Salubrité contrôle l'approvisionnement en eau surtout dans les zones urbaines mais, comme indiqué dans la communication qu'il a présenté au Colloque sur les ressources hydrologiques des petites îles (Suva, Fidji, 27 Juin-9 Juillet 1984) : "Aucune eau fournie pour la consommation ne répond aux normes de salubrité en ce qui concerne la qualité bactériologique". Dans les îles, la surveillance et le contrôle sont extrêmement limités comme c'est le cas dans tous les pays insulaires du Pacifique.

Bibliographie

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NOUVELLE-CALEDONIE

Laboratoires

A. Service mobile d'hygiène

Il s'agit d'une petite unité mobile composée d'un médecin et d'un technicien médical qui peut opérer n'importe où dans le territoire. Le service posséde un spectrophotomètre et un matériel de filtration par membrane, et peut analyser des échantillons d'eau (teneur en coliformes, solides en suspension et paramètres chimiques de base).

B. Bureau d'Hygiène Municipale (Nouméa)

Ce Bureau se compose d'un médecin et de 15 techniciens et est chargé de la surveillance générale des approvisionnements en eau d'alimentation, des problèmes vectoriels et de la prévention des épidémies transmises par l'eau. Il analyse des échantillons d'eau (pollution microbiologique, solides en suspension, DBO et paramètres chimiques de base).

C. Institut Pasteur

Il s'agit d'un laboratoire officiel de recherche s'occupant particulièrement de bactériologie et de parasitologie.

D. Service des Mines

Il s'agit d'un laboratoire officiel de recherche s'intéressant particulièrement à l'incidence des travaux d'exploitation minière sur les propriétés physico-chimiques des eaux.

E. Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM)

L'ORSTOM a un excellent équipement d'analyse mais n'analyse pas pour en vérifier la salubrité ou le degré de pollution.

Législation

La loi No. 105 de 1968 sur les ressources en eau et leur pollution réglemente les rejets de polluants dans les eaux de surface, les eaux souterraines et les eaux côtières. La pollution marine est expressément interdite par la loi No. 73-447 de 1973 (pollution par les hydrocarbures) et par la loi No. 76-599 de 1976 (rejets des navires et aéronefs). Aucune législation n'est en cours d'élaboration en ce qui concerne la qualité des eaux intérieures et des eaux d'alimentation. Deux nouvelles organisations ont récemment été créées pour contrôler ce secteur. L'une est le Comité Technique de l'Eau (CET) créé en mars 1982 et chargé de l'évaluation, de la gestion, de la conservation et de la prot-ction des ressources en eau. Le second est le comité technique de l'assainissement créé en décembre 1982 et chargé de contrôler les actions d'amélioration de la salubrité en ce qui concerne l'utilisation de l'eau. Ces comités sont chargés d'intégrer les activités des différents groupes intervenant dans le contrôle et l'utilisation des ressources en eau.

21. WALLIS ET FUTUNA

Dans ces îles, l'eau est fournie soit par pompage de la lentille d'eau douce, soit par les cours d'eau, soit par le captage des eaux de pluie (grâce aux toitures). Les eaux ne sont guère traitées. Sauf pour d'occasionnelles analyses bactériologiques, il n'y a pratiquement pas de contrôle de leur qualité.

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SUMMARY OF THE REVIEW SECTION

Attempts have been made to summarise the current status of regional countries with respect to monitoring facilities and monitoring activities in Tables 2 and 3. These tables are self-explanatory showing that both monitoring facilities and activities vary considerably within the region. It is obvious that a few of the smaller countries will require additional equipment to carry out even basic chemical analysis of water resources.

While some monitoring of drinking water quality takes place in almost every country, the extent of monitoring of other inland and coastal water is rather poor. At present it is impossible to establish a baseline for many coastal and inland water situations because of a lack of data. One of the objectives of the SPREP programme should be to obtain further data for the establishment of baseline situations.

The legislation situation is also extremely variable. Some countries have comprehensive legislation passed or drafted e.g. Guam, PNG, Cook Islands, TTPI states, while others have relatively old inadequate legislation which is being revised, e.g. Fiji. Still other countries have legislation which is badly lacking in some areas, e.g. Tonga (coastal water pollution) or not drafted in a consistent comprehensive form e.g. Vanuatu. The lack of effective monitoring programmes in most countries negates the effectiveness of such legislation as does exist.

The existence of legislation and a regular monitoring programme is, of course, not the complete solution to contamination problems. This is evident in FSM in particular, where there has been regular monitoring of drinking water for some time together with a significant number of special studies on contamination problems.

Due to the poor state of the reticulation systems action to overcome the well defined problems has been slow in coming. However, without adequate monitoring the problems would not have been defined.

One final point on the monitoring activities that is of considerable concern is the lack of adequate investigation of known problem areas. This is most obvious where mushrooming population and industrial development are causing increased industrial and sewage effluents to be discharged into coastal or inland waters without any significant studies being made on the impact on these water resources e.g. Suva and Vila harbours, Tarawa lagoon. A related problem is that of sewage or saltwater contamination of groundwater which is believed by several workers to be leading to a deteriorating situation in many atolls.

TABLE 2. SUMMARY OF FACILITIES AVAILABLE FOR WATER QUALITY ANALYSIS

State	Available Equipment						
	Complete[1] Laboratory	GLC	AAS-HGA	AAS	Complete[2] Wet Chemical	Basic[3] Chemical	Bacterial[4]
American Samoa						x	x
Cook Islands						x	x
FSM						x	x
Fiji							
- INR		x	x	x	x	x	x
- Govt. labs		x		x	x	x	x
French Polynesia	x	x	x	x	x	x	x
Guam							
- WERI			x	x	x	x	x
- GEPA		x		x	x	x	x
Kiribati						x	x
Marshall Islands						x	x
Nauru				x		x	x
New Caledonia		x	x	x	x	x	x
Niue						x	x
Northern Marianas					x	x	x
Palau						x	x
PNG							
- NAL				x	x	x	x
- UPNG		x		x	x	x	x
- Govt. labs				x	x	x	x
Pitcairn Island							
Solomon Islands				x	x	x	x
Tokelau							x
Tonga				x		x	x
Tuvalu							x
Vanuatu						x	x
Wallis & Futuna							x
Western Samoa				x	x	x	x

1 Includes GLC with FID, NPD and ECD, AAS-HGA and all equipment listed in footnotes 2, 3 & 4

2 Includes UV-VIS, pH-ion meter, turbidimeter, analytical balance, fume hoods, digestion apparatus

3 Includes ability to determine chloride, residual chlorine, salinity and pH

4 Includes MF equipment, incubators and autoclave

TABLE 3. SUMMARY OF MONITORING ACTIVITIES

State	Drinking Water			Inland Waters			Coastal Waters		
	1*	2	3	1	2	3	1	2	3
American Samoa		x			x			x	
Cook Islands		x				x			x
FSM		x			x			x	
Fiji		x				x			x
French Polynesia	x	x			x			x	
Guam	x			x			x		
Kiribati		x				x			x
Marshall Islands		x			x			x	
Nauru		x				x			x
New Caledonia	x	x			x			x	
Niue		x				x			x
Northern Marianas		x			x			x	
Palau		x			x			x	
PNG		x				x		x	
Pitcairn Island			x			x			x
Solomon Islands		x				x			x
Tokelau		x				x			x
Tonga		x				x			x
Tuvalu		x				x			x
Vanuatu		x				x			x
Wallis & Futuna			x			x			x
Western Samoa		x				x			x

*

1. Comprehensive regular monitoring
2. Irregular or incomplete monitoring
3. Occasional or no monitoring

Correspondents in the countries of the region were asked to indicate the needs of their countries in the area of coastal and inland water quality. As expected, many common needs were identified.

- o More rigorous and/or continuous monitoring
- o More equipment, especially for basic chemical tests
- o Instrument maintenance assistance
- o Training programmes for (a) public health officers and (b) laboratory technicians
- o Water quality inspectors have a very extensive job to carry out, frequently with limited training and experience
- o More effective legislation
- o Better liaison between laboratories within the larger countries of the region
- o Better use of existing facilities within the larger countries
- o Availability of closer facilities for complete water testing

The authors of this paper have observed a number of other problems that will need to be addressed if a meaningful long-term water quality programme is to be established.

- o Standardization of laboratory methods and quality control of results
- o Development of a pool of regional expertise in water quality work through undergraduate and postgraduate training programmes (at present many professional officers working in this are non-regionals on limited tenure contracts)
- o More efficient dissemination and circulation of information within the region (it is anticipated that SPREP may lead to a considerable improvement in this area)
- o Improved liaison between bodies interested in water quality in the region

RECOMMENDATIONS

A coordinated programme must be established to attack the problems listed in the previous section. Obviously with the limited resources available in the region it will not be possible to successfully deal with all the problems at once. There is a need, therefore, for a stepwise water resources assessment and development programme.

It is recommended that this stepwise development programme should include the following:

1. Training/Education Activities

   (a) Village education programmes on the problems of water quality and the fragility of water quality (i.e. the ease with which water becomes polluted and the invisibility of many of the major water contaminants) should be initiated. These would also stress the importance of good water quality for the community as a whole. The production of appropriate educational materials in vernacular languages and field demonstrations should be encouraged.

   (b) Many of the problems of water quality are caused by a lack of knowledge of the extent of the resource or by poor management. A regional training programme in water research and management skills should therefore be initiated as soon as possible. This would include training activities in water quality testing, assessment of water resources (including research into new methods) and water resource management skills (including simple testing procedures).

2. Monitoring Activities

   Increased monitoring of water resources is required to provide data for the development of baseline information. This would involve regular sampling programmes with a wide range of analyses on the samples collected. Also a number of suspected water pollution problems in the region have not been fully investigated so the actual extent of the problem is not known.

3. Resources

   In order to carry out increased monitoring activity some of the smaller countries of the region will require the provision of equipment to enable them to determine basic chemical and bacteriological properties of water resources without sending the samples overseas.

   Associated with this is the provision for the region as whole of an equipment maintenance service. Many countries have complained that the analysis of water samples and other water resource evaluation activities have been hampered because of equipment failure. The establishment of a maintenance service would be of particular benefit to smaller countries with limited technical capabilities.

4. Information Coordination and Dissemination

Much of the information on water resources of the region is not published in the normal way but is frequently in the form of government or consultants reports. It would be of considerable assistance if this information together with that available in normal journal publications could be collected, coordinated and disseminated to interested bodies. This work could be done through SPREP (via the SPC library) or through the Pacific Information Centre of the USP Library.

5. Advisory Service

The provision of an advisory service on all aspects of water resource evaluation including coastal and inland water quality is essential. This service would include giving advice on method selection, equipment purchases, more efficient utilization of present resources, the necessity or otherwise of specific testing programme, the design of monitoring or evaluation programmes, interpretation of data and technical troubleshooting. Such a service is already available (on a commercial basis) at the INR for water quality assessment, but this service needs to be expanded to incorporate other aspects of water resource assessment and evaluation.

6. Coordination of Laboratory Activities

An urgent need is improved coordination between the analytical laboratories in the region. There is only a limited laboratory establishment in the region, but there is much more that could be done with improved coordination. This coordination should extend to metropolitan laboratories on the fringes of the region e.g. in New Zealand (DSIR) or Australia particularly in the completion of "full" analyses for some of the smaller countries.

This coordination activity should also include work on quality control of results. Methods used need to be tested to assess their suitability for use in laboratories of the region. Inter-laboratory calibration exercises and the provision of standard samples are essential for the generation of good quality data throughout the region.

APPENDIX I

SPREP COASTAL AND INLAND WATER QUALITY PROJECT

Questionnaire

At the April, 1983, Suva meeting of the South Pacific Regional Environment Programme Consultative Group a number of regional institutions were selected to undertake preliminary research in 1983 into specific environmental areas of concern. The institutions concerned and their areas of investigations are:

1. University of Technology, Lae, PNG

   - Soil erosion and sediment deposition

2. University of Guam Marine Laboratory, Guam

   - Mangrove, seagrass, coral reef, lagoon estuarine ecosystems

3. ORSTOM, Noumea

   - Oceanography

4. University of PNG Science Faculty, Port Moresby

   - Biocides - usage and environmental problems

5. Institute of Natural Resources, USP, Suva

   - Coastal and inland water quality

In all cases the coordinating institution will work in cooperation with other relevant regional laboratories and organizations.

To further this programme INR is preparing a comprehensive survey of present activity in water quality assessment and control in the SPREP region. The purpose of this questionnaire is to gather the following data:

(a) Present practices in monitoring drinking water quality; recreational water quality; domestic, industrial and agricultural effluents; estuarine and coastal pollution.

(b) Present laboratory facilities and methods for this monitoring.

(c) Present legislation and its enforcement in these matters.

With the information received and compared it is hoped to recommend to the SPREP Management Committee a programme to upgrade laboratory facilities, standardize methods where appropriate and extend environmental water monitoring activities. We are interested in all laboratory facilities which might be used, if necessary, for water analysis e.g. agricultural research laboratories, mineral resource laboratories, hospital laboratories, public works department laboratories and educational institutional laboratories. The attached questionnaire is in two parts. Section A is to gather information on laboratory facilities and should be completed by all appropriate laboratories in your country. Section B concerns present legislation and monitoring and should be completed by your Public Works Department or other water testing authorities.

Questionnaire A

1. What is the primary role of your laboratory?

2. Does your laboratory carry out any analysis of water samples at present? If so, what analyses are done, for what reason and how many per year?

3. What instrumentation is presently available in your laboratory?

4. What is your present staff and what qualifications and experience (briefly) do they have?

This questionnaire was compled by:

Name:

Position:

Address:

Questionnaire B

1. What government legislation presently exist with respect to

   (a) drinking water quality and testing
   (b) waste water disposal
   (c) pollution of rivers, lakes, estuaries and coastal areas?

2. What analyses are at present carried out to check water quality? Please give details on number of samples, frequency of sampling and geographic distribution of samples.

This questionnaire was completed by:

Name:

Position:

Address:

APPENDIX II

Respondents to Questionnaires

1. American Samoa:

Pati Faiai
Executive Secretary
Environmental Quality Commission
Office of the Governor
Pago Pago
AMERICAN SAMOA 96799

2. Cook Islands:

Mrs S Woorton
Charge Technologist
P O Box 109
Rarotonga
COOK ISLANDS

Dr K.J. Mokotupu
Director of Public Health
Ministry of Health
Rarotonga
COOK ISLANDS

3. French Polynesia:

Mons. A. Fraizier
L.E.S.E.
B P 529
Papeete
FRENCH POLYNESIA

4. Kiribati:

John Wanneck
Public Utilities Board
Betio, Tarawa
KIRIBATI

5. Nauru:

Don Lauder
Chemist
Nauru Phosphate Company
NAURU

Dr Kiki Thoma
Director of Health and Medical Services
NAURU

6. New Caledonia:

Renaud Pianet
Centre ORSTOM
B P A5
Noumea
NEW CALEDONIA

7.	Niue:	Bradley Punu Acting Director of Agriculture Dept. of Agriculture & Fisheries Alofi NIUE
		Harry T. Nemaia Director of Health Department of Health Alofi NIUE
8.	Solomon Islands:	Gilbert Leve Senior Health Inspector Honiara Town Council P O Box 324 Honiara SOLOMON ISLANDS
9.	Tonga:	Salesi Finau Senior Health Inspector Ministry of Health Nuku'alofa TONGA
10.	Tuvalu:	Faiatea Fab Latosi Pathology Laboratory Princess Margaret Hospital Funafuti TUVALU
11.	Vanuatu:	R.J. Marks Applied Geologist Dept. of Geology, Mines and Rural Water Supplies G P O, Vila VANUATU
		K.D. Kalorib Senior Laboratory Technician Central Hospital Port Vila VANUATU
12.	Western Samoa:	N. Petaia Lecturer Secondary Teachers College Apia WESTERN SAMOA
		Uaita Leumaga USP School of Agriculture Private Bag Apia WESTERN SAMOA

G.A. Williams
Head of Science Department
Chanel College
Apia
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Bernie Zagalla
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