South Pacific Regional Environment Programme

Land-based Pollution Sources in Kiribati:

A Case Study

by

Philomena Gangaiya
University of the South Pacific
Suva, Fiji

Published in **May 1994**
in **Apia**, Western Samoa

Acknowledgements

I wish to express my utmost gratitude to Ms Tererei Abete who worked tirelessly throughout my visit to make arrangements for the satisfactory conclusion of the consultancy. The ways in which Tererei helped are too many to specify, suffice to say that without her assistance I would have faced considerable difficulty in my efforts.

Thanks are also due to Timai for accompanying me during many of my interviews and to the many officials and representatives of institutions who readily made available every information that was requested.

I also wish to thank the United Nations Environment Programme for providing the funds that allowed me to conduct this study for the Government of Kiribati and the South Pacific Regional Environment Programme (SPREP).

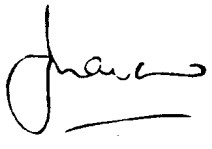
The Author.

Foreword

This report presents the findings of a case study on land-based pollution sources in Kiribati. The study was commissioned by the South Pacific Regional Environment Programme as part of a regional pollution assessment and monitoring programme for the South Pacific. Kiribati was chosen as an example of a country where there is relatively little development.

Land-based pollution sources are discussed under the categories of solid waste, domestic wastewater, industrial waste, wastes from agricultural activities and household hazardous substances. For each particular waste category an assessment of the legislative framework for waste management is carried out. This is followed by a presentation of the current system of waste management and the potential within the system for creating an impact on the environment. The testing of water quality at a number of sites in South Tarawa was carried out to establish the degree of contamination of resources. Some recommendations have been made for improvements in waste management strategies.

The study has shown that systems of waste disposal currently in place are having a noticeable impact on the quality of the environment. Remedial measures are necessary if the environment is not to deteriorate further.



Vili A. Fuavao

Director

Contents

1. Introduction

Most South Pacific island countries are characterised by small land masses surrounded by vast stretches of ocean. As such the marine environment is an important resource base for the people of these countries, with the livelihood of many people being closely connected with the sea. The potential for enhanced development and utilisation of marine resources is considerable, particularly as the demand for resources increases and the land becomes limited in its capacity to fulfil this demand. It is therefore imperative that appropriate measures are taken to safeguard the quality of both the marine and terrestrial environments.

There are two general ways in which environmental quality can deteriorate. The first, over which man has relatively little control, is through the forces of nature such as floods, hurricanes and landslides. The second is the introduction, deliberate or otherwise, into the marine environment of substances that cause pollution. This can be regulated. It is generally believed that pollutants generated on land are amongst the most significant threats to the quality of the marine environment, as indicated by the following statement made at the UNCED, 1992:

> "Degradation of the marine environment can result from a wide range of sources. Land-based sources contribute seventy percent of marine pollution. Many of the polluting substances originating from land-based sources are of particular concern to the marine environment since they exhibit at the same time toxicity, persistence and bio-accumulation in the foodchain."

In the island countries of the South Pacific the above statement is especially applicable because of the concentration of development activities along coastal areas from where the ease of mobilisation of pollutants into the marine environment is greater. Increasing populations, changing landuse patterns and increasing development has meant that the amounts and types of substances being generated that could become pollutants are increasing in magnitude and complexity and therefore it is important to devise proper management strategies for these substances.

However, before this can be done, an assessment of the amounts and types of pollutants generated is necessary. The type of activities that could generate pollutants are recognised but the extent of pollution from each such activity is not generally known for South Pacific island countries.

This study was commissioned by the South Pacific Regional Environment Programme (SPREP) as part of a more comprehensive investigation into land-based pollution sources in South Pacific island countries with different degrees of development. This report presents the findings of a case study of Kiribati, a country with little industrial development but where because of increasing demand on extremely limited and vulnerable resources pollution is becoming a matter of considerable concern.

The draft National Environment Strategy (NEMS, 1993) document for Kiribati, under the section on Waste Management and Pollution, has identified the lack of data on pollutant sources and amounts as a serious constraint to planning for waste management. The results of this study could help alleviate this problem.

Specific objectives of the study were to:

a. identify the land-based pollution sources in Kiribati;

b. determine the extent of pollution of the marine and terrestrial environment from these sources;

c. assess the capability of the existing frameworks to manage the pollution.; and,

d. recommend ways in which management could be improved.

The full terms of reference of the study are given in Annex 1. The author of this report visited Kiribati from 30th November to 11th December 1993 and worked closely with officers from the Environment Unit of the Ministry of Environment and Natural Resources Development. The list of people contacted and the work programme during the visit is given in Annex 2.

The approach adopted in this report is similar to that by Convard (1992) in her regional report on land-based pollution sources which is the consideration of wastes under the broad categories of solid waste, domestic wastewater, industrial wastes, and wastes from agricultural practices. An additional section on household hazardous waste has been added as it was felt that this category needed separate treatment.

As stated in the terms of reference, the report is intended to be of use to other countries with comparable characteristics. It is also likely to be used as resource material for training of personnel involved in waste management in the South Pacific.

2. Country Background

The assessment of the waste management situation in any country must take into consideration all those particular features of the country that are likely to have a bearing on the prevailing or proposed waste management systems. Such features for Kiribati are described in the following subsections. Much of the material has been obtained from the Kiribati Country Report for UNCED (1992) which has detailed documentation of the many features of Kiribati, and the draft NEMS report.

2.1 Physical Environment

The Republic of Kiribati straddles the equator between 4^0 43' N and 11^0 25' S and lies west of the International Dateline between 169^0 32' and 150^0 14' W. It has a total land area of 822.8 km^2 and an associated ocean area of 3.5 million km^2, giving a land area to ocean area ratio of 1:4000. It consists of 33 islands in three main groups - the Gilbert islands in the west, the Phoenix islands in the centre and the Northern and Southern Line islands to the east (see Fig. 1). Banaba, a single island to the west of the Gilbert islands is also part of the group.

The islands within the country are extremely isolated and fragmented. The distance between Banaba in the west and Kirimati (of the Northern Line islands) in the east is 3,870 km and the distance between Teraina in the Northern Line islands to Flint island in the Southern Line islands is 2,050 km. The main Gilbert group, consisting of 16 small atolls or limestone islets, make up 278.4 km^2 (33.8%) of the total land area. The Phoenix group, consisting of eight scattered islands, make up 28.7 km^2 (3.5%) of the total land area and the Line islands, consisting of three northern and five southern islands, make up 515.7 km^2 (62.7%) of the total land area. The administrative centre of the country is located in Tarawa, an island in the middle of the Gilbert group.

Kiribati is located in the dry belt of the equatorial oceanic climate zone. The mean daily temperature ranges from 26 to 32°C with recorded extremes of 22 and 37 °C. The annual rainfall is extremely variable both spatially and temporally. Annual averages in the Gilbert and Phoenix groups range from 1000 mm to 3000 mm, while in the Line islands it varies from 700 mm to 4000 mm. Prolonged droughts with as little as 200 mm of rain per year are common in central and southern Gilberts, on Banaba, the Phoenix islands and on Kirimati.

Winds between the northeast and southeast quadrant occur throughout the year. During the drier months from June to November, the winds are generally from the southeast, while during the wetter months of the year, December to May, the winds are from the north and east quadrant. Currents generally flow from the east to the west.

2.2 Population

The population was estimated to be 72,298 in the 1991 Census. It is unevenly distributed with 96% living in the Gilbert group, one third of whom live in the tiny islets of South Tarawa (see Fig.2). The population density estimated for the entire country is 85 per sq. km but South Tarawa has density of 1,596 per sq km with 4.167 persons per sq km on Betio. The net annual growth rate of population is 2.1%. With this rate the population is expected to double in 35 years. Considerable migration of people from the outer islands to Tarawa is occurring.

2.3 Resource Endowment and Use

Apart from resources associated with the marine environment, Kiribati's resources in other areas of land, soils, water, minerals and terrestrial ecology are extremely limited. For this reason it is extremely important that the environment is properly managed because mistakes cannot be easily rectified.

Fig. 1: *Location map of Kiribati.*

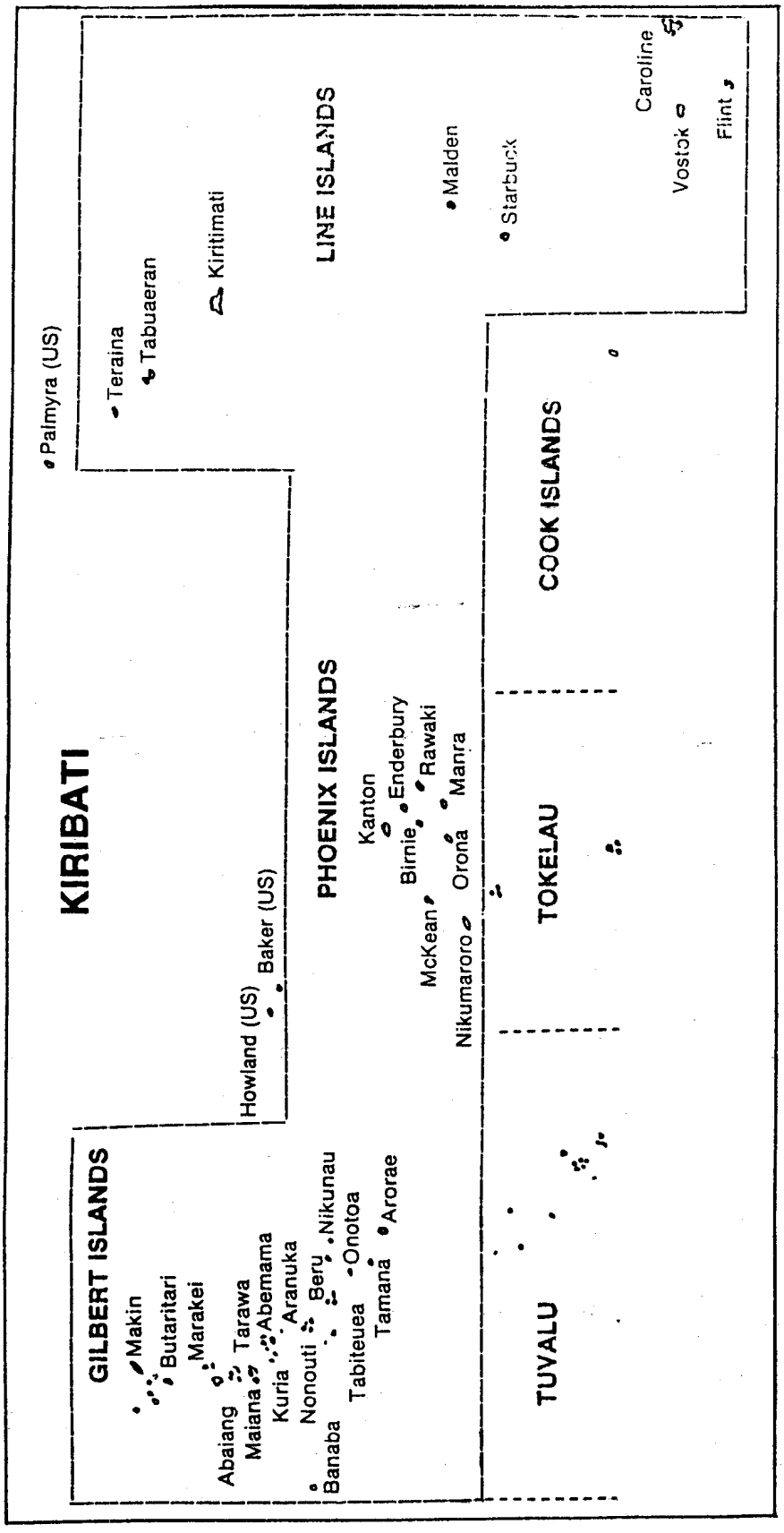
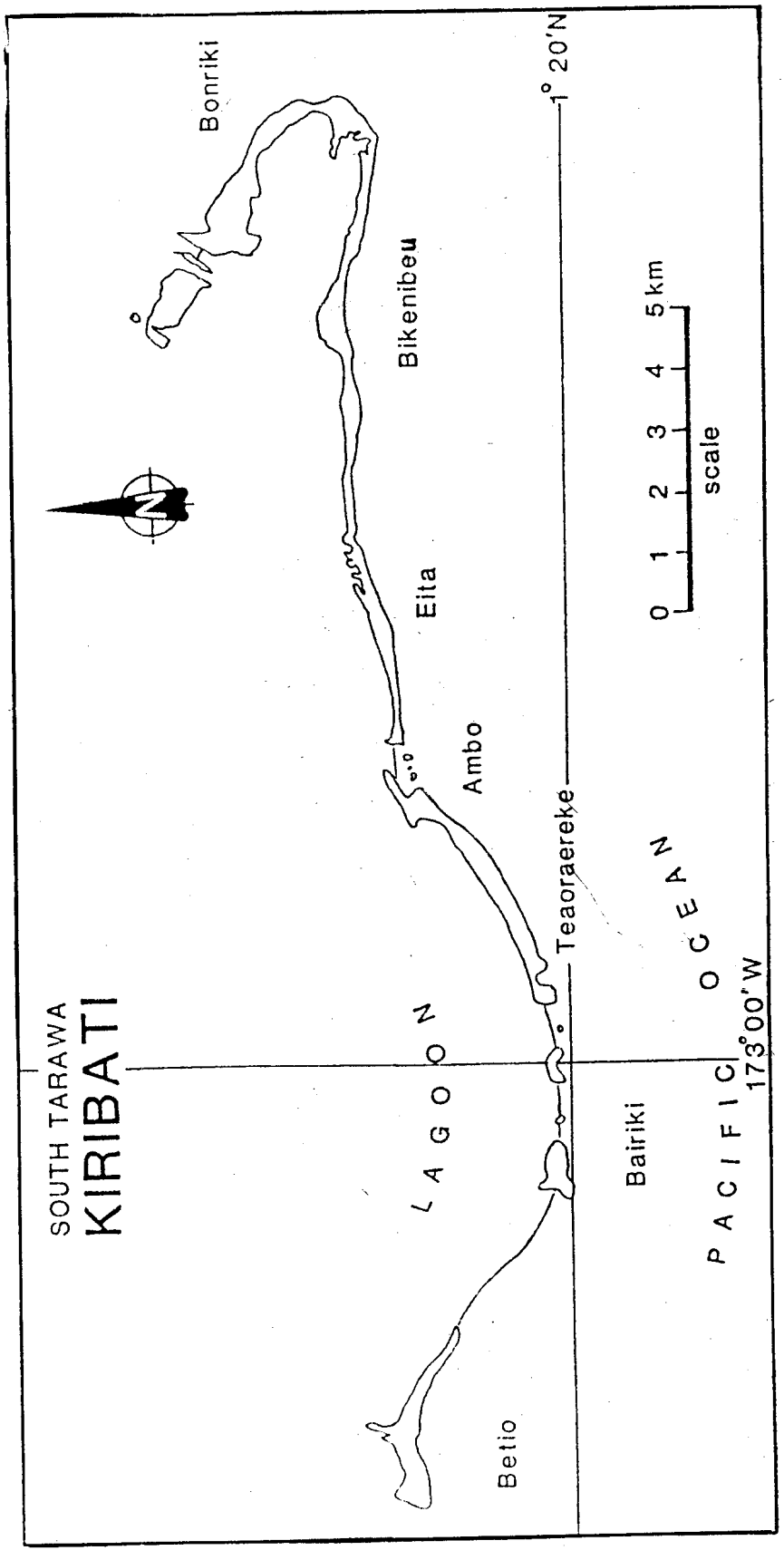


Fig. 2: *Location map of South Tarawa.*



2.3.1 Land

Almost all land in Kiribati is owned by the i-Kiribati (the people of Kiribati), except for the land in the Line and Phoenix groups and small portions of reclaimed land which are owned by the State. Acquisition by sale or gifts is a complex process which requires compliance with the various legislative structures governing land ownership in Kiribati. There is provision for leasing of native land which the State has utilised for development of infrastructure and associated services in South Tarawa.

Population increase arising from urbanisation and the severe shortage of land in South Tarawa for expansion of development activities and the recurrent costs of leasing land has created some interest in the possibility of land reclamation by the State. Land has been reclaimed for many years by private land owners. Under the existing legislation, the Minister responsible may authorise reclamation irrespective of ownership of land boarding on the foreshore or seabed. All reclaimed land would subsequently belong to the State.

2.3.2 Soils

The atoll soils of Kiribati are reported as being possibly the most infertile in the world (UNCED Country Report, 1992). Their properties are consistent with those expected for young atoll soils - shallow, alkaline, coarse textured and mineralogy dominated by carbonates; essentially very similar to the coral-limestone parent material from which they are derived. Potassium, which is one of the three essential nutrients for plant growth, is present in extremely low concentrations and the carbonate mineralogy and the associated high pH values render micronutrients such as trace elements unavailable for plant growth. The fertility of the soils is therefore determined by the organic matter content which is a source of nutrients lacking in the soil. The incorporation of organic matter would thus ensure that some recycling of nutrients would occur. Under these circumstances the practice of discarding large quantities of organic leaf litter as garden wastes daily in South Tarawa would appear to be a needless waste of vital nutrients from an already impoverished soil.

2.3.3 Water

A major source of freshwater on Kiribati is groundwater, in the form of a lens, hydrostatically floating on the higher density saltwater beneath the island. The quantity and quality of the lens water is determined by the shape and width of the islands, the extent of replenishment through rainfall, the amount of water use and degree of infiltration of pollutants and other substances into the lens. On South Tarawa the ground water is extracted and distributed through reticulation to households although wells are also commonly used to access the groundwater. The lens in many parts of South Tarawa are known to be highly contaminated.

Rainwater is also collected for use by some people but there remains considerable additional potential for its use. On Teraina, which is about 3m above sea level there is a relatively large freshwater lake.

2.3.4 Minerals

The mineral resources of Kiribati include: sand, coral, gravel and limestone rock aggregate; tricalcic phosphate rock; guano deposits; and undetermined, potentially important concentrations of deep-sea-bed polymetallic manganese nodules and cobalt-rich crusts.

Sand, coral, gravel and limestone rock deposits are abundant and are consequently being exploited for the purposes of construction and reclamation of causeways, seawalls, fishponds, etc. The environmental implications of unchecked and uncontrolled mining of such material in terms of coastal erosion and disturbance of marine habitats are significant and there have been reports of landowners attempting to seek compensation for damages caused as a result of such activity.

As for phosphate, it is believed that significant amounts still remain on Banaba. Some interest was shown by a mining company in the mid 1980's for remining but the interest has since lapsed due to economic reasons.

Many of the islands of Kiribati have deposits of fossilised sea-bird guano although larger deposits in the Phoenix and Line islands have been mined. Smaller deposits exist elsewhere which could be a source of fertiliser for local use.

2.3.5 Vegetation, Flora and Fauna

The indigenous vegetation and flora of Kiribati are also reported as being amongst the poorest on earth (UNCED Country Report, 1992). Significant modification has taken place through excessive removal and use for construction and other purposes, clearing for agricultural and settlement purposes, foraging by pigs and in the case of Banaba, 70 years of open-cast phosphate mining.

Primary inland forest in the main Gilbert group is reported to be essentially non-existent, having been replaced by coconut-dominated vegetation. Some of the wetter islands of the Line group support closed groves of Pisonia, coconuts and pandanus. House yards and village gardens exhibit a greater proportion of introduced exotics and tree crops such as coconut palms, pandanus, papaya, native fig and breadfruit. Other food plants include the staple giant swamp taro which is also cultivated in excavated pits called "babai" pits.

The fauna of Kiribati is also among the poorest. Its native terrestrial fauna has only one reported endemic veterbrate, the Line islands reed warbler (*Acrocephalus aequinoctialis*), and the only mammal the Polynesian rat (*Rattus exulans*).

2.3.6 Marine Resources

The UNCED Country Report for Kiribati (1992) identifies the crucial importance of fisheries, both to subsistence diet and economic development. The main categories of fisheries resource include: the lagoonal and reef or inshore fishery, the offshore fishery and mariculture or aquaculture of finfish and seaweed. The seaweed *Eucheuma cottonii* is grown on a commercial basis.

In terms of subsistence, the sea and in particular the Tarawa lagoon is used extensively by the local people to obtain food for their daily protein supply. The marine food resources constitute a renewable resource if managed wisely. Traditional conservation practices for sustainability in marine resources are still prevalent, although mostly in rural areas.

2.4 Economy

The constraints to appreciable economic and other development in Kiribati are the severe limitations in the quality and quantity of available land, particularly in South Tarawa and the fragmented and scattered nature of the islands which makes the management of development efforts an extremely difficult one. The country's major asset is the sea but the benefits from it have not been fully realised as a result of the limited capacity of the country to exploit it.

Over 80% of the Kiribati workforce is engaged in subsistence agriculture and fishing. The production base of the country is narrow, with exports mainly of fish and copra, which have been affected negatively by poor fish catches and low world market prices for copra.

As already indicated, infrastructural and economic development is confined largely to Tarawa and Kirimati where public sector and public enterprise activities dominate. The government is responsible for providing essential basic services including electricity generation, fuel supply, communications, shipping, printing, etc.

Kiribati is also highly dependent on external assistance, which since 1982 has been equivalent to around 40% of GDP.

2.5 Environmental Issues

Given the limitations of resources on Kiribati it is a wonder that the i-Kiribati managed to sustain themselves on the islands for thousands of years. They were successful in doing so through the harmonisation of their lifestyles with the constraints of nature. However, changing values and lifestyles, increasing population and urbanisation and the quest for development in the material sense has meant that there has been a departure from the traditional means of the fine act of balancing demands with availability towards lifestyles and attitudes which are resulting in the depletion and degradation of resources more rapidly than their natural capacity for regeneration and rejuvenation.

Herein lies the primary cause of the environmental concerns of Kiribati, significant amongst which are:

- rapid urbanisation in South Tarawa where resources and infrastructure have not been adequate to meet the increasing demand.
- departure from traditional towards more materialistic lifestyles without the necessary knowledge and resources of the "modern" ways of dealing with the pressures on the environment.

The effects of these two features has effected the environment, resulting in coastal erosion, marine resource depletion, and contaminated water supplies.

The draft NEMS report has identified the management of wastes and the control of pollution as one of the major concerns of Kiribati, particularly in South Tarawa where 32% of the population live. Many of the community health problems in South Tarawa are attributed to the contamination of water supplies with human wastes. The management of solid wastes and small but significant quantities of hazardous waste also calls for urgent action.

The use of neighbouring islands and oceanic areas as a dumping site for wastes by others is a concern as is the long term impact of nuclear weapons testing and nuclear pollution on the people of Kiribati. These two issues are not dealt with in this report.

2.6 Environmental Management

The Government of Kiribati (GOK) is acutely aware of the deteriorating quality of the environment in Kiribati, particularly in South Tarawa and has made a commitment both nationally and internationally to take measures for conservation. On the international scale, the GOK is signatory to several treaties and conventions designed to protect the regional and global environment.

Within the country, there is no single comprehensive legislation regulating the management of the environment. Up until recently aspects relating to management of the environment were carried out independently by various sections of the government only to the extent that their normal activities demanded such management.

The Government has taken measures to change the situation by creating an Environment Unit (EU) with the Ministry of Natural Resources Development which is now known as the Ministry of Environment and Natural Resources Development (MENRD). Although various government departments, local government and village councils continue to manage the environment in sectoral manner, the EU is responsible for formulating overall environmental policy in close consultation with the Kiribati Task Force on the Environment (KTFE), an inter-agency body set up initially to guide the preparation of the UNCED Country report and the NEMS report and which now has been given a more permanent stature.

3. Solid Waste

The term *solid waste* has been used in this report to refer to all refuse material generated in homes, offices, businesses, hospitals and other institutions that would normally be accepted for disposal at a municipal waste disposal site. Hazardous or special wastes are considered separately in Section 7.

Depending on the nature of the wastes disposed of at a tip site, the permeability of the underlying material and the proximity of the site to the ocean, any site has the potential to pollute groundwater and the marine environment, either through contamination of surface runoff or through contamination of percolating leachates.

Several reports point to solid waste disposal as being of major environmental concern in Kiribati (e.g. draft NEMS report, Pulea and Farrier, 1992). The lack of a satisfactory solid waste management framework is evident in visual indications of widespread and sometimes illegal open dumping of wastes along many sections of the foreshore. Apart from creating an environment which is aesthetically not pleasing, such practices lead to the degradation of the surrounding marine environment.

In this section an assessment is carried out of the solid waste management framework in South Tarawa and recommendations for improvements where necessary are made.

3.1 Current System of Solid Waste Management

Tulega (1992) has identified the sources of solid waste in South Tarawa as domestic households, institutions (schools, motels, hotel and the hospital) and some industries. A solid waste collection and disposal service is provided in South Tarawa by two local government authorities - the Betio Town Council (BTC) which is responsible for Betio and the Teniano Urban Council (TUC) which covers the area from Bairiki to Temaiku (see Fig. 3).

3.1.1 Legislation for Solid Waste Management

Pulea and Farrier (1992) in their preliminary report on environmental law in Kiribati have reported that provisions for solid waste collection and disposal in environmental legislation are minimal. Public Health Regulations and the Local Government Act were found to contain some vague provisions. The responsibilities of a local government authority are prescribed by the Minister from a long list of activities, amongst which those relating to solid waste management are:

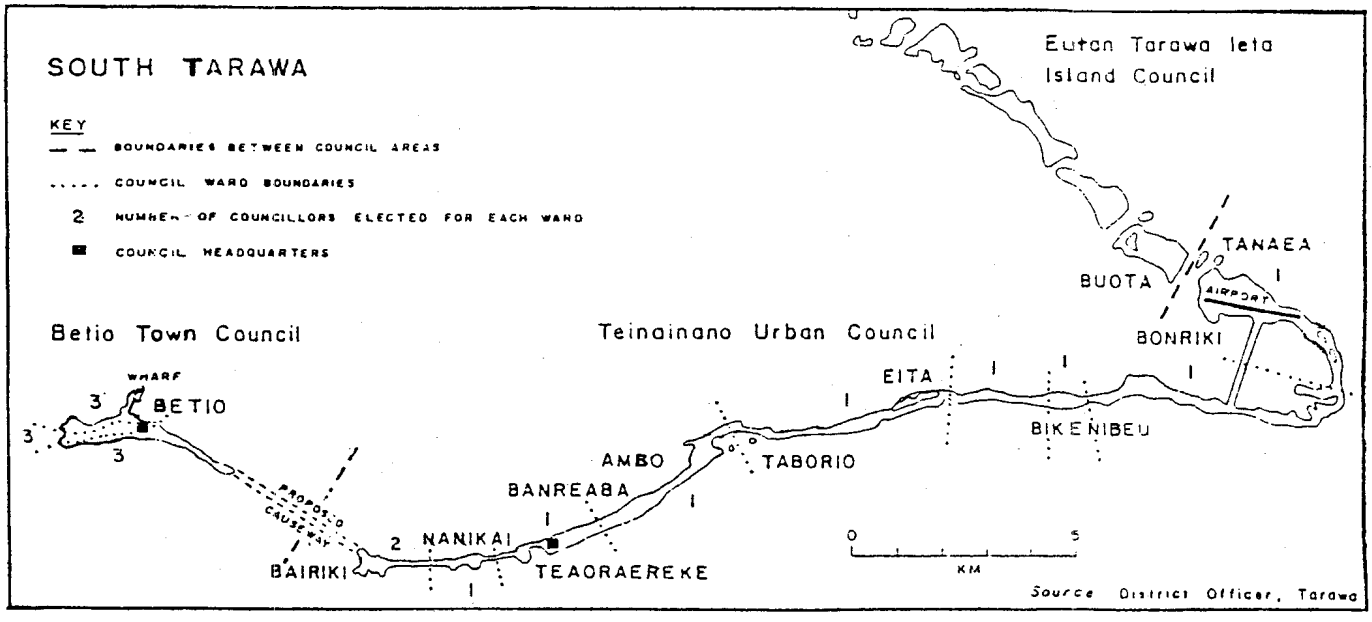
- carrying out sanitary services dealing with rubbish and excreta and prohibiting acts detrimental to the sanitary condition of the area
- preventing and removing public nuisances
- providing that the owners and occupiers of land maintain it, clear it and keep it free of vegetation and rubbish.

The local government authorities have the authority to formulate bye-laws for the execution of their functions. During this consultancy, the BTC and TUC bye-laws were investigated to determine the extent of Council provisions for solid waste management. The two Council by-laws were found to be essentially the same in all respects. Provisions for solid waste management are contained in the Public Health By-laws, including:

- it is an offence to throw or deposit in any part of a village, or in any street or public place any glass, china, earthenware, tin, carton, paper or other refuse, so as to create or tend to create a litter.
- -it is an offence to throw from the land into the sea any material of the nature described above.
- -where any refuse which may become insanitary lies in any land the Council may order owner or occupier of land to clear refuse away.
- the penalty for contravention of the bye-laws is a fine of $20 or in default imprisonment for 6 weeks.

The question of whether legislation covering solid waste management is adequate has to be considered together with whether legislation alone is sufficient to regulate waste management in societies where long entrenched cultural practices dictate to a large extent the means of dealing with such wastes.

Fig. 3: Urban Councils in South Tarawa



For example, although the bye-laws cited above clearly make it an offence for refuse to be disposed of into the sea, this practice is still prevalent as it was one of the traditional ways of disposing of solid waste, occasionally with the deliberate intention of reclaiming land or to protect coastlines from erosion. The Councils appear not to have taken any action against offenders to date.

It was not possible in the time available during the consultancy to establish the extent to which the general public is aware of the regulations but even assuming that it is, the imposition of penalties for contravention as provided for in the bye-laws would hardly be the ultimate solution to the problem of solid waste management. Clearly, public awareness of all waste management issues must be cultivated before enforcement of legislation is attempted.

Notwithstanding these issues, the legislation covering solid wastes is seriously deficient in respect of provisions for means of dealing with or disposing of refuse that safeguard the vulnerable resources of Kiribati. Currently, all solid waste is disposed of in foreshore areas. The Central Land Planning Board is responsible for designating sites for waste disposal.

3.1.2 Refuse Collection and Disposal

It is a common practice among the i-Kiribati to clear their household plots of all leaf litter and other such material every morning. This material together with other household rubbish is generally piled into a heap at the roadside in areas which are in the collection route of the Council vehicles or taken to common collection grounds in other areas not serviced directly. Only a few households consisting mainly those of expatriates and some government officials appeared to be using a receptacle (generally a 44 gallon drum) for on-site storage of refuse.

A business venture dealing with the collection of aluminium cans for recycling overseas was seen to be in place at the time of the consultancy. Although many institutions and households appeared to be collecting cans for supplying the venture, indications were that significant numbers of cans were still being discarded at waste tips.

It was also observed that glass bottles were not usually discarded as household waste. They are partly buried in an inverted position to make boundaries for gravel beds and paths around household plots.

The disposal of bulky wastes comprising old vehicles and other large mechanical structures has been a major problem in South Tarawa. The tendency was for such material to be abandoned at the roadside, along foreshore areas or in household plots. The corroded remains of these are still evident in many areas around South Tarawa. In recognition of the need for an adequate management strategy for such wastes the GOK is undertaking an EEC funded project in which the scrap metal from the bulky wastes will be compacted and sent overseas for recycling.

For the collection of wastes left at the roadside by householders and other institutions, the Urban Councils use a tractor with an attached trailer. Two to three workers use rakes and shovels to load the trailer and the refuse is disposed of at tip sites which are all located in foreshore areas. The BTC uses a tip site at Temakin and the TUC has two disposal sites - at Bairiki and Nanikai. Disposal in other foreshore areas is also carried out if requested by landowners for the purposes of land reclamation. There is essentially no management of the tip sites except for occasional burning when the waste heap becomes unmanageable. There are no containment walls and wastes get easily dispersed by the seawater and deposited in adjacent foreshore areas.

The reason for using foreshore areas for waste disposal appears to be the desire to reclaim land as a consequence of the severe shortage of land in South Tarawa for further development. A land reclamation feasibility study was commissioned by the GOK in 1985 which concluded that there were substantial areas around South Tarawa that could be reclaimed although it was made abundantly clear that such developments would have to be preceded by detailed investigations of the dynamics of coastal processes, particularly sediment movements. No detailed investigations of this nature appears to have been carried out yet. The importance of such studies is highlighted by the coastal landform changes brought about since the construction of the causeways and the implications that the causeways themselves may be responsible for some of these changes.

Land has been reclaimed as a result of waste disposal at the Temakin site to the extent that the original coast line has been extended further towards the sea by approximately 50 metres. However the quality of the reclaimed land is very poor as evident from the extremely uneven surface and marshy nature of the ground in some areas.

This appears to be due to the largely organic nature of the waste disposed of at the site and the differential subduction of the underlying material arising from the different degrees of decomposition of the component materials. It would seem that the land would continue to undergo alterations as the material decomposes further and therefore the land cannot be used for any immediate developments. The effect of coastal processes such as interference with sediment movements as a result of reclamation can also not be predicted in the absence of proper investigations of the nature described above.

However, even if the changes brought about by the above two factors are of no concern in the use of foreshore areas for waste disposal, the issue of contamination of the surrounding marine environment with leachates from the dump site should be a deterrent, particularly as more and more hazardous substances find their way into the dump site. Thus the long term benefits, if any, to be derived from land reclamation through waste disposal at foreshore areas does not seem to justify the potential for degradation of the marine environment.

Another option for waste disposal that appears to have been considered, although only peripherally, is inland landfill areas. This is an extremely risky proposition in view of the reliance of the people on ground water that has already deteriorated significantly in areas, the shallow groundwater table and the extreme permeability of the soils. This option should be ruled out completely.

So the question arises: *What is the best solid waste management strategy for Kiribati?* To answer this question satisfactorily, it is essential to have information about the amounts and types of solid waste that are generated in South Tarawa which hitherto was not available. Thus a solid waste generation survey was conducted during this consultancy to obtain this information. This is detailed in Section 3.2.

3.2 Solid Waste Generation Survey

Tulega (1992) identified domestic households as contributing approximately 87% to the total amount of solid waste generated in South Tarawa. On the basis of this information, a domestic solid waste generation survey, procedural details of which are given in Annex 3, was carried out in Bairiki to determine the:

- the rate of waste generation in Kg/person/day which would be used to determine the total amount of wastes that are generated and that would need disposal
- the bulk density of the waste which would enable decisions to be made on whether the waste can be compacted and thereby be of use for dump site management
- the percentage composition of the waste which is necessary to determine the potential for recycling.

It was assumed that the waste generation patterns amongst locals in Bairiki would be representative of those of South Tarawa.

3.2.1 Results of the Survey

The results of the survey are given in Table 1. The survey samples consisted largely of local households although a number of expatriate households were also included for comparison purposes.

During the course of the survey it became evident that the characteristics of solid waste generation from local households were quite different from those of expatriate households and the results from these sources were therefore treated separately. In addition, the waste generation from local households did not appear to be determined by the number of people in the household. The amount of waste generated by a local household consisting of only a few individuals was occasionally greater or almost always equal to the amount of waste generated by a household consisting of many more individuals. For this reason the wastes generated from local households is interpreted in terms of kg/household/day.

Some of the obvious features of the results are:

- Amongst locals, the bulk of the waste generated arises from the garden or household plots which consists essentially of dry breadfruit leaves and some sand swept up with the leaves. The lightness of this material imparts a very low bulk density of 100 kg/m^3 which under normal circumstances would be expected for highly developed countries with a significant proportion of consumer packaging material.
- the next most significant constituent of the refuse from locals is metals which consisted mostly of beer cans. Even though there is an aluminium can collection operation on South Tarawa, significant numbers of cans were found to be discarded in the waste. The effectiveness of the recycling venture has to be increased.

Table 1: Waste Generation Characteristics in Bairiki

	Locals	Expatriates
Generation rate	4.2 kg/household/day	0.6 kg/person/day
Bulk density	100 kg/m^3	130 kg/m^3
% Composition		
Food and vegetable	5	33
Paper	2	22
Textiles	<1	<1
Plastics	2	12
Garden	75	<1
Metals	7	16
Glass	3	17
Others	6	<1

- on a household basis, the locals are producing more refuse than expatriates. The rate of generation amongst expatriates is 0.6 kg/person/day. Assuming an average expatriate household of four persons this would result in an output of 2.4 kg/household/day, approximately half the amount generated by local households.
- the food and vegetable output from local households is very much smaller than those of expatriate households. This is not unexpected as most locals feed such material to their pigs.
- packaging material such as paper, plastics, glass and metal make up much greater proportions in expatriate waste. With increasing consumerism amongst locals their waste generation patterns could be expected to resemble those of expatriates.

3.2.2 Implications of the Results

The data generated by the survey can be used to estimate the amount of space required for waste disposal. With a waste generation rate of 4.2 kg/household/day and a total household count of 3,268 in South Tarawa (1991 census), the amount of waste generated per year would be approximately 5000 tonnes. A bulk density of 100 kg/m^3 would mean that the total volume of this waste will be 50,000 m^3. Considering the small bulk density, the waste could probably be compacted to half its volume, ie to 25,000 m^3 and decomposition of the largely organic material could further reduce it by half, ie to 12,500 m^3.

If the wastes were to be disposed of at site to a height of 1 metre then a surface area of 12,500 m^2 or 0.0125 km^2 would be required per year. This means that an area the size of Bairiki (about 0.5 km^2) would probably be covered in 40 years.

The above crude calculation does not take into account the future increases that could be expected in both the number of households and the amount of waste generated by each household. Such considerations would reduce the time required to fill a given area.

The important point that should be noted is whether the GOK is prepared to allocate such land area for waste disposal when there is already so much pressure from other quarters for land.

The survey data can also be used to determine the amount of useful nutrients that are wasted if leaf litter is discarded in waste tips. Of the 5000 tonnes of waste produced annually, 75% or 3,750 tonnes is leaf litter which consists essentially of dried breadfruit leaves. There is some belief that the drying and falling of leaves is accompanied by a significant reduction of the nutrient content of the leaf material.

Green and dry breadfruit leaves were therefore analysed for their nitrogen, phosphorus and potassium content. The results in Table 2 show that nitrogen and potassium (but not phosphorus) concentrations in the leaf tissue are reduced considerably with drying.

Nevertheless, 3,750 tonnes of leaf litter is equivalent to a loss of 14.25 tonnes of nitrogen, 12.75 tonnes of phosphorus and 7.13 tonnes of potassium from soils of South Tarawa annually. Should the GOK allow such a waste of nutrients from soils which are already seriously deficient in nutrients. Clearly the circumstances of Kiribati would tend to suggest that a programme of organic matter incorporation and waste minimisation for other waste constituents would be the best strategy.

If a waste management strategy of the nature proposed in the next section is followed the need for a waste disposal site would be removed. The terms of reference relating to disposal site management are therefore no longer applicable.

Table 2: Mineral Composition of Breadfruit leaves, in Tawara, Kiribati.

	Green leaves	Dry leaves
Nitrogen (g/100 g dry matter)	2.2	0.38
Phosphorus (g/100 g dry matter)	0.34	0.34
Potassium (g/100 g dry matter)	0.66	0.19

The *Public Health Act and Regulations* contain general provisions for enhancing and maintaining sanitation and community health of the people of Kiribati. Under the Public Utilities Ordinance, the Public Utilities Board (PUB), a government owned corporation under the Ministry of Works and Energy, is given exclusive rights over the supply of water in any designated area. At the moment, however, its operations are only limited to South Tarawa and Tanaea in North Tarawa. Groundwater from two areas at Buota and Bonriki are drawn and distributed to all areas.

The PUB has power to declare any area as a water reserve. However, in some reserve ares there have been problems with people squatting on the land and constructing toilets and wells which expose the groundwater to potential pollution. Any acts which cause contamination of the water supply is punishable with a fine of up to $50 or 3 months imprisonment. However prosecutions are wrought with culturally sensitive issues of land and resource ownership.

Pulea and Farrier (1992) point out that the President, with advice from Cabinet, has power to make regulations to prevent pollution of any water, as well as ensure sanitary control of water reserves. Regulations preventing contamination of water supplies can also be made under the Public Health Act.

With regard to sewerage, the PUB also has the exclusive right to perform functions relating to the supply of sewerage facilities and the disposal of sewage. In practice, the PUB is only involved in these services in areas which are served by the centralised sewerage system, in Betio, Bairiki and Bikenibeu. Considerable problems with both its effective use and maintenance have been reported that tend to detract from the original objective to protect community health and sanitation. These are discussed in more detail later.

In areas which are not under the control of the PUB, theoretically the local government authorities are responsible for regulating sewerage facilities. Under the Local Government Act the local councils can be made responsible for:

- formulating building regulations in relation to sanitation facilities;
- carrying out sanitary services dealing with rubbish and excreta and prohibiting acts detrimental to the sanitary condition of the area; and,
- preventing water pollution.

The by-laws of the local government authorities have the following provisions for regulation of sewage disposal:

Building By-laws

- every building other than a reef latrine to have proper guttering and water storage
- adequate provisions for the satisfactory carriage and disposal of all rainwater, surface water, wastewater or sewage

Control of Animal By-laws

- pigs to be confined in a pen and the pen to be kept clean
- the pen is not to be constructed within 100 ft of a well, street, building or dwelling.

Public Health By-Laws

- no person on any beach can do any act which is likely to damage, foul, litter, deface or disorder the beach or anything situated thereon;
- no person shall erect a latrine on a beach without Council permission;
- beach latrines are to be constructed such that discharge is covered at low tide;
- no person is allowed to bathe or wash or collect shellfish within 100 ft of a latrine;
- every well shall be walled or fenced to a height of 2 ft above level of the surface, be walled from surface to base and be kept clean and wholesome at all times;
- no person shall bathe or wash or do any act likely to foul or pollute the area surrounding the well, within a distance of 50 ft from a well; and,
- no person shall defecate or urinate in any open space within 50 ft of any dwelling or building or in any street or public place.

Contravention of any of the above by-law would lead to a fine of $20 or in default imprisonment for 6 weeks. As is obvious from the above by-law there is adequate provision for the regulation of human and animal waste disposal by the Councils to protect community health and the environment. However, the Councils are not actively involved in such activities.

3.3 Solid Waste Management Strategy for Kiribati

The solid waste generation survey has revealed that most of the waste is essentially organic in nature. Bearing in mind the severe shortage of land and the vulnerability of the environment, the most sensible waste management strategy would appear to be organic matter incorporation or composting and waste minimisation in other areas. Ways in which this could be accomplished are outlined below:

3.3.1 Organic Matter

As stated earlier, loss of valuable nutrients from already infertile soils could be considerable if organic matter is continually discarded. The community must be made aware of this loss and be encouraged to practice composting.

Some householders appeared to be already doing this by constructing containment areas around breadfruit trees and depositing all leaf litter within. However, more widespread community participation is necessary before any major impact on the amount of waste generated is felt.

The concept of organic matter incorporation is obviously not alien to the people as such a practice was necessary for the cultivation of "babai" pits. For this reason it would not be difficult to solicit community participation for this strategy to be a success. It is strongly recommended that a study be undertaken to determine ways in which community participation in composting organic waste material can be achieved.

3.3.2 Metals

There is already provision for the collection of aluminium cans for recycling overseas by a private venture but significant number of such cans are still being discarded elsewhere. The effectiveness of this venture must be increased to a level that completely alleviates the problem of aluminium can disposal. The business enterprise should receive full government support and any taxes being imposed should be removed.

Other metallic objects needing disposal can be crushed and compacted with bulky wastes in the EEC funded project.

3.3.3 Glass

Alternative uses for glass, such as already described must be encouraged and the viability of exporting overseas for recycling also investigated.

3.3.4 Paper and Plastics

Recycling would obviously be the best option for the disposal of all materials but the recycling of plastics in particular is a complicated process. In view of the small amounts being generated at the present time some other means of disposal may be more suitable. High temperature incinerators are not very popular but considering the special circumstances of Kiribati, a strategically located incinerator operated with very strict controls may be an option. However the environmental and other implications of installing such an incinerator should be very carefully considered against other disposal options.

Although wastes consist mainly of organic matter at present, this situation is not likely to continue with increasing consumerism. In order to ensure that the proportion of non-biodegradable material remains manageable, the GOK should explore the possibility of imposing strict controls of the importation of material with such packaging material.

3.4 Recommendations

It is recommended that:

- a solid waste management strategy be undertaken that is geared towards organic matter incorporation and waste minimisation.
- a study be undertaken to find ways in which community participation in organic matter incorporation efforts can be obtained.
- the aluminium can collection and recycling venture currently in place be made fully effective with total government support and removal of taxation.
- a high temperature incinerator be considered as an option for disposal of small quantities of non-biodegradable wastes.

- on a household basis, the locals are producing more refuse than expatriates. The rate of generation amongst expatriates is 0.6 kg/person/day. Assuming an average expatriate household of four persons this would result in an output of 2.4 kg/ household/day, approximately half the amount generated by local households.
- the food and vegetable output from local households is very much smaller than those of expatriate households. This is not unexpected as most locals feed such material to their pigs.
- packaging material such as paper, plastics, glass and metal make up much greater proportions in expatriate waste. With increasing consumerism amongst locals their waste generation patterns could be expected to resemble those of expatriates.

3.2.2 Implications of the Results

The data generated by the survey can be used to estimate the amount of space required for waste disposal. With a waste generation rate of 4.2 kg/household/day and a total household count of 3,268 in South Tarawa (1991 census), the amount of waste generated per year would be approximately 5000 tonnes. A bulk density of 100 kg/m^3 would mean that the total volume of this waste will be 50,000 m^3. Considering the small bulk density, the waste could probably be compacted to half its volume, ie to 25,000 m^3 and decomposition of the largely organic material could further reduce it by half, ie to 12,500 m^3.

If the wastes were to be disposed of at site to a height of 1 metre then a surface area of 12,500 m^2 or 0.0125 km^2 would be required per year. This means that an area the size of Bairiki (about 0.5 km^2) would probably be covered in 40 years.

The above crude calculation does not take into account the future increases that could be expected in both the number of households and the amount of waste generated by each household. Such considerations would reduce the time required to fill a given area.

The important point that should be noted is whether the GOK is prepared to allocate such land area for waste disposal when there is already so much pressure from other quarters for land.

The survey data can also be used to determine the amount of useful nutrients that are wasted if leaf litter is discarded in waste tips. Of the 5000 tonnes of waste produced annually, 75% or 3,750 tonnes is leaf litter which consists essentially of dried breadfruit leaves. There is some belief that the drying and falling of leaves is accompanied by a significant reduction of the nutrient content of the leaf material.

Green and dry breadfruit leaves were therefore analysed for their nitrogen, phosphorus and potassium content. The results in Table 2 show that nitrogen and potassium (but not phosphorus) concentrations in the leaf tissue are reduced considerably with drying.

Nevertheless, 3,750 tonnes of leaf litter is equivalent to a loss of 14.25 tonnes of nitrogen, 12.75 tonnes of phosphorus and 7.13 tonnes of potassium from soils of South Tarawa annually. Should the GOK allow such a waste of nutrients from soils which are already seriously deficient in nutrients. Clearly the circumstances of Kiribati would tend to suggest that a programme of organic matter incorporation and waste minimisation for other waste constituents would be the best strategy.

If a waste management strategy of the nature proposed in the next section is followed the need for a waste disposal site would be removed. The terms of reference relating to disposal site management are therefore no longer applicable.

Table 2: Mineral Composition of Breadfruit leaves, in Tawara, Kiribati.

	Green leaves	Dry leaves
Nitrogen (g/100 g dry matter)	2.2	0.38
Phosphorus (g/100 g dry matter)	0.34	0.34
Potassium (g/100 g dry matter)	0.66	0.19

Indications from TUC were that building plans brought in for approval were required to have adequate provisions for wastewater disposal but once permits were granted there was no follow up to determine whether requirements were complied with. Part of the problem seems to be the lack of manpower in the Council staff to address these issues and also the reluctance by Council staff to interfere with traditional behavioural patterns of the people.

In spite of the above difficulties, Pulea and Farrier (1992) have identified a lack of coordination and acknowledgment of responsibility by the various agencies involved in water supply and human and animal waste disposal which would need to be addressed before the overall management situation can become fully effective.

4.1.2 Sewage Disposal and Water Quality

The present reticulated sewerage system on South Tarawa serving most of the densely populated areas of Bikenibeu, Bairiki and Betio uses salt water flushing systems with discharge through ocean outfalls in each of the three areas. There is direct connection to some houses and offices whilst others are serviced through connection to toilet blocks, each block servicing about six or seven households in an area.

A salt water flushing system has also been installed at the new hospital where wastes are discharged into a septic tank with the effluent being pumped out and discharged through a separate ocean outfall. No provision is in place for emptying the septic tank.

The remaining areas of South Tarawa are not sewered and rely on other means of human waste disposal such as pit latrines, septic tanks and the use of beaches and other areas. Table 3 which contains statistical information from the 1991 Census shows the extent of use of each type of facility in different areas of South Tarawa. Careful inspection of the statistics reveals that in some areas householders must be using more than one type of disposal system as the sum of the households in the different categories exceeds the total number of households recorded for that area.

The use of more than one type of disposal system is not unexpected but the interpretation of the data becomes somewhat complicated. Nevertheless, the statistics show that significant numbers were still defecating on the beach in 1991. Investigations during this consultancy suggest that the situation has not changed since then. The practice of using the beach has been in existence for a long time and it is reportedly difficult to change peoples behaviour in this regard in the short term.

The performance of the reticulated sewerage scheme has deteriorated as a result of inadequate maintenance of the system. Some seventy percent of the toilet blocks are believed to be unserviceable. The toilet block concept in general has not been a success because the householders were reluctant to walk long distances to toilet blocks when the beach was more convenient. The deteriorating quality of the mechanics (pumps, fittings, etc) of the sewerage system often results in the emanation of extremely foul odours. There is a possibility that leakages may be occurring and infiltrating the groundwater but this possibility has not been investigated.

The environmental effects of the discharge of untreated sewage via outfalls into the marine environment on the ocean side were studied by Bellair et al (1985). The study concluded that sewage was undergoing satisfactory dilution and that very few people would be exposed to faecal coliform levels in excess of those regarded environmentally safe.

The situation with pit latrines and septic tanks is that there is always the possibility of leachates entering the groundwater. Although it is required by law that reserve areas used for extracting water for reticulation purposes remain free of human habitation, there have been problems with people squatting in these areas and constructing open pits for water extraction and waste disposal thereby exposing the water lens to potential contamination. In other areas pit latrines are believed to be constructed dangerously close to wells that are used to access the groundwater. Animal wastes from pigs is also a source of pollution of the groundwater.

Table 3: Summary of Statistical Information from 1991 Kiribati Census.

LOCATION	POPULATION 1990	No OF HOUSE HOLDS	PERSONS PER HOUSEHOLD	TOILET BLOCK	COMM-UNAL TOILET	HOME FLUSH TOILET	WATER LATRINE	LAGOON BEACH	OCEAN BEACH	OTHER	RAIN WATER TANK	PIPE SYSTEM	OPEN WELL	PROTECTED WELL	OTHER
TANAEA	77	12	6.42			10	1	4	2	1	11	a	1		1
BONRIKI	929	124	7.49	9	10	2	5	85	47	33	9	79	45	4	1
TEMAIKU	410	72	5.69	8	3	2	10	7	44	25	11	20	52	7	15
ANANAU C/WAY	785	101	7.77	2	1	6	27	49	63	21	17	37	71	12	4
BIKENIBEU	5055	602	8.40	220	32	168	94	124	107	14	211	523	289	58	10
ABARAO	458	67	6.84	1		13	10	24	49	2	18	52	34	11	
EITA	1182	165	7.16	10	16	27	66	82	105	53	41	112	94	46	31
TANGINTEBU	164	27	6.07	1	1	12	3	11	13	4	11	7	8	5	1
TABORIO	434	51	8.51	7		13	22	35	37	4	18	44	14	15	1
AMBO	652	91	7.16	1		13	8	64	56	5	22	64	12	24	1
BANRAEBA	789	104	7.59	10	4	11	16	61	73	5	18	51	42	58	4
ANTEBUKA	467	55	8.49	6	2	18	12	25	25	16	14	24	13	23	1
TEAOREREKE	1677	210	7.99	13	30	33	28	122	146	44	55	68	105	33	27
NANIKAI	623	82	7.60	2		1		79	81		16	81	1	1	
BAIRIKI	2228	293	7.60	190	39	1	18	15	18	1	137	253	107	66	6
TAKARONGA	4590	608	7.55	309	82	188	26	62	91	16	254	528	154	58	15
TEMAKIN	4636	604	7.68	210	129	240	41	82	96	54	290	475	119	30	31
TOTALS	25154	3268	7.70	999	349	758	387	931	1053	298	1153	2 46	1141	451	149
PERCENTAGES				30,57	10.68	23.19	11.84	28.49	32.22	9.12	35.28	74.85	34.91	13.80	4 56

Table 3 also includes data on the sources of fresh water for householders in different areas of South Tarawa. If the number of householders using an open well is combined with those using a protected well, then the proportion using wells for some of its fresh water needs is 49%. This is quite a significant proportion considering that reticulated water which has been treated is theoretically available in all areas included in Table 3.

The reason for this appears to be the inability or unwillingness of people to meet the cost of the reticulated water and their subsequent need to use well water to supplement their fresh water needs for washing, bathing, etc. However, this pattern of water use should be a cause for concern in areas where the ground water is known to be contaminated because infection from contaminated utensils could also occur.

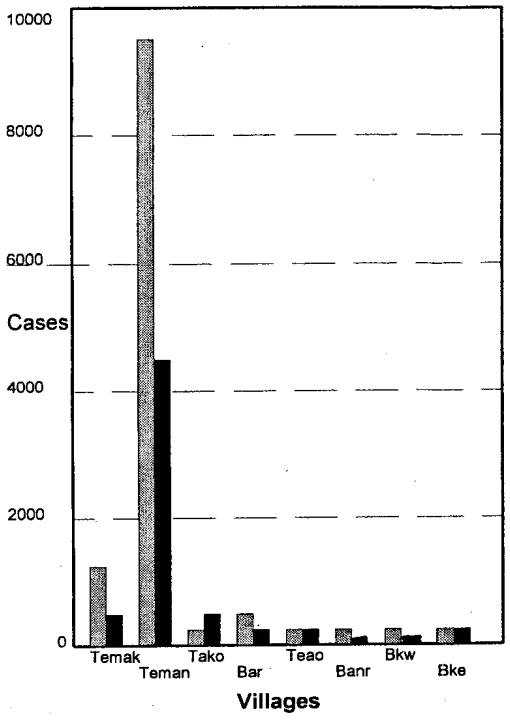
Investigations during this consultancy suggest that the groundwater in Betio where many householders still rely on wells, may be contaminated with human or animal waste. A recent study of water quality in Tarawa lagoon (Kelly, verbal communications) has shown that many nearshore areas continue to be contaminated with faecal coliform levels far in excess of those considered safe for primary contact or shellfish culture.

4.1.3 Water Quality and Community Health

Fig. 5 presents information about the number of diarrhoeal cases recorded in different areas of South Tarawa in 1992 and 1993. Although the distribution is strikingly obvious with the central area of Betio, identified as TEMAN in Fig. 5 having by far the largest number of cases, the information must be interpreted with some caution with due consideration given to the factors causing such high numbers to be recorded.

Firstly, it should be remembered that the information presented in Fig. 5 is the number of cases that were reported at health centres in the various areas and not the actual number of incidents that may have occurred. Thus the number recorded at any particular site would be affected by the accessibility of the health centre to the people. Secondly, central Betio has the highest population density of all area in South Tarawa and therefore more infections would be expected.

Fig. 5: Geographic distribution of cases of diarrhoea in South Tarawa.



Temak - Betio, at site of waste dump.
Teman - Central Betio
Tako - Eastern side of Betio
Bar - Bairiki
Teao - Village near Atoll Research Programme
Banr - Village near Tarawa Motel
Bkw - West Bikenibeu
Bke - Bikenibeu, near St. Mary's Church

However, high population densities in themselves do not cause diseases. The causative agent is the presence of pathogenic organisms and high population densities contribute towards the widespread dispersion of the infection. A study should nevertheless be carried out to determine whether the water quality is a major cause of the community health problems in Betio.

4.2 Initiatives for Improvement of Human Waste Disposal

The issue of human and animal waste disposal and water quality is a vulnerable environment such as that of Kiribati is understandably a complex and difficult problem, especially in the absence of sufficient resources to instate a safe and effective community sewage collection and treatment system that services every household. The various choices for human waste disposal available to people all impose some degree of risk for contamination of water resources and fisheries. The issue obviously needs urgent attention. Some initiatives that have been taken to address the problems are:

- *a request by the GOK to Australia for assistance with upgrading sanitation and water supply facilities.*

  A field appraisal of the request has recently been completed and has concluded that technical assistance alone would not be effective in improving community health and the environment in South Tarawa. It was recommended that a multidisciplinary approach addressing all aspects of community health such as engineering, health and hygiene education, family planning, social mobilisation, financial management, institutional streng-thening, land use planning, etc be undertaken. The project would be expected to run for at least 10 years with annual budgets of the order of several million dollars.

  Clearly, without several major donor support this type of a project cannot be implemented and therefore long term solutions are dependent to a large extent on whether the GOK is able to secure funds to undertake such a project.

- Bio-Systems Analysis, a programme funded by USAID has been involved for some years in *a comprehensive study of the factors controlling the health of the Tarawa lagoon with a view to formulating a management strategy* for it. It is hoped that as a result of this study steps can be undertaken to improve the quality of both the water and the fisheries in the lagoon.

- In recognition of the preference of people to have latrines nearer their homes, a *WHO project for latrine construction using sound design specifications was undertaken for the non-sewered areas of South Tarawa and the Outer Islands.*

  The project was handed over to the Ministry of Health with WHO providing the basic equipment. This project was subsequently transferred to the TUC.

  Problems with improper implementation of this project have been reported, particularly as a result of inadequate supervision of toilet installations. This state of affairs is unfortunate especially as the satisfactory implementation of this project could have solved some of the problems in this area. The project needs to be reevaluated to determine the degree of success achieved in fulfilling the original objectives.

- the draft NEMS document reports *a proposal for a pilot study into alternative sanitation technology* that is both environmentally friendly and culturally acceptable. Three types of bio-toilet systems would be investigated: a) Closed, bio-toilets with fertiliser production for individual householders; b) Sealed tank toilets with pumper truck collection, biogas production and fertiliser production; and c) the "Enviroflow" biofilter system which can provide waste and wastewater treatment for communities ranging from 10 to 5,000 people.

  The above proposal appears to be a very worthwhile initiative and should be given high priority among the various programme profiles in the draft NEMS document. Funding of this project should be contingent on the continuous monitoring and evaluation to ensure the project is concluded in a satisfactory manner.

4.3 Recommendations

It is remmended that:

- the GOK continue to seek satisfactory solutions to the water quality and community health problems of Kiribati and South Tarawa in particular.
- a proposal for a pilot study into alternative sanitation technology in the draft NEMS document be given one the highest priority in the programme profiles.
- any project undertaken to address water quality and community health problems be monitored continually such that they are completed satisfactorily.
- a community awareness campaign on water quality and sanitation be carried out.

5. Industrial Wastes

In the island countries of the South Pacific, it is generally found that industries and other related enterprises, which are almost exclusively situated in areas very close to the sea, discharge their wastes directly into the sea, often with very little prior treatment. The water bodies into which these wastes are discharged are often enclosed by the land on one side and fringing coral reefs on the other so that water exchange with the open ocean water is limited. Under these circumstances, there is bound to be some impact on the quality of the marine environment.

The level of industrial development in Kiribati is almost negligible and one could therefore be led to believe that industrial wastes do not pose a significant threat to environmental quality in Kiribati. While this may be true to some extent, it must be remembered that wastes which are usually considered under the category of industrial wastes may also be generated through activities which are not strictly industrial processes as such.

Oil storage depots, for instance, are the source of petroleum-based wastes in a number of South Pacific island countries. There are two oil storage depots in South Tarawa as are other service industries (power generation, vehicle maintenance, etc) which could generate industrial wastes. All such establishments were visited during the consultancy.

In this section, the wastes produced by establishments of the above nature are described and an attempt is made to identify those that are likely to have an impact on the environment. But first, the level of legislative control on industrial waste discharge is investigated.

5.1 Legislative Control

There is no specific legislation for protection of the environment against pollution from industrial wastes. Some general legislation is in place which requires the protection of resources, including protection from pollution but the nature of pollution, especially from land-based sources is not specified.

There is some provision for the enactment of regulations within certain acts. Examples of legislation with general provisions for protection against pollution include:

- *Local Government Act 1984*, through which local councils can be made responsible for the prevention of water pollution. Further provisions are present in Council by-law.
- *Marine Zones Act 1983*, which contains powers for regulations to be made in relation to measures for the protection and conservation of the marine environment.
- *Fisheries Ordinance 1977*, which refers to the President's power to make regulations relating to the conservation and protection of all species of fish.
- *Public Utilities Ordinance*, which make it an offence to pollute a water reserve or water supply. Again, the President has powers to make regulations to prevent pollution of any water. Similar provisions are present in the Public Health Act.
- *Harbours Ordinance*, which prohibits the discharge of oil into the harbour by any vessel or shore installation. Offenders can be fined $100 and imprisoned for six months in default, as well as being required to clean up.

5.2 Sources of Industrial Waste in Kiribati

All industries and related establishments are confined almost exclusively to South Tarawa. Representative establishments from the categories described below were visited and information about the nature of wastes generated obtained.

5.2.1 Power Generation Plant

There is one diesel-powered electricity generating plant (2.6 Megawatt capacity) on Betio which services all of South Tarawa. The diesel consumption is 40,000 litres per week.

The wastes generated include exhaust smoke (which could include toxic gases), waste oil and cleaning water which may be contaminated with oil. The smoke is released into the atmosphere through a chimney which is almost at the same level as the roof of the plant. Although the bulk of the exhaust is probably blown over the lagoon and not towards human settlements on South Tarawa, it would be desirable for the chimney to be extended and a scrubber put in to "detoxify" the exhaust gases.

The disposal of waste oil appears to be a problem. Although some waste oil was reported to be given to the Marine Training School for their fire fighting drills, this means of disposal is not adequate. According to the management of the PUB, a volume approximating 12,000 litres of waste oil was in storage at the time of the consultancy and no suitable method of disposal was in sight. Obviously there is an urgent need for an environmentally safe method of disposal to be found.

The cleaning water from the plant is allowed to seep into the ground which could be a source of contamination of the groundwater. Some mechanism for containment and treatment of cleaning water is necessary.

5.2.2 Oil Storage Depots

There are two oil storage depots in South Tarawa - the Kiribati Oil Company which imports benzine, kerosene and diesel; and Air BP which imports aviation fuel. The Kiribati Oil Company facility was visited and the following information on consumption for 1992 was made available:

Table 4: Consumption of Oil Products in Kiribati in 1992.

Products	Consumption (litres)
Benzene	2,675,147
Kerosene	969,388
Diesel	6,110,752

When a shipment of oil products arrives, the oil products are pumped into tanks on land through a pipeline with seawater being pumped in between different products. Before filling a land tank with any particular product, the pipeline is cleared of seawater (normally contaminated with oil). The seawater is fed into a separator which separates the oil from the seawater. The oil from the separator can be a mixture of different products and is considered to be waste oil. The seawater which could still retain some oil is discharged into Betio harbour. The fate of the waste oil was not made very clear although there were some indications that it was pumped out and left to seep into the ground within the storage yard.

5.2.3 Mechanical Garages

There are numerous small mechanical garages in South Tarawa but the only one of major significance is the Plants and Vehicle Unit under the Ministry of Works and Energy. The wastes generated by this Unit are waste oil (consisting of various vehicle repair and maintenance fluids) and scrap metal. It was estimated that every four years, about thirty to forty government vehicles went off the road. Some abandoned vehicles were kept for spare parts and others taken for the scrap metal venture. Some waste oil was given away but the bulk of it (5 to 6 drums per month) was dumped at the Temakin tip site.

5.2.4 Photoprocessing and Printing

There are two such establishments - the Uekara Printery and the Government Printery both of which were visited. The Uekara Printery takes on about 10 printing jobs per month whereas the Government Printery has about 50 per month. The wastes consisting of printing and photoprocessing chemicals are washed down the sink.

5.2.5 Food Processing

Only two food processing factories were reported to be present in South Tarawa - the Tarawa Biscuit Co. Ltd. and the Outer Island Fisheries Project. The biscuit factory was found to generate very little waste let alone wastes that could contaminate the environment. The fisheries project was only involved in the filleting and some basic preservation of fish fillets. The only wastes produced were approximately 100 kg per week of fish parts not suitable for processing. These were either sold off cheaply or thrown into the nearby sea.

5.3 Assessment of Pollution from Industrial Wastes

One particular type of industrial waste stands out as being of considerable risk to the fragile environment of Kiribati - petroleum and oil related products. Investigations carried out during this consultancy have revealed that large amounts of these substances are being generated as wastes and disposed of in a manner that is likely to contaminate the environment.

At the oil storage depot, there is a separator to separate the bulk of the oil from the seawater that is released back into the ocean. However, there is no monitoring of the performance of the separator to establish that oil remaining in the water has been reduced to an acceptable level. There is therefore the possibility that some oil is being discharged into the marine environment. The presence of small amounts of oil in the water will not bring about any immediate visual changes in the quality of the environment but the ecological risk of chronic sources of petroleum contamination is probably much larger than has yet been established.

In other places waste oil is allowed to seep into the ground quite freely. Considering the importance of groundwater as a source of water for the people and the ease with which groundwater can get contaminated, this type of practice must be stopped immediately.

5.4 Regulation of Industrial Discharge

Relatively little is being done by regulatory authorities at the present time to control discharge of industrial wastes. This is not surprising as authorities were probably unaware of industrial wastes as being of major concern in the environmental scenario. This report has found that attention needs to be directed in this area as well, particularly where disposal of petroleum and other waste oil products are concerned.

Some regulatory mechanisms would have to be introduced. However, it should be remembered that a vigilant regulation of oil discharges would require regular monitoring to ensure that acceptable criteria are met which, in the absence of regulations specifying acceptable levels and laboratory capability for testing, would remain a difficulty.

It is therefore recommended that measures are taken to:

- formulate criteria for disposal of industrial waste into water bodies.
- enhance the capability of one particular laboratory so that some minimal testing in areas on most concern can be undertaken.
- carry out regular monitoring of waste discharges.

The disposal of large quantities of waste oil in an environmentally acceptable manner also needs attention. A waste oil recycling venture has recently been commissioned in Western Samoa. The GOK may wish to explore ways in which the technology or the facility itself could be useful in its waste oil management strategy.

5.5 Recommendations

It is recommended that:

- the discharge of industrial wastes into the environment be regulated through the formulation of appropriate criteria.
- the capability of a laboratory be enhanced such that testing in areas of concern can be undertaken..
- some monitoring of waste discharges be carried out.

6. Pollution from Agricultural Activities

Agriculture and environment are related paradoxically. On the one hand, agriculture demands good environmental quality. On the other hand, agriculture contributes to habitat loss through release of sediments, nutrients from fertilisers, and pesticides to the marine environment. Sediments are damaging to reefs and marine organisms, nutrients cause eutrophication and all its associated problems and pesticides are known to exhibit a high level of toxicity and persistence in the environment.

In Kiribati, commercial scale agriculture includes copra production and seaweed culture. Because of the flatness of the land, sedimentation from agricultural activities is thought not to be significant. Pesticides are widely available and fertilisers are also used, particularly in crop research projects. Some attempt is made in this section to determine the potential for pollution from fertiliser and pesticide use.

6.1 Legislation

Although there is no specific legislation relating to the management of agricultural substances in ways to prevent pollution, it would seem that if there is reason to believe that fertilisers and pesticides are contributing to the pollution of marine and terrestrial resources, then the management of these substances could be regulated within the framework of the general legislation already described for the protection of resources.

6.2 Pesticides

At the time of the visit to Kiribati, the person in-charge of pesticides was on leave and information regarding pesticide imports, availability and use could not be obtained. Information given to Tulega (1992) suggests that about fifty different pesticides were available in Kiribati in 1992, with many of them sold in local stores. So, it appears that these substances are freely available. Some regulatory measures may be necessary to control the use of pesticides so that human health and the environment are protected.

6.3 Fertilisers

The major user of fertilisers in Kiribati is the Tree Crop Research programme, mostly for crop improvement within the copra industry. The main fertilisers being used are potassium chloride and smaller amounts of a mixture of trace elements. The rate of application of the potassium chloride fertiliser is 1kg/tree/year (data supplied by Tree Crop Research personnel). Considering the low fertility of the soils of Kiribati and their high pH values, it is unlikely that the applied fertilisers are being leached into the groundwater.

6.4 Recommendations

It is recoomended that regulatory measures for pesticides be introduced such that human health and the environment is protected from contamination.

7. Household Hazardous Substances

Household hazardous substances include substances such as household building materials and cleaners, batteries and workshop and garage fluids which possess any of the following properties: inflammable, reactive, explosive, corrosive or toxic. Many such substances are known to be available in Kiribati where people generally lack awareness of the dangers of their improper disposal. The need for some quantitative information on the extent of availability of these substances was identified by the environmental personnel and an attempt was therefore made to obtain the relevant data from the major suppliers in Kiribati. This information is presented below:

7.1 Extent of Availability

The amounts of paints and related substances held in stock at various times in the 1991 -1993 period by one of the major hardware suppliers in South Tarawa - the Kiribati Supplies Co. Ltd are shown in Table 5:

Table 5: Stocks of paints and related products stocked by one South Tarawa retailer:

Type	Amount (litres)
Paint-general:	
(primer, undercoat, gloss, etc)	14,000
latex	1,370
galvanising or endrust	600
marine anti-fouling	200
fluorescent	30
aerosols	24
Paint thinners/turpentine	1,380
Tinters	583
Varnish	580
Paint stripper	130
Wood preservatives	80
Grease	88 (kg)

Information about household cleaners and batteries was obtained from one of the three importers of these goods - Abamakoro, and are shown in Table 6.

Table 6: Stocks of household cleaners and batteries stocked by one South Tarawa retailer.

Type	Annual amounts (litres)
Insecticides (Mortein)	864
Dettol	720
Pine O Clean	1,440
Harpic	1,440
White King Bleach	16,200
Liquid Detergent	2,880
Powder Detergent	101,520 (kg)
Batteries	(numbers)
Large (D)	518,400
Medium (C)	207,360
Small (AA)	829,440
Total	**1,555,200**

7.2 Regulation of Availability

The data presented in the previous section show that except for batteries, other substances are probably available in only moderate amounts when compared to more developed South Pacific island countries. The concern about the environmental implications of household hazardous substances in Kiribati, however, should not be the volume of such substances in circulation but rather the fact that they are widely available and without proper care could easily infiltrate the drinking water supplies and other parts of the environment. There is thus the need to control the supply of such materials, perhaps through imposing regulations on the importation, storage, use and disposal of hazardous substances.

The data project an alarming situation for batteries. The number of batteries being imported by one of the three importers is 1.5 million per year. The amount for all three importers could be as high as 4.5 million per year - approximately 60 batteries per person per year. The environmental implications of such a large number of batteries in a small place as Kiribati are a grave concern. The GOK is not unaware of the problem.

Plans are underway for a battery awareness programme to be launched in 1994 which will inform people about the issues involved and encourage them to use longer-life batteries. It is also recommended that a study be undertaken to establish whether demand for batteries can be reduced.

7.3 Recommendations

It is recommended that:

- the GOK look at ways in which the importation, storage, use and disposal of hazardous substances (including household substances) can be regulated.
- a study be undertaken to establish whether demand for batteries can be reduced.

8. Water Quality

As part of this consultancy, water quality measurements were made for eight samples collected from coastal sites, an inland well and the reticulated drinking water supply in South Tarawa. The measurements made were nutrient (nitrate and phosphate) concentrations and faecal coliform counts, measurements which allow the degree of contamination of water to be ascertained.

8.1 Location of Sampling Sites

Site descriptions for each of the eight samples are given below. The location of all sampling sites are listed in Table 7, with the first six shown in Fig. 6. All samples were collected about 50 m from the shore at depths of about half a metre during the incoming high tide.

Table 7: Locations of water quality testing sites around Tarawa.

Site no.	Location
1-LS*	Bikenibeu village between St. Mary's church and Maneaba
2-LS	Bikenibeu opposite Air Tungaru Office
3-OS**	Sewerage outlet, Bairiki
4-OS	Channel in middle of Betio causeway
5-OS	Sewerage outlet, Betio
6	Temakin dump site
7	Well at house behind Temanoki store, Betio
8	Reticulated tap water at Atoll Research Unit

* LS - lagoon side

** OS - ocean side

The first five sites are the same as those studied by Naidu et al (1987). This was done so that any changes in water quality over the last six years could be detected. Equivalent site identifications in Naidu et al are indicated in Table 8.

Table 8: Corresponding site numbers for this study and that by Naidu et al (1987)

This study	Naidu et al (1987)
1-LS	2
2-LS	4
3-OS	S2
4-OS	13
5-OS	S3

Sample 4 which is from the channel in the middle of the Betio causeway is considered to be representative of a clean site.

8.2 Methods of Determination

Nitrate was determined by the cadmium column reduction - colorimetric method and phosphate by the phospho-molybdate colorimetric method. Faecal coliform counts were determined with a field microbiological kit using the membrane filtration technique. Samples for microbiological analysis were collected in presterilised bottles and those for nutrient analysis in clean polyprylene bottles. All analyses were performed within ten hours of collection.

8.3 Results

The results are given in Table 9. The nitrate concentrations ranged from 13 to 160 µg/L for seawater samples to over 9000 µg/L for the well water. The phosphate concentrations ranged from <24 µg/L for seawater samples to up to 210 µg/L for the well water. Faecal coliform counts ranged from 0 to 12,000 counts/100 ml of water.

Table 9: Results of Water Quality Measurements around South Tarawa

Sample Site	F.Coliforms counts/100ml	Nitrate µg/L	Phosphate µg/L
1-LS	2,200	110	<24
2-LS	49	28	<24
3-OS	5	28	<24
4-OS	0	20	<24
5-OS	50	13	<24
6	12,000	160	100
7	712	>9000	210
8	0	>1200	70

8.4 Interpretation of Results

8.4.1 Faecal Coliforms

The highest faecal coliform count was obtained for Sample 6 which was collected at the Temakin dump site. The source of contamination appears to be the widespread use of the waters edge for defecation by the people living in nearby villages. The wastes dumped at the site also contribute.

The second-most contaminated site (Sample 1) is the area between St. Mary's church and the Maneaba at Bikenibeu. This area is reportedly not serviced by the public sewer system and therefore there is the likelihood of people defecating on the beach. According to the United States Environmental Protection Agency guidelines for recreational waters, the above two sites would be unsuitable as the faecal coliform counts exceed the guideline value of 200 counts/100 ml of water. The area in Bikenibeu where sewerage facilities are available (Sample 2) would appear to be acceptable although further monitoring may be required before this can be confirmed.

The clean site (Sample 4) did not show any evidence of contamination. Obviously there is a continuous flushing of the channel with clean open ocean water.

As for the sewerage outlet sites (Samples 3 and 5) both had counts of less than 200/100 ml of water although the one at Bairiki appeared to be less contaminated than the Betio site. The source of contamination cannot be ascribed directly to the sewerage outlets as there was clear evidence at the two sites of the foreshore areas being used for defecation by people.

Comparison of faecal coliform results obtained during this study with those of Naidu et al. (1987) for the five similar sites are seen in Table 10. This shows that water quality, as measured by faecal coliform counts and contamination patterns, have not changed much since 1987.

The well water sampled on the island of Betio (Sample 7) was highly contaminated making it unsuitable for drinking or washing utensils with. This result tends to suggest that the groundwater on Betio has been infiltrated by human or animal faecal material as also found by Naidu et al (1987). The chlorination of the reticulated drinking water appears to be effective as sample 8 was completely clear of faecal coliforms.

Fig. 6: Locations of sampling sites in South Tarawa.

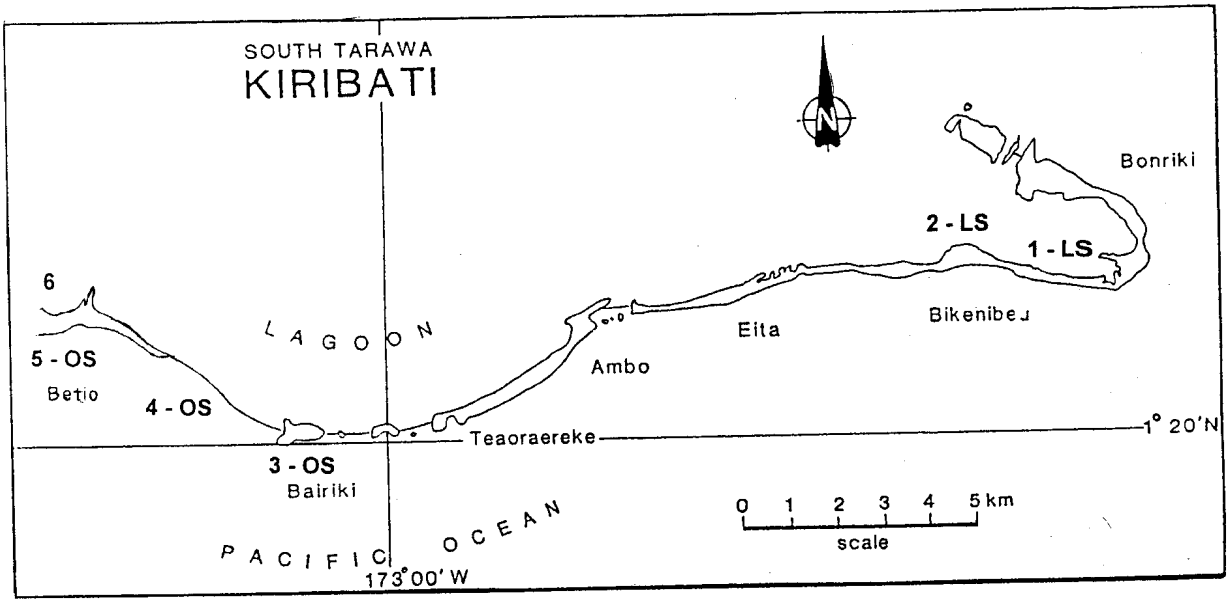


Table 4: Comparison faecal coliform measurements for the 1993 and 1987 studies.

Sample Sites	Faecal Coliform Counts (counts per 100 ml water)			
	1993 Study	*1987 Study*		
1-LS	2,200 H/IC	7,700 H	2,900 H/OG	0 L
2-LS	49 H/IC	200 H/OG	2,400 H/OG	0 L
3-OS	5 H/IC	0 L/OG	7 L/OG	9 H/OG
4-OS	0 H/IC	0 IC		
5-OS	50 H/IC	246 L/OG	5 OG	24 IC

Tides H - high L - low
OG - outgoing IC - incoming

8.4.2 Nitrates

Relatively uncontaminated coastal sites (2, 3, 4 and 5) had nitrate concentrations in the range 13 - 28 µg/L. Much higher values (50 - 998 µg/L) were reported by Naidu et al (1987) although previously Johannes et al (1979) had reported values quite similar (10 - 42 µg/L) to the results obtained in this study. This would tend to suggest that unless some drastic change in water quality had taken place in 1987 (which is quite unlikely), the results of 1987 are highly questionable.

Seawater samples (1 and 6) which showed high levels of faecal contamination also had higher levels of nitrate which is indicative of the relationship between faecal contamination and nutrient enrichment. The tap water and well water samples had nitrate concentrations which were about two orders of magnitude greater than uncontaminated seawater. In fact, the nitrate content of the well water could render it unsuitable for human consumption according to WHO guidelines for drinking water quality.

8.4.3 Phosphates

Phosphate levels in all coastal samples except at the Temakin dump site were less than the detection limit of 24 µg/L. Again, Naidu et al (1987) reported higher values (3 - 86 µg/L) whereas Johannes et al (1979) had found values in the range 3 - 16 µg/L.

Some of the 1987 data may again be suspect, particularly as very low results are also being obtained by Bio-Systems in their Tarawa lagoon management project (verbal communications). There is also evidence that phosphate concentration of incoming ocean water is much higher than for coastal waters, contrary to the finding of Naidu et al (1987).

The water at the Temakin dump site and the tap and well waters had measurable amounts of phosphate (70 - 210 µg/L), in general agreement with their higher nitrate results.

8.5 Overall Patterns

The limited amount of testing carried out during this consultancy and discussions held with other people currently involved in major projects on water quality in Kiribati tend to suggest that nutrient enrichment of coastal waters as a result of human and animal waste discharge is not occurring to any significant degree and therefore is not a cause for concern at the present time.

However, faecal coliform contamination is significant and urgent action is necessary in this area. The project being undertaken by Bio-Systems for an overall management system for the Tarawa lagoon should therefore be seen as most appropriate and when complete should be implemented without delay.

The quality of groundwater in South Tarawa needs to be monitored very closely, particularly in areas where it is accessed for human use. Where well water is found to be unfit for consumption measures should be taken to prevent people from using the well.

8.6 Recommendations

It is recommended that:

- the plan for the management of the Tarawa lagoon being formulated by Bio-Systems be implemented immediately upon completion.
- well water samples be regularly monitored and those wells found to be unfit for human use be closed.

9. Conclusions

This study has shown solid wastes, domestic wastewater, industrially related wastes, possibly agricultural wastes such as pesticides and household hazardous substances, contribute to the pollution of marine and terrestrial environments in Kiribati, particularly South Tarawa.

Although the volume of wastes generated is probably much smaller when compared to some of the more developed Pacific island countries, the impact on the environment could be quite considerable because of the extremely fragile nature of the country's resources. The environmental problems of South Tarawa are compounded by intense pressure on limited resources due to rapid urbanisation.

Under these circumstances it is absolutely necessary that waste disposal is carried out under strict control such that community health and the environment are protected. However, in Kiribati the waste disposal system was found to be generally lacking in such controls. As a result the quality of the environment is deteriorating.

The extreme shortage of land for disposal of solid wastes has led to the use of foreshore areas for waste disposal. These are ecologically and geomorphologically very sensitive areas and the implications for environmental degradation can be many. In the absence of suitable disposal sites for solid wastes, the management strategy recommended is one that aims for organic matter incorporation and waste minimisation. Such a strategy would not be difficult to implement as a very large proportion of the waste is organic in nature. In order to ensure that waste composition remains relatively unchanged some government intervention may be necessary for imposing controls on the importation of goods with non-biodegradable packaging material.

The contamination of the marine environment and groundwater from domestic wastewater has long been recognised as a major environmental concern. A number of studies including this one indicate that nearshore waters and fisheries and groundwater show evidence of faecal contamination. Many of the community health problems of the people have been linked to the problems of water quality and sanitation. This is an area that needs urgent attention and every effort must be made to address this problem.

There is relatively little awareness within the country about the extent of problems with industrial wastes. This is not surprising particularly as Kiribati can hardly be considered to have even a moderate degree of industrialisation. Nevertheless, wastes are being produced by certain enterprises that can be categorised as industrial wastes, oil-related products being of most concern. This study has found that oil is being disposed of into the environment without any strict controls. This needs to be rectified immediately.

The potential impact of agriculturally based activities on environmental contamination probably arises mostly from the injudicious use of pesticides. Some regulation of pesticide use is necessary.

Another environmental concern is the widespread availability of hazardous substances, especially those used in the home and workshop. An alarming number of batteries are being imported into the country and up until recently there were no programmes in place to educate people on safe methods of disposal of hazardous substances. There are plans for a battery awareness programme to be launched in 1994 and it is suggested that similar programmes be planned for other hazardous substances.

The capability of the existing frameworks in Kiribati to regulate environmental contamination appears to suffer from a number of factors, significant amongst which are gaps in legislation, poor coordination between some regulatory authorities, lack of adequate resources and sound overall policies for environmental conservation. These problems are well recognised and have been documented for action in the proposed National Environment Strategy.

Overall the study has shown that waste disposal is having a noticeable impact on the quality of the environment in Kiribati. It is important that the problem of waste disposal and pollution be addressed before the environment deteriorates to an irretrievable degree.

References

Bellair, J.T., Chidgey, S.S., Mathews, R. and Wallis, I.G. 1985. *Tarawa Outfall Reconnaisance Survey.* Report by Consulting Environmental Engineers (Australia) prepared for the Department of Housing and Construction, Canberra, 45p.

Convard, N.S. 1992. *Kiribati Land-based Pollution Survey Draft Summary of Information.* SPREP unpublished report.

Johannes, R.E., Kimmerer, W., Kinzie, R., Shiroma, E. and Walsh, T. 1979. *The Impact of Human Activities on Tarawa Lagoon.* South Pacific Commission, Noumea, 83p.

Naidu, S., Aalbersberg, W.L.G., Brodie, J.E., Fuavao, V.A., Maata, M., Naqasima, M., Whippy, P. and Morrison, R.J. 1987. *Water Quality Studies of Selected South Pacific Lagoons.* UNEP Regional Seas Reports and Studies No. 136; and SPREP Reports and Studies No. 49.

Pulea, M. and Farrier, D. 1992. *Preliminary Report on Environmental Law in Kiribati.* Document prepared for the National Environment Strategy (NEMS), SPREP.

Tulega, L.C. 1992. *A Study Report on Waste Management and Disposal on South Tarawa (Kiribati).* SPREP unpublished report.

Anexes

Annex 1: Terms of Reference for the Consultancy

The Consultant will, during the consultancy period (29 November-20 December 1993):

1. work closely with designated government staff (officers of the Ministry of Land and Environment) of the Kiribati Government, and will visit sources and quantify information on land based pollutants; the unpublished report by L C Tulega on "A Waste Management Study in Kiribati," and that section of the report on LBPS in Western Samoa by Miss Nancy Conard, could be used as a basis for the field study;
2. carry out a survey of existing waste management practices and waste management legislation in the Republic Kiribati in both urban and rural areas;
3. identify all the waste source types and category of wastes in the Republic of Kiribati;
4. assess present and future waste loads and, if possible, cross-check against total import data;
5. estimate and predict existing refuse dump life and make provisions, if need, be to prolong it through reduction of waste;
6. assess the viability of existing dump in public health, social and economic grounds;
7. assess the possibility of leachates from the dump reaching water courses underground water supplies and coastal waters by conducting water quality tests near and off the sites; To conduct water quality tests on six sites around South Tarawa, deemed to be polluted as compared to a reference site which is healthy and unaffected;.
8. work closely with local counterparts and show them wherever and whenever possible how to identify types and categories of waste, how to assess loads of pollutants and to apply the results in the calculation of the life span of the dump; also demonstrate how water quality monitoring is planned and carried out;
9. spend at least one hour of your last day in Kiribati with the Secretary for Environment and Natural Resources Development to discuss your findings and interim recommendations;
10. generally give advice and assistance to the government of Kiribati whenever possible if required; and,
11. produce a report to be integrated into a regional study on land-based pollution sources, detailing findings and recommendation; this report is to make recommendations on assessments, strategies for waste management, waste disposal site management, pollution monitoring and pollution control and disposal site restoration; the report must adhere to the attached Guidelines for SPREP reports.

Annex 2: Work Programme During Visit

Date	Event
28 Nov	Arrival in Tarawa
29 Nov	Meeting with Environment Unit personnel - Tererei Abete and Craig Wilson. Preparation for solid waste survey
30 Nov	Selection of samples for solid waste survey - interview with householders Meeting with Taniera Teibuako from the Kiribati Oil Co. Ltd. Inspection of storage yard
1 Dec	Conducting solid waste survey. Meeting with Rameka Takirua, General Manager and Winuea Tarua, Actg. Water Suprintendant from the Public Utilities Board Meeting with Rabunataai, Town Clerk, Betio Town Council Meeting with Arthur Webb, Tree Crop Research Programme Meeting with Being Yeeting, Bio-Systems
2 Dec	Conducting solid waste survey (cont'd) Meeting with Neeri Tiaki, Senior Health Inspector, Health Dept. Meeting with Willie Tokataake, Project Manager, Outer Island Fisheries Project
3 Dec	Conducting solid waste survey (cont'd) Meeting with Katang Koae, Uekara Printery and Toon Amanu, Govt. Printery Meeting with Kannangaki Utiera, Mechanical Suprintendant, Plant and Vehicle Unit
4 Dec	Conducting solid waste survey (cont'd)
5 Dec	Conducting solid waste survey (cont'd)
6 Dec	Conducting solid waste survey (cont'd) Meeting with Kiribati Supplies Co.Ltd and Abamakoro personnel
7 Dec	Conducting solid waste survey (cont'd) Meeting with Rine Ueara, Town Clerk, Teniano Urban Council Meeting with Ibeatau Keanginimakin, General Manager, Tarawa Biscuit Co. Ltd Preparation for water quality survey
8 Dec	Sampling and analysis of water samples
9 Dec	Meeting with Secretary and Deputy Secretary, MENRD for briefing on findings of study Report writing
10 Dec	Report writing/ public holiday in Kiribati
11 Dec	Depart for Suva

Annex 3: Survey on Solid Waste Generation in Bairiki

A survey to determine waste generation rate, composition and density was carried out in Bairiki during the course of the study with help from the staff of the Environment Unit. The survey was carried out largely in the manner suggested in a WHO Workshop on Solid Waste Management held in Suva, Fiji in November, 1992. A total of 25 dwelling types consisting of households of various socioeconomic status were selected.

The wastes generated by each dwelling were collected for a period of seven days and measurements were made to determine the amounts and types of wastes generated. Ideally, the survey should cover 8 days but because of time limitations this could not be done. Details of the survey are given below:

Objectives:

1. To determine the volume of waste that would require on-site storage, transportation and disposal.
2. To determine appropriate methods of collection and disposal of solid wastes.
3. To identify recycling or resource recovery potential of solid waste.
4. To generate data that would enable the estimation of the expected life span of any disposal site.

Expected Outputs:

1. Daily generation rates in kg/person/day.
2. Density of solid waste in kg/m^3
3. Composition of solid waste generated in percentage by weight.

Preparation for Survey

1. All necessary resources for the survey were organised as follows:

Transport: An open truck belonging to the Environment Unit was used for the collection and transport of garbage

Manpower: A driver and a casual worker were assigned for the survey by the Environment Unit

Equipment: Plastic garbage bags, Weighing scale and buckets (volume: 8 litres), Plastic sheet for sorting garbage, Gloves

2. A preliminary visit to the selected areas around Bairiki was made and dwellings were selected on a random basis. Each dwelling included in the survey was assigned a number and six garbage bags with the sample number clearly written on them were given to each.
3. The following information was obtained for each dwelling:
   - number of people on-site
   - container used for on-site storage
   - means of garbage disposal
   - frequency of public garbage collection in area

Procedure during Survey

1. Each day garbage bags containing the rubbish were collected from each dwelling and taken to the sorting site.
2. Each bag was weighed and its weight was recorded against the number on the bag.
3. The contents of the bag were then emptied out into buckets and the number of buckets filled was also recorded.
4. The contents of the bag were then separated into different constituents (vegetable and food, paper, textiles, plastics, garden, metals, glass and ceramic and others) and the weight of each constituent was then determined and recorded.
5. The results for each day were analysed to determine:
   a. bulk density from the total weight and volume
   b. waste generation rate from total weight and number of persons contributing.
   c. the proportion of each constituent in the waste.
6. Results for the seven days were used to obtain average results.