An assessment of health impacts from environmental hazards in Fiji
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Abbreviations and Acronyms

SPREP - South Pacific Regional Environment Programme
MAFF - Ministry of Agriculture, Fisheries and Forests
MOH - Ministry of Health
DoE - Department of Environment
DoEH - Department of Environment Health
USP - University of the South Pacific
USEPA - U.S. Environment Protection Agency
WHO - World Health Organisation
*E.coli* - *Escherichia coli* bacteria
SOPAC - South Pacific Applied Geoscience Commission
LTA - Land Transport Authority, Fiji
IAS - Institute of Applied Science
CBH - Central Board of Health
PWD - Public Works department
CWMH - Colonial War Memorial Hospital

As - Arsenic
Cu - Copper
TDS - Total dissolved solids
NO₃ - Nitrate
NH₃ - Ammonia
PO₄ - Phosphate
K - Potassium
Na - Sodium
Mg - Magnesium
mg/L - milligrams per Liter or parts per million
kg/mnth - kilograms per month
ug/L - micrograms per Liter
mS/cm - millisiemens per centimeter
Assessment of health impacts from environmental hazards in Fiji

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1 Linkage between health and the environment in Fiji

1.1 Introduction

1.1.1 Background

Fiji Islands, officially the Republic of the Fiji Islands (often referred to simply as Fiji), is an independent island nation in the southern Pacific Ocean, located approximately 3,100 km northeast of Sydney, Australia, and approximately 5,000 km southwest of Honolulu, Hawaii. Fiji was a British colony from 1874 to 1970, when it achieved independence. Suva is the country’s capital, largest city, and commercial center.

1.1.2 Size

Fiji consists of more than 300 islands about 100 of them are inhabited. The islands cover a total land area of 18,376 sq. km. The two largest islands, Viti Levu (10,429 sq. km) and Vanua Levu (5,556 sq km), comprise more than 85 percent of the total area. Fiji’s large islands are of volcanic origin, with mountains rising to a maximum elevation of 1,324 m at Mount Tomanivi on Viti Levu. Some of the smaller islands are coral formations, rising only a few meters above sea level.

![Figure 1 A: Map of Fiji Islands](image)

1.1.3 Population

The population of Fiji according to 1996 census was 772,625; however (1998 estimate) was 802,611, giving the country an overall population density of 44 persons per sq. km (113 per sq. mi). About 40 percent of the people live in urban areas, in Suva (population, 1986, 69,665), Lautoka (27,728), Nadi (7,709), Lami 18,814 (1992), Nausori Town 15,745 (1992). Approximately 20% of people live in poverty,
increasingly in urban/periurban areas where the cash economy predominates; thus impacting on access to health facilities and care. The lack of basic amenities such as piped water, adequate sanitation and garbage disposal is thought to be a major factor in a number of disease outbreaks including the dengue outbreak of 1997/8.

1.1.4 Seasonal and Climatic factors:

The climate is of tropical oceanic type with maximum rainfall between January and March. At this time of year there is an increase in vector borne disease more generally, leptospirosis and dengue fever in particular.

Between the months of November and April, Fiji is prone to tropical cyclones. There are 10-15 cyclones per decade with a small number causing severe damage; the last being Cyclone Sia and Ami in January of 2003. This resulted in a rise in diarrhoeal diseases and significant destruction of rural homes and infrastructure. The reef system protects most of Fiji from local and distant tsunamis, however global warming and the rising sea level may diminish this protection.

1.1.5 Economy

Fiji’s economy is dependent on the sugar industry and tourism. Two political coups in 1987 and in 2000 adversely affected the economy of the country and caused a loss of skilled and educated workers to leave the country. In 1997 Fiji’s labor force stood at 317,714; most people were employed in salaried or wage positions. Agriculture, forestry, and fishing employ 46 percent of Fiji’s workers and in 1997 contributed 18 percent of the gross domestic product (GDP).

Industry, including mining, manufacturing, and construction employs 15 percent of Fiji’s wage earners and, in 1997, contributed 26 percent of GDP. The government instituted tax-free incentives in 1988 that created a flourishing garment industry. Ready-made garments are now the chief manufactured items. Gold and silver are the principal minerals mined.

1.2 Environmental Factors:

Fiji is fortunate in having considerable resources, timber, land, marine products, and some minerals. But in recent years their exploitation has not been sustainable, in fact they have been ‘mined’ for quick economic return without effective environmental and social considerations and regard for the future. This is common in marine products, forests and agriculture. The poor logging and forest management is ‘mining’ the timber and water catchment’s resources, the ginger industry is ‘mining’ the soil resources, so as the sugar industry on the marginal coastal lands. Over the years, many development assistance agencies have encouraged this shortsighted approach through their focus on narrow economic targets.

Fiji’s resources are not large enough to absorb such treatment indefinitely, yet each year technology advances are available to more young people such as our ability to disrupt and destroy natural ecosystems increasingly outstrips our understanding of these ecosystems and their importance for the nation’s future survival.
1.3 Pollution
Many of the Fiji’s more serious environmental problems, some of which are highly visible, occur in urban areas or in their immediate vicinity. Fiji’s population growth rate is moderate, but the urban and peri-urban growth rate is high, and is clearly outstripping infra-structural planning and development. Thus it is primarily responsible for the important social issues of environmental concern, such as housing, water and sanitation. Direct regulating control of water or air pollution and monitoring are absent. Because of this, there is a serious lack of data on the types and extent of pollution present in the country.

1.4 Tourism Industry
Tourism contributes to environmental degradation in several ways, namely: coastal reclamation and dredging for resort construction has led to the loss of biological habitats of marine life and mangroves which Fijian villagers depend on for subsistence. Wastes from hotels and tourist facilities are primarily sewage either from sophisticated system in major hotels to septic tanks in smaller tourist facilities. Since most hotels and resorts rely upon water and beach quality, they have self-interest in maintaining the quality of their surrounding environment. The quality of effluents is monitored by some of the larger hotels, but there is no monitoring of beaches and recreational waters.

1.5 Sugar Industry
This is the second largest industry in Fiji, generating approximately $300 million in revenue, through the production of 470,000 tonnes of sugar. Approximately 700km2 of land is used in growing sugar cane in Fiji. The main environmental hazards of cane fields are the ‘inputs’ use, fertilizer weedicides and pesticides. There are no regulations to specifically control how they are used on farms and other work places. Cane farming in Fiji is strictly a smallholder and labour intensive enterprise. Much of the land area on the two principal islands in the Fiji group is mountainous, the eroded remnants of volcanic activity that created the islands. Sugarcane farming is mainly concentrated along the generally dry northern and western portions of Viti Levu and the northern coast of Vanua Levu. The soils are extremely rich in organic matter and with sufficient rainfall and appropriate levels of management expertise are capable of producing in the range of 16 tons of cane per hectare.

1.6 Saw milling
Saw milling is becoming big in Fiji, especially when there is a big demand for pine chips in Japan and pine timber for local and overseas market. There are about 20 sawmills with timber treatment facilities. 70% of the logs are chipped for sale to Japan and the remaining 30% converted to timber. In terms of solid waste, these sawmills produce about 14,000 tons of wood waste a year, which accumulates in rubbish tips that are continuously smoking from spontaneous fire. Some chemical wastes containing copper, chromium and arsenic are generated by treatment plants.

1.7 Mining
There is only one active mining operation conducted in Fiji, the Emperor Gold Mining at Vatukoula. There are two potentially serious environments hazardous in the
operation of the gold mine; the gaseous discharge from smokestack, which if improperly controlled could liberate significant quantities of sulfur dioxide and arsenic. The effluent from the tailing ponds if poorly controlled could have unacceptable high concentrations of suspended solids and hazardous levels of cyanide.

1.8 Hazardous wastes:
There is very little information available on the generation, storage or disposal of hazardous wastes in Fiji and no specific regulations available to deal with the safe storage, transportation and disposal of this material. Existing laws and regulations are quite inadequate. Hazardous wastes include materials, which are corrosive, such as strong acids, alkalis and phenols: materials, which pose fire hazard during normal handling eg. Hydrocarbons, solvents; reactive materials which are liable to explode, generate toxic fumes or react violently with air, water heat, or toxic materials, especially those that are threatening the life or health of people, plants and animals. Toxic materials include asbestos, heavy metals, cyanide, chlorinated hydrocarbons such as the organochlorine pesticides and PCB’s; organophosphorus and carbamate insecticides are widely used in agriculture and even in the home, it also includes infectious hospital wastes and many other chemicals and wastes.

1.9 Overview of Environmental Health in Fiji
Environment is now seen in Fiji as an important determinant of health. There is now a general realization that human health depends on how well we manage the interaction between human activities and the environment.

1.10 Responsible agencies
Environmental Health activities in Fiji are administered at the National level by the Central Board of Health and at the district level by Local Authorities. The latter can be either Rural Local Authority, which oversees rural districts, or Municipal Councils, which oversee the urban towns and cities.
The Minister of Health appoints membership to the Central Board of Health and Rural Local Authorities while ratepayers elect their representative Councilors in Towns and Cities. The roles and responsibilities of these Local Authorities towards control of pollution are defined under the Public Health Act.

1.11 Air pollution and health
Because of the rapid relatively rapid urbanization in Fiji, industries and vehicles are increasing faster than the controlling agencies are able to maintain control. In consequences the pollution situation is deteriorating. Principal atmospheric pollutants from stationery sources are;

- Dust from quarries, asphalt plants, cement works, stone crushers, furniture making and road dusts from vehicles.
- Odor nuisances from fish canneries, slaughterhouses, sewage treatment plants; edible oil refineries, beer factory, soap factories and garbage disposal sites.
- Poisonous gas and fume emissions from diesel buses and lories, petrol driven vehicles, the gold mine, asphalt plants, and soot and smoke from sugar mills and timber mills.
1.12 Water pollution and health

Surveillance of water quality is under the responsibility of the PWD and the DoEH of the Ministry of Health. The Pathology laboratory at CWM Hospital and Lautoka carry out regular bacteriological monitoring of drinking water supplies. The National Water Quality Laboratory at Kinoya and Institute of Applied Science at University of the South Pacific carry out chemical monitoring.

Pollution of surface and groundwater from agriculture, domestic and industrial activities has not been regularly monitored and recorded as a problem. This may be due to non-detection rather the absence of a problem.
2 Rationale for Assessment

Environmental Pollution is an issue of grave concern, not so much because levels are suspected to be dangerously high, but because there is no monitoring in place for the nation to learn whether there is a danger.

2.1 Air pollution and health:
Air pollution in Fiji is not as bad as some of the highly developed countries in the world but we do have our pollution problem in the form of emission from vehicles, smoke from sugar mills, cement factory, dust from quarries and stone crushers, wood dust from furniture making, and dust from construction works and gravel roads.

Industries are not monitored to gauge the amount and type of pollutants released into the environment.

There is no regular monitoring of air pollution and data from spot checks are fragmentary. This indicates that levels of dust and particulate can be high in certain locations such as City and Town Bus terminals. However, the levels of pollutants in the environment (carbon monoxide, nitrogen oxide, sulfur dioxide and hydrogen sulfide) and their effects on health are not known. No in depth research on this has been conducted in the past and is believed to be one of the many researches that are needed to be done in Fiji.

2.1.1 State of air pollution in Fiji
The most common causes of pollution in Fiji are from construction works, factories, manufacturing processes, vehicles, power generators, open burning, incinerators, mines, sugar mills and stone crushers. The other causes of pollution are the cement factory in Lami, stone crushers in Laqere, the sugar mills in Lautoka, Ba, Rakiraki and Labasa, furniture shops, steel works, mines, open burning, incineration, vehicles and airplanes.

2.1.2 Sources of air pollution
Transportation is one of the principal sources of air pollution as gasoline and diesel fuel is used releasing carbon monoxide, oxides of nitrogen, lead, hydrocarbons, oxidants, suspended particulate matter and sulfur dioxide. It is assumed that air pollution is increasing because of the increasing number of vehicles on the road (Fig 1A).
The consumption of petroleum and petroleum products has also increased (Fig 1B).
Figure 1 A– Distribution of Vehicles registered in Fiji

Figure 1 B– Amount of petroleum & petroleum products (during 1985-1996) in Fiji
2.1.3 Morbidity by various age groups and location from respiratory diseases

Air pollution can contribute to a wide variety of effects on humans and the environment depending on the particular type of pollutant. Increased susceptibility to coughs, chest discomfort, headaches, respiratory illness, increased asthma attacks, bronchitis, pulmonary emphysema and reduced lung function are believed to be due to air pollution. The Ministry of Health data reveals that based on hospital admissions the number suffering from respiratory infections was 5686/100,000 population in 1999 alone.

2.2 Water Supply and Health

The quality and accessibility of drinking water are of paramount importance to human health. Drinking water can contain disease causing agents and toxic chemicals. To control the risks to public health, systematic water quality monitoring and surveillance are required (WHO Guidelines for Drinking Water Quality Volume 3).

2.2.1 Water Resources

Access can be influenced by factors such as the population served, the reliability of the supply and the cost of the water to the consumer. These can be converted into quantified water supply service indicators that should be included in integrated water supply surveillance programmes.

Fiji is reliant on surface water as its principal water resource. All of the major cities and towns are dependent on surface water which is usually stored in large dams (Fig 1 D). Villages and settlements in rural areas are currently dependent on groundwater and surface water intakes. These intakes are susceptible to seasonal fluctuations and drought which are of major concern throughout the rural and outer island areas.

In the Global Water Supply and Sanitation Assessment in 2000 (WHO), the coverage of the population in Fiji with access to an improved water supply was 43% for rural areas and 51% for urban areas. The figures indicate that water coverage throughout Fiji remains low. This is particularly evident in the rural areas where the PWD judged a figure of 51% as an over optimistic estimate.

A recent study undertaken by SOPAC on Pacific Water Utilities indicated that Suva has the highest percentage of people served with reticulated water. Although service levels are high in Suva, the percentage coverage for the total urban areas of Fiji suggest a large deficit in service provision and functionality.

Some community development programmes are promoting the use of rainwater as a means of emergency preparedness during times of drought.
2.2.2 Water supply Treatment and distribution

PWD is the main service provider for water treatment and reticulation in urban and peri-urban areas.

59.90% of the total population has access to treated reticulated water supply.

There are variations in the form and nature of drinking water treatment processes in Fiji. The major municipalities use the conventional treatment processes of Sedimentation, Filtration and Disinfection. Water is disinfected with chlorine gas or calcium hypochlorite and fluoridated with sodium silica fluoride.

There are some rural districts which do not use Filtration but water goes direct to Disinfection with Calcium hypochlorite. Island resorts either have their own small packaged treatment facilities or have water transported by barge.

During drought, water is barged or trucked into communities by PWD. However, water tanks are not chlorinated before use and there is limited control on the quality of water provided or on quality control of the tanks.

The majority of water supply systems for rural villages and island communities are distributed by pipes direct from the source to the consumer without any form of treatment.
2.2.3 Water Quality Monitoring and Surveillance

There are currently 4 major organizations that carry out water quality monitoring programmes in Fiji. The key agencies involved in water supply in Fiji at the national level are the PWD, Dept. EH, Dept. MR and SOPAC. At the local level, Private Companies and community groups are the main stakeholders. Their roles and responsibilities are outlined in Table 1A below.

**Table 1A: Responsibilities for Water Supply (Source: W. Delai, Ministry of Health, 2002)**

<table>
<thead>
<tr>
<th>Agency</th>
<th>Type of programme</th>
<th>Area</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>National PWD Department</td>
<td>Service provider</td>
<td>Urban &amp; rural</td>
<td>Capital works&lt;br&gt;Systems rehabilitation&lt;br&gt;Operation &amp; maintenance&lt;br&gt;Management &amp; cost recovery&lt;br&gt;Water quality</td>
</tr>
<tr>
<td>Environmental Health Department MOH</td>
<td>Monitoring &amp; regulatory</td>
<td>Urban &amp; rural</td>
<td>Quality monitoring &amp; surveillance&lt;br&gt;Health education</td>
</tr>
<tr>
<td>Department of Mineral Resources</td>
<td>Advisory/monitoring</td>
<td>Urban &amp; rural</td>
<td>Bore hole siting, drilling&lt;br&gt;Technical advise</td>
</tr>
<tr>
<td>Private bottling companies/Hotels/private supplies</td>
<td>Service provider</td>
<td>Urban &amp; rural</td>
<td>Bottle water supply&lt;br&gt;Desalination Water quality&lt;br&gt;Operation &amp; maintenance</td>
</tr>
<tr>
<td>SOPAC</td>
<td>Advisory</td>
<td>Urban &amp; rural</td>
<td>Research&lt;br&gt;Hygiene promotion &amp; education</td>
</tr>
<tr>
<td>Local Water committees</td>
<td>Monitoring &amp; service provider</td>
<td>Rural</td>
<td>Operation &amp; maintenance</td>
</tr>
<tr>
<td>NGO’s</td>
<td>Advisory</td>
<td>Urban &amp; rural</td>
<td>Health education</td>
</tr>
</tbody>
</table>
2.2.4 Public Works Department

The PWD collects and analyses samples from within the Urban treated water supply of Suva, Lautoka, Nadi and other towns. Table 5 below outlines the number of samples collected for the year 2000:

Table 1B Samples collected by PWD during the year 2000
(Source: W. Delai, Ministry of Health, 2002)

<table>
<thead>
<tr>
<th>Administrative Division</th>
<th>Number of Samples collected</th>
<th>% Contaminated 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central/Eastern</td>
<td>1,325</td>
<td>4</td>
</tr>
<tr>
<td>Western</td>
<td>470</td>
<td>14</td>
</tr>
<tr>
<td>Northern</td>
<td>206</td>
<td>44</td>
</tr>
</tbody>
</table>

The results represent the quality of treated water supplies. No data was available on water quality analysis on untreated or “high risk” supplies.

The results indicate an unsatisfactory quality of water available to consumers from sources that should have been free of contamination.

Frequency of sampling varies according to the location. In Suva, samples are taken weekly, Western division on fortnightly basis, and the Northern division and southern parts of Vitilevu samples are taken once a month. Fixed-point sampling is undertaken on each of the distribution system, and occasional household testing is undertaken depending on availability of human resources.

Samples for microbiological analysis are collected in sterilised bottles (dosed with sodium thiosulphate). Samples from taps are flamed before being collected. All samples are transported in an icebox below 4 °C and transported to the laboratory in less than 6 hours.

The major focus is on measuring efficiency of the treatment processes in each of the piped supplies. PWD carries out weekly testing of treatment works for temperature, pH, Conductivity, Colour (TCU), Turbidity, Total Dissolved Solids (TDS), Residual chlorine, Total Coliforms and Thermotolerant coliforms. Occasional samples are collected from rural areas to analyse a range of microbiological, chemical and physical parameters.

2.2.5 Sampling & Analysis

Records from the Department of Environmental Health indicated that an average of 15 samples are collected per month from all divisions. The sources of samples vary from treated water to unprotected surface water sources. The Department is currently testing for physical, chemical and biological parameters.

Water samples for microbiological analysis are either analyzed on site using portable testing kits or dispatched to the nearest major Hospital. However, samples for chemical analysis are analyzed either at the Institute of Applied Science laboratory at USP (IAS) or Agriculture Department Research Station in Suva.
The IAS laboratory is well developed with capacity to analyze a whole range of parameters including heavy metals such as Cadmium, Lead and Mercury in water, sediment or food. Samples of water from major Hotels plus private supplies are analyzed on a monthly basis.

The Institute is currently developing their capacity to test for pesticides because there is limited knowledge on levels of pesticides in water.

Private Bottling Companies including the world renowned Fiji Water is undertaking regular testing of their own supplies for quality control and to meet the requirements for export.

Table 1D: Water sample results collected by EHOs for year 2000
(Source: W. Delai, Ministry of Health, 2002)

<table>
<thead>
<tr>
<th>Medical Division</th>
<th>Type of water</th>
<th>No. of samples</th>
<th>No. contaminated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>Treated</td>
<td>121</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Untreated</td>
<td>73</td>
<td>62</td>
</tr>
<tr>
<td>Western</td>
<td>Treated</td>
<td>156</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Untreated</td>
<td>61</td>
<td>53</td>
</tr>
<tr>
<td>Eastern</td>
<td>Treated</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Untreated</td>
<td>29</td>
<td>21</td>
</tr>
<tr>
<td>Norther</td>
<td>Treated</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Untreated</td>
<td>33</td>
<td>25</td>
</tr>
</tbody>
</table>

The results show a significant high number of contaminations with samples, which were obtained from untreated water supplies. It is of great concern that in all Divisions, some treated supplies were also contaminated. These were probably due to some very old cast iron pipes, which could have breaks allowing penetration of polluted water. It can also be a reflection of the type of treatment system in use.

The Institute of Applied Science at USP has a well-developed laboratory with capacity to analyze a whole range of parameters including heavy metals such as Cadmium, Lead and Mercury in water, sediment or food. Samples of water from major Hotels plus private supplies are analysed on a monthly basis. The Institute is currently developing their capacity to test for pesticides because there is limited knowledge on levels of pesticides in water.

Private Bottling Companies including the world renowned Fiji Water is undertaking regular testing of their own supplies for quality control and to meet the requirements for export.

2.2.6 Sanitary Surveys & Water Quality Standards

Both the PWD and Dept EH are carrying this out on a weekly and monthly basis. It has been noted that limited attention is paid to sanitary inspection of water facilities. A more proactive approach is required.
There are no country specific water quality standards in Fiji at the moment. The participating agencies are currently using the WHO Drinking Water Quality Guidelines for monitoring and surveillance.

Legislation that cover water supply are the Water Supply Act and the Public Health Act. They are outdated and provisions are not sufficient to ensure adequate monitoring and surveillance of water quality.

2.2.7 Existing and possible major water pollution sources and pollutants

There is a vast increase in industrial and agricultural activities in recent years and have contributed to environmental contamination in Fiji. This has raised concern on chemical pollutants from agricultural chemicals, hazardous waste, laboratory waste and microbiological pollutants from unsafe sewage disposal. Microbiological contamination is always the priority because of the link to infectious diarrhoeal diseases as compared to chemical contamination, which may have a lower priority but is also important because some chemicals have acute impact on health for eg. the case of nitrate and its toxic effect particularly on infants.

Table 1 E: Pollutant and possible sources in Fiji-Source:Bureau of Stats, Fiji

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Sources of pollutant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural chemicals [pesticides, herbicides, etc.]</td>
<td>Sugar cane, vegetable, other forms of commercial farming and contaminated sites</td>
</tr>
<tr>
<td>Laboratory chemicals</td>
<td>Hospital, private and industry laboratories</td>
</tr>
<tr>
<td>Waste oil</td>
<td>Oil depot, power stations, service stations, garages and storage depot</td>
</tr>
<tr>
<td>Timber treatment chemicals [copper, chromium &amp; arsenic]</td>
<td>Saw mills, timber treatment depot and contaminated site</td>
</tr>
<tr>
<td>Pathogenic organisms and other contaminants [thermotolerant coliforms, E.coli, faecal streptococci, etc.]</td>
<td>Sewerage treatment plant, septic tank, pour flush &amp; pit latrines, industries, dairy farms, piggeries, etc.</td>
</tr>
</tbody>
</table>

Pollution of drinking water in Fiji is also at risk from activities within the catchment areas such as; erosion because of increased planting on steep slopes and logging. Fishing activities within the river systems can also contribute to pollution of water sources. Further inland, poor catchment management also increases sediment, nutrient and pollutant loadings in streams, rivers and eventually upon reefs and lagoons.
In the rural areas, there are very few water closets connected to the sewer system compared to the significantly high number of households with septic tank and water-seal toilets systems. The latter two systems are more prone to contaminate the aquifers through ground seepage. Depending on their location and the underlying soil structure, they can contribute to health risk through contamination of drinking water supplies, recreational waters and aquatic food sources.

2.3 Chemical and hazardous waste

A survey carried out in 1998 on “Persistent organic pollutants” by SPREP, MAFF, DoE and USP found the following total volume of unwanted chemicals in Fiji (Table 1 F).

<table>
<thead>
<tr>
<th>Chemical category</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture chemicals</td>
<td>21,210 kg</td>
</tr>
<tr>
<td>Other obsolete chemicals</td>
<td>75 kg</td>
</tr>
<tr>
<td>Oil potentially contaminated with PCB</td>
<td>Nil</td>
</tr>
<tr>
<td>Laboratory chemicals</td>
<td>&gt;800 L/yr</td>
</tr>
<tr>
<td>Waste Oil</td>
<td>&gt;8,000 L/year</td>
</tr>
<tr>
<td>Contaminated sites</td>
<td>19 potential sites</td>
</tr>
</tbody>
</table>

Table 1F: Chemical waste in Fiji (1998)

The study recommended that more specific details be obtained prior to any clean up and disposal operations because the chemical quantities were estimated based only on visual assessment of the individual stockpiles.

The 1998 study found that the main stockpiles of unused obsolete pesticides, herbicides and other chemicals were associated with former MAFF research stations. The stations are either located on flood-prone areas or near to waterways. Therefore there is a great risk of water and adjacent land contamination with hazardous chemicals. The most significant stockpiles of waste chemicals and pesticides totaling approximately 19 tonnes were at research stations Lakena, Lomaivuna, Navua,
Korokadi, Dreketi, Sigatoka and Legalega. Enquiry with MAFF Koronivia revealed that the chemicals were still where they were in 1998.

The Fiji Government has now prohibited the following pesticides from being imported, exported, manufacture, used or disposed in Fiji (Table 1G below): Source Minister for Labour, Industrial Relations Order dated 1st July, 2003.

<table>
<thead>
<tr>
<th>Common Name- CAS No.</th>
<th>Trade Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dieldrin - 60-57-1</td>
<td>Dieldrin; Dieldrex 30; ICI Dieldrin; Lanes Dieldrin</td>
</tr>
<tr>
<td>2. Phenyl Mercuric Acetate (PMA) 62-38-4</td>
<td>Lanes Mercurial Dry Seed Dressing Mercurial Dry Seed Dressing</td>
</tr>
<tr>
<td>3. 2,4,5-T Trichloropentoxyacetic acid) 93-76-5</td>
<td>2,4,5-T; 2,4,5-TButoxone; Butoxone 2,4,5-T; Noweed 2,4,5-T</td>
</tr>
<tr>
<td>4. Benzene Hexachloride (BHC) 608-73-1</td>
<td>BHC Miscible Oil Lanes BHC</td>
</tr>
<tr>
<td>5. Captafol 2425-06-1</td>
<td>Difolatan Haipan 800 Haipen 800 Orthidifolatan Wetable Powder Fungicide Vegetable spray Wettable powder fungicide</td>
</tr>
<tr>
<td>6. Chloradane 57-74-9</td>
<td>Chlordane Flick Chlordane Lanes Chloradane</td>
</tr>
<tr>
<td>7. DDT 50-29-3 Dichlorodiphenyltrichloroethane</td>
<td>Chlordane Flick Chlordane Lanes Chloradane</td>
</tr>
</tbody>
</table>

Table 1G. Pesticides banned from Fiji by Ministerial Order 1st July 2003

The only previous study done was by Szmedra (2002) who investigated the health impacts of pesticide use on rural population in the sugar producing regions of Fiji. The findings, which were based on using interviews only without medical examination, did reveal certain problems experienced by users of pesticides. There were indications that problems with eyes, skin, respiratory tract and nervous system were significantly higher amongst users than non-users.
2.4 Morbidity from gastro-intestinal diseases for Fiji

Health Statistics
Notifiable diseases data from the Ministry of Health records high levels of water related diseases. Fig 1 G below outlines recorded number of cases of diarrhoea from 1995 – 2000.

![Graph showing diarrhoea cases from 1995 to 2000](image)

Fig 1 F: National levels of recorded diarrhoeal cases since 1995
(Source: Ministry of Health, 2002)

Infantile diarrhoea
For the period 1995-2000, the highest recorded cases of infantile diarrhoea was in 1998 with 12,272 followed by 9,445 cases in 1999 and 8,253 in 1996. It is to be noted that included under diarrhoea are other ill-defined intestinal infections. The cases continued to decrease over the years to 4067 in 2002 (Table 1 Ha).

<table>
<thead>
<tr>
<th>Year</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infantile diarrhoea</td>
<td>12,272</td>
<td>9445</td>
<td>6697</td>
<td>7388</td>
<td>4067</td>
</tr>
<tr>
<td>Dysentery</td>
<td>358</td>
<td>134</td>
<td>111</td>
<td>244</td>
<td>83</td>
</tr>
<tr>
<td>Food/Fish poisoning</td>
<td>1790</td>
<td>2884</td>
<td>1944</td>
<td>1758</td>
<td>1128</td>
</tr>
<tr>
<td>Enteric fever</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 1 H (a): Food-borne and water-borne diseases in Fiji from 1998-2002)

Dysentery
Dysentery recorded during the period also showed that 1998 had the highest with 358 cases and decreased to 111 in 2000. The number increased again in 2001 to 244 before reducing to 83 in 2002.

Food poisoning
Food poisoning cases, which included fish poisoning, ranged from 1128 in 2002 to 2884 in 1999 for the whole country.
2.4.1 Morbidity by location from gastro-intestinal diseases.

The cases of the same gastro-intestinal diseases for Suva City during the same period are shown below.

<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infantile diarrhoea</td>
<td>1,016</td>
<td>443</td>
<td>338</td>
<td>8</td>
<td>321</td>
</tr>
<tr>
<td>Dysentery</td>
<td>54</td>
<td>9</td>
<td>14</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Food/Fish poisoning</td>
<td>67</td>
<td>41</td>
<td>84</td>
<td>31</td>
<td>65</td>
</tr>
<tr>
<td>Enteric fever</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Table 1 H(b): Food-borne and water-borne diseases in Suva City from 1998-2002*  
*(Source: Ministry of Health Statistics section).*

The Ministry of Health Statistics section supplied the following data on cases of Infantile diarrhoea, Dysentery and Fish/food poisoning during the period 1998-2002 for the whole country.

![Infantile diarrhoea 1998-2002](Image)

*Fig 1G: Comparison in No. of cases of Infantile Diarrhoea by districts from 1998-2002*  
*(Source MOH Statistics section)*

The trend over the years according to Fig 1J has been similar with the same districts recording higher number of cases compared to the others. Several districts stood out with high number of cases of Infantile diarrhoea. These were Nadi, Ba, Tavua, Suva Rural then Suva City, Rewa, Savusavu and the others.

It is significant to note also that districts with treated water supplies also had cases of infantile diarrhoea pointing to the fact that other risk factors are involved.
The most number of cases of Dysentery were from Ovalau, which included the whole of Lomaiviti group. Ba, Lautoka, Suva City and Ra followed this. Other provinces followed with less than 50 cases per year.

The incidence of dysentery is a possible reflection of the drinking water quality. Rural areas with untreated water supplies such as Ovalau, Ba, Ra and Tavua had high number of dysentery cases. It is also significant to note that even those districts with treated water supplies also showed cases of dysentery. This may indicate involvement of other risk factors such as poor food hygiene.

Over the period 1998 to 2002, the Medical districts that had very high number of cases of food poisoning were Lautoka and Suva Rural followed by Nadi, Tavua and Rewa.

Fish poisoning is lumped together with food poisoning for the period. There are similarities in the trend of fish and food poisoning over the years with high number of cases recorded in the two cities of Lautoka and Suva. Highest number of cases was recorded in 2002.

The data do not show which fish is the most poisonous. The presence of chemical pollutants in waters is believed to be one of the contributors to poisoning in fish. Iron, heavy metals, nitrogenous compounds and phosphates were the substances often cited.
3 Project Objectives

a) Assessment of Water and Gastro-Intestinal disease:

- to determine the prevalence of general morbidity and mortality due to selected gastrointestinal diseases of the populations of selected villages and towns.
- to analyze the data by age, gender, location and mode of water supply;
- to describe the quality of drinking water from the reticulated water supply, streams and creeks, wells, rooftop catchments and springs
- to identify which waterways are most likely to be polluted with agrochemicals and hence affecting the quality of life of the nearby residents.
- to undertake statistical analysis to establish correlation between water and health variables.

b) Assessment of Chemicals in Water Catchment areas

- to determine the types and chemical makeup of agrochemicals (fertilizers, pesticides and herbicides) used in the farming pursuits.
- to determine the quantity applied annually.
- to determine the frequency of application.
- to define the geographic location of their usage.
4 Methodology

4.1 Questionnaire survey

All the members of the survey team at a workshop designed the Questionnaire, which contained the relevant indices. The survey questionnaire was designed to obtain the following background information:

**Administrative:** Medical Division, Medical Subdivision

**Household information:** number, ethnicity, gender, age groups and locality

**Water Supply:** Source and type of drinking water supply used (spring, reticulated supply, well, borehole, stream, tank etc) and whether water was treated.

Number of people using the supply by age, gender, race

**Agrochemicals in Catchments**

The same structured interview was used with farmers in the catchments to further elucidate the following:

**Farming:** type of farming, acreage under crops

**Types of agrochemicals used:** formulation and brand name, their usage, amount and type, Application rates, and Geographic location of usage

**Diarrhoea incidence:** whether anyone in the family ever suffered from diarrhoea with in the last 3 days or 3 months by age group.

Household data was collected through face-to-face interview of an adult member of the family. Interview was carried out by EHOs and conducted in either the vernacular or English language.

Farmers generally do not keep a record of the amount of agrochemicals nor the frequency of application, so they were requested to recall their practices from memory.
4.2 Selection of Localities

The research was confined to the main islands of Viti Levu and Vanua Levu as well as the smaller Ovalau Island in the Eastern Division.

On Vanua Levu, Macuata and Savusavu subdivisions were initially selected. Unfortunately Cyclone Ami ravaged Macuata province in early January 2003 and the only data obtained was from Savusavu, although Macuata was of more relevance to the survey because of it being the major canefarming area of the Northern division.

On Viti Levu, sampling survey was carried out at the following rural Medical subdivisions; Korovou, Suva, Lautoka, Nadi, Sigatoka, Ba, Tavua, Rakiraki, Nausori, and Navua. Therefore the Medical areas of Naitasiri, Bua, Macuata, Lau, Kadavu, Rotuma and Taveuni were not included in the survey.

Study localities were selected by the local area EHO who was responsible for selecting at least 8 communities for study and the main criteria for selection was the scale of commercial farming. The communities were to include Fijian villages and settlements to ensure that the farming practices of the indigenous population would not be missed. The localities were selected from a list of areas known to be under some farming developments. For each locality surveyed, the number of households sampled was not less than 10% in a village or settlement.

Generally, for most of the districts all the households in a village were included in the survey whereas for settlements, because the houses were scattered over a wider area the “not less than 10% rule” was applied.

4.3 Data Collection.

The survey was initially planned for 3 months to take place from October to December 2002. However due to problems of logistics and overload with the laboratories the study dragged on for much longer. This was compounded by the cyclone mentioned earlier which necessitated redeployment of staff to affected areas for assessment and rehabilitation work.

A total of 1618 respondents were captured in the research.

When there were very poor response to the questions on cases of diarrhoea within the respondents family, surveyors were then asked to extract data either from hospital admissions or from outpatient register that relate to those areas which were surveyed.

This process took longer than expected because of the deficiencies in recording data such as patient address at the Health facilities. It was difficult to locate diarrhoea cases that relate to specific localities where the surveys were carried out. Some people also visit Private Pracitioners, while others use traditional remedies. As a result, the data on diarrhoea obtained from subdivisions do not really reflect the true situation.

4.4 Field Water Sampling

Water samples were collected from the common drinking water sources of the study sites and from nearby receiving waters.
4.4.1 Water sampling for bacteriological analysis.
Tap mouth was sterilized by flaming a cotton wool soaked in methylated spirits (SVM). The tap mouth was heated until moisture in the mouth boiled as indicated by a 'hissing' sound. Tap was allowed to run before the sterile bottles were filled.

For water sources that did not have proper standpipes [e.g. spring, well] a sterile ladle was used in collecting samples for bacteriological analysis. Water was scooped using a sterile ladle and poured into sterile sampling bottles ensuring that ladle does not touch mouth of bottle to prevent cross contamination. Samples from receiving waters were collected by first rinsing the sterile bottles in the receiving water and then dipping the bottle facing the flow.

The samples were required to be immediately dispatched within less than 6hrs to either CWM Hospital or Lautoka Hospital for Bacteriological analysis for Total coliforms, *Faecal coliforms* or *E.coli*.

4.4.2 Water sampling for Chemical analysis

The acid washed bottles were filled with water to be sampled and then rinsed. This was then poured out and then refilled before dispatch to the laboratory.

Samples for Physico-chemical analysis were sent either to USP’s Institute of Applied Science or MAFF Research laboratory for analysis for a range of parameters including Nitrate, Ammonia, Potassium, Sulphate, Chloride, Calcium, Magnesium, conductivity, pH, Total dissolved solids (TDS) and Suspended Solids and even Arsenic.

The results were compared to WHO drinking water standards, and analysed with data from the community health nurse, local clinical and hospital.

The extra load on those laboratories was a major drawback in water sampling and analysis.

4.5 Data Analysis

The EpiInfo 2000 was used to analyse the data from the questionnaire survey.
5 Results
5.1 Ba Subdivision
5.1.1 Farming types

Ba is one of the biggest producers of sugarcane. However, in the survey, there were only 26% of the respondents from Ba who were cane farmers as compared to 62% crop farmers. There were 11% rice farmers and 1% fruit farmers. Crop farmers were predominately Fijians while cane farmers were mostly Indo-Fijians (Fig 1.1).

![Pie chart showing farming types in Ba subdivision]

Fig 1.1 Farming practices by respondents from Ba subdivision

5.1.2 Fertilizer usage

Of the respondents interviewed in Ba, 18 farmers use NPK at a rate of 1800kg/month. 62 farmers, who were mainly Fijian subsistence farmers, did not use any artificial manure.

5.1.3 Pesticide/weedicide usage

The survey showed that respondents in Ba had more preference for Paraquat using an estimated total of 266L/month. This was followed by Attack with 96L/month and 2L/month of Diuron80 and Rambo.
The quantity of Paraquat was low compared to most of the other districts. For similar comparison in the quantity and users of specific pesticides/weedicides refer to the following Figures: (Fig 1.10 for Attack; Fig 1.20 (Argozone); Fig 1.23 (Other Pesticides/weedicides); Fig 1.29 (E40); Fig 1.35 (RoundUp); Fig 1.38 (Malthion); Fig 1.46 (Rambo); Fig 1.51 (Diuron80)

5.1.4 Water sources and quality
Of the 80 respondents from Ba, the majority (66 families) depended on obtaining water from the nearest river/creek while 13 families obtained their water supply from privately owned wells and 1 family depended solely on a spring.

The Total coliform level in November (2002) from the spring source at Tavarau settlement was grossly polluted with 4600 c.f.u and 50 F.coli/100ml. Total coliforms for Nakavika Borehole showed 900 c.f.u./100ml. Karavi settlement Well, as well as the PWD sources at Navatu and Elevuka had lower levels at <3 c.f.u/100ml of Total coliforms. Khalsa Rd borehole showed an unsatisfactory level of 750 c.f.u of F.coli/100ml.

Khalsa Rd Creek, Khalsa Rd Borehole, Nakavika Borehole and Tauvarau Well all had Electrical Conductivity that ranged from 1414uS/cm to 9990uS/cm at 20C, which were well above the recommended WHO guideline of 400uS/cm. pH levels for all the sources were all within the neutral range (Fig 1.4).
The results for chemical analysis in November 2002 showed TDS ranged from 182mg/L at Khalsa creek, 222mg/L for both Khalsa Borehole and Nakavika Borehole. Tavarau well had the highest reading of 834mg/L (Fig 1.5)

Ammonia levels for the same water sources ranged from 0.2 to 0.5mg/L, which were below the WHO Criteria for drinking water of 1.5mg/L that is considered safe. The highest Nitrite level was 0.7mg/L at the Khalsa Borehole, well below the 3.0ppm guideline value. Chloride levels for the same sources however, were very high and ranged from 1420 to 1775mg/L, all exceeding the 250ppm guideline value.

The levels of Copper, Zinc, and Sulfates for Tavarau Well, were all <0.1mg/L which were all below their respective WHO drinking water guideline values. Potassium, Sodium levels are shown below (Fig 1.6).

5.1.5 Incidence of diarrhoea
Ba had a total of 20 cases of diarrhoea from the survey questionnaire. Tavarau and Nakavika had 3 Indo-Fijians with diarrhoea below 4 years of age during the period compared with 1 Fijian. Karavi settlement had the highest number with 13 cases for the same age groups.
5.2 Lautoka Subdivision

5.2.1 Farming types

Lautoka respondents were made up of 51% root crop farmers, 29% sugarcane farmers, 18% farming other crops and 2% fruit farmers (Fig 1.8) although this district is another major produce of cane for the country.

5.2.2 Fertilizer usage

Amongst the respondents from Lautoka, 44 farmers use NPK at a rate of approximately 3950L/month. 9 farmers stated they did not use any artificial manure.
5.2.3 Pesticide/weedicide usage

![Graph showing pesticide usage in Lautoka subdivision.](image)

*Fig 1.9 Comparison in users of Pesticides and Weedicides by respondents in Lautoka subdivision*

Most respondents from Lautoka prefer using E40. As far as quantity was concerned, E40 estimated at 127L/mnth. This is followed by Rambo (92L/mnth), Paraquat (60 L/mnth) then RoundUp with 34L/mnth. Fewer farmers use Argozone (18L/mnth), Attack (6L/mnth), Diuron 80 (16L/mnth) and those who used their own and other formulations was estimated at 12L/month. Respondents in Lautoka do not use Malthion.

![Graph showing quantity of Attack used by respondents in Lautoka subdivision.](image)

*Fig 1.10 Comparison by districts in users and quantity of Attack*

The quantity of Attack used by respondents in Lautoka was very low compared to other districts. For similar comparison in the quantity and users of specific pesticides/weedicides refer to the following Figures: (Fig 1.3 for Grammaxone; Fig 1.20 (Argozone); Fig 1.23 (Other Pesticides/weedicides); Fig 1.29 (E40); Fig 1.35 (RoundUp); Fig 1.38 (Malthion); Fig 1.46 (Rambo); Fig 1.51 (Diuron80)

5.2.4 Water sources and quality

The majority of respondents from Lautoka (79 families) obtained their water from treated PWD supplies. 33 families depended on obtaining water from the nearest
river/creek while 6 families obtained their water supply from privately owned wells and 4 families depended solely on spring. There were 8 families who relied solely on rainwater as their principal source. The piped water supplies at Vakabuli, Matawalu and Vitogo recorded Nitrogen levels that ranged between 0.3 - 0.4mg/L. The spring supply at Vatamai also recorded 0.4mg/L. However the well supply at Navoka and the piped supplies at Navoka and Vunato showed levels below 0.1mg/L (Fig 1.11).

The levels of Phosphorous in all the drinking water sources and receiving waters were all <0.01 mg/L. With the exception of Vunato Creek and Vitogo Creek, all the other water sources mentioned above, had Potassium levels of 2mg/L or less. Vunato Creek had 7mg/L while Vitogo Creek recorded the highest at 45mg/L of Potassium.

Samples for bacteriological analysis were taken on 11/3/2002 after rainy spell when a lot of run-offs were getting into the creek. The untreated drinking water sources from Abaca Creek, Natalau creek, Barara creek, Vuda creek, Wailoko creek and Lauwaki creek all showed gross contamination with more than 24,000 Total Coliforms and Faecal coliforms/100ml. The borehole at Wailoko was also grossly polluted with 930 coliforms and 930 F.coli/100ml.

Samples taken from the treated supplies at Natalau and Esivo settlement, Lauwaki and Barara taps however were relatively safe with zero F.coli and <3 Total coliforms.

5.2.5 Incidence of diarrhoea

There were problems with accessing data from the PATIS programme at Lautoka Hospital for the study sites. The only data accessed was from the Lautoka Health Center, which had 7 cases of diarrhoea from the study sites during the period of January to March. It is significant that there were 2 cases of dysentery at Barara settlement and 1 case at Navoka in the 15-44 age group. Vakabuli, Vitogo, Lauwaki and Navoka villages had cases of diarrhoea. Vakabuli also had Enteric fever. There were 6 food poisoning cases and they were in the adult age group (Fig.1.12)
5.3 Levuka Subdivision

5.3.1 Farming types
There were only three main crops in Levuka; root crops such as dalo made up 62% while other crops totalled 37% ha. Fruit farmers made up only 1% of the respondents (Fig 1.13).

5.3.2 Fertilizer usage
Of the respondents from Levuka, 16 used NPK as fertilizer.
5.3.3 Pesticide/weedicide usage

There was greater preference for Paraquat with respondents using an estimated total of 60L/mnth. Argozone made up 24L/mnth and followed by Round Up at 22L/mnth. Farmers who concocted their own mixture used an estimated quantity of 36L/mnth. Respondents in Levuka do not use Attack, Diuron 80, E40 or Malthion.

For comparison in the quantity and users of specific pesticides/weedicides refer to the following Figures: (Fig 1.3 for Grammaxone; Fig 1.10 (Attack); Fig 1.20 (Argozone); Fig 1.23 (Other Pesticides/weedicides); Fig 1.29 (E40); Fig 1.35 (RoundUp); Fig 1.38 (Malthion); Fig 1.46 (Rambo); Fig 1.51 (Diuron80)

5.3.4 Water sources and quality

The majority of respondent from Levuka (39 families) obtained their water from the nearest river/creek while 25 families relied solely on rainwater as their principal source.

None of the respondents surveyed were connected to any treated water supply.

All the sites (on Map 1.2) are exposed to possible pollution from farming activities, wild animals and other human activities such as fishing, bathing and washing.

Vuniivisavu village water source (Sites 1 & 2) can be polluted from a nearby village dumpsite and piggeries in addition to human activities such as swimming.

Nasaumatua village source (Site 3) can be polluted by farming activities, rodents and wild pigs. Vatu settlement (Site 4) has nearby farming activities, possible exposure to contamination from rodents and wild pigs besides being used as a swimming site and washing area.

Nasaqa village (Site 5) is liable to pollution from nearby farm activities and agrochemicals as well as rodents and wild pigs.

Bureta village water source has adjacent pollutant sources as well. These are farming activities, rodents and wild pigs. There are also nearby areas for bathing and washing.
The results of chemical samples in all the water sources surveyed were not of a major concern with TDS and Electrical conductivity both below the unsatisfactory levels of 1000ppm and 250ppm respectively. However the Chloride levels should be of concern because they were above 250ppm and the taste could be objectionable.
The readings for Ammonia indicate possible pollution from animal or human urine, faeces or decomposing products. This was supported by the bacteriological analysis, which showed that the water sources at Vuniivisavu, Nasaumatua water catchment, Vatu creek and Tai creek were all grossly contaminated with coliforms and with more than 15 *E.coli*/100ml.

The sample from Vatu creek had the highest MPN of 120 *E.coli*/100ml followed by Vuniivisavu and Tai creeks with 75 *E.coli*/100ml. Nasaumatua had 21 while the reservoir tank at Vuniivisavu had the least with 15 *E.coli*/100ml.

### 5.3.5 Incidence of diarrhoea

According to the Hospital records at Levuka, there were a total of 121 cases of diarrhoea during the 3-month (January-March) period, 2003.

The majority of cases (88) were Fijians, 13 were Indians and 20 cases shared by the other racial groups. There was no breakdown according to age.
5.4 Nadi Subdivision

5.4.1 Farming types
Respondents from Nadi were mainly sugarcane farmers who made up 99% while 1% planted root crop (Fig 1.18).

![Fig 1.18 Farming practices by respondents from Nadi subdivision](image)

5.4.2 Fertilizer usage
81 farmers used an estimated total of 1767kg of fertilizer per month while only 1 farmer said that he did not use artificial fertilizer.

5.4.3 Pesticide/weedicide usage
Respondents in Nadi used a wide cross section of agrochemicals compared to the other subdivisions. Most respondents in Nadi had greater preference for Paraquat using an estimated total of 332L/mnth, followed by Argozone with an estimated quantity of 344L/mnth (Fig 4.20). These were followed by Diuron80 (252L/mnth), Round Up (102L/mnth), Attack (72L/mnth), E40 (20L/mnth) and Rambo (10L/mnth). Malthion and Other formulations made up 2L/mnth each.

![Fig 1.19 Comparison in users of Pesticides and Weedicides by respondents in Nadi](image)
For comparison in the quantity and users of specific pesticides/weedicides refer to the following Figures: (Fig 1.3 for Grammaxone; Fig 1.10 (Attack); Fig 1.23 (Other Pesticides/weedicides); Fig 1.29 (E40); Fig 1.35 (RoundUp); Fig 1.38 (Malthion); Fig 1.46 (Rambo); Fig 1.51 (Diuron80)

5.4.4 Water sources and quality
The majority of respondent from Nadi (10 families) depended on rainwater supply as the principal source. 8 families depended on boreholes while 6 drew their water from private wells. Only 2 families were connected to the treated PWD supply and 1 family depended on obtaining water from the nearest river/creek.

There were no water samples for chemical analysis done by the Nadi office. Bacteriological water sampling carried out in April 2003 showed gross contamination with F.coli in the untreated Boreholes located at Momi, Nalovo and Nabila settlements.

The untreated well supplies at Vunavoli Uciwai settlement and Amgali settlement also showed gross contamination with F.coli

Consumers drawing water from any of the above water sources are at risk of suffering from a range of gastrointestinal diseases.

5.4.5 Incidence of diarrhoea
There was no data available on the incidence of diarrhoea from Nadi subdivision.
5.5 Navua Subdivision

5.5.1 Farming types
Of the total respondents in Navua, 69% were root crop farmers, 13% were rice farmers, 10% farmed other crops and 8% were fruit farmers (Fig 1.21).

![Pie chart showing farming types in Navua](image.png)

Fig 1.21 Farming practices by respondents from Navua subdivision

5.5.2 Fertilizer usage
30 respondents said that they used NPK at an estimated total of 14,715kg per month. On the other hand, 29 respondents said they did not use any artificial manure.

5.5.3 Pesticide/ weedicide usage
There was greater preference by respondents for Paraquat with respondents using an estimated total of 522L/mnth. Round Up was 128L/mnth followed by Rambo with 90L/mnth. Argozone made up 61L/mnth and Malthion used per month was 34L. Farmers who concocted their own mixture used an estimated quantity of 82L/mnth. Respondents from Navua did not use Attack, Diuron 80 and E40.
Respondents from Navua did not use as much unknown formulations as the other districts. For similar comparison in the quantity and users of specific pesticides/weedicides refer to the following Figures: (Fig 1.3 for Grammaxone; Fig 1.10(Attack); Fig 1.20 (Argozone); Fig 1.29 (E40); Fig 1.35 (RoundUp); Fig 1.38 (Malthion); Fig 1.46 (Rambo); Fig 1.51 (Diuron80)

5.5.4 Water sources and quality
The majority of respondent from Navua (35 families) depended on obtaining water from the nearest river/creek while 25 families were connected to the treated PWD supply. 1 family depended solely on rainwater. The treated drinking water supply for Navua which was sampled from Vakabalea and Tokotoko all showed safe levels of <0.1µg/L of Cadmium and <1.0µg/L Lead. The guideline value for Lead is not more than 0.01mg/L. Cadmium in natural waters is usually below 0.01µg/L (WHO) and the guideline value should be 0.003mg/L. The other drinking water sources at Tubarua dam, Wailoaloa dam and Wainiyaniu dam also showed <0.1µg/L of Cadmium, <1.0µg/L Lead. Levels of Arsenic in all the drinking water sources were well below 0.01mg/L, the maximum guideline value that is safe.

Nitrates readings from Tubarua dam was 0.12mg/L, while Wainiyaniu dam and Wailoaloa dam were both <0.034 mg/L. The treated water supply at Vakabalea, Namelimeli and Tokotoko had Nitrate levels that ranged from 0.035 to 0.2mg/L, well below the 50mg/L recommended under the WHO guideline (Fig 1.24).
Phosphate levels at the treated Navua water supply and all the untreated sources were < 0.018mg/L with exception of Vakabalea, which was 0.04mg/L and Wainiyanitu dam, which had 0.09mg/L. Vakabalea and Wainiyanitu would therefore have greater presence of algal growth.

Levels of Potassium were highest in the receiving waters at Tokotoko (189mg/L) followed by 18.3mg/L at Deuba River and Namelimeli creek thence Waridrada creek at 1.27mg/L. The other drinking water sources recorded values below 0.5mg/L.

5.5.5 Incidence of diarrhoea
There were no cases of diarrhoea reported from the Navua subdivision. This can be due to either under reporting or missing data.

5.6 Rewa Subdivision
5.6.1 Farming types
There were more Root crop farmers (56%), followed by other crops (29%) then Rice 15% (Fig 1.25)
5.6.2 Fertilizer usage
There were 28 respondents from Nausori said they used an estimated total of 2770kg NPK per month. The other 27 respondents said they did not use any manure.

5.6.3 Pesticide/weedicide usage

![Graph showing pesticide type usage in Rewa](image)

*Fig 1.26 Comparison in users of Pesticides and Weedicides by respondents in Rewa*

Most respondents from Rewa prefer Paraquat but according to the quantity used, Rambo was the highest with an estimated 344L/mnth. Paraquat was 174L/mnth followed by those who used their own formulations, which totaled 146L/mnth. Those preferring RoundUp and Argozone used 10L/mnth of each.

For comparison in the quantity and users of specific pesticides/weedicides refer to the following Figures: (Fig 1.3 for Grammaxone; Fig 1.20 (Argozone); Fig 1.23 (Other Pesticides/weedicides); Fig 1.35 (RoundUp) and Fig 1.46 (Rambo). According to the survey, respondents in Rewa did not use Attack, Diuron80, E40 or Malthion.

5.6.4 Water sources and quality
The majority of respondent from Nausori (24 families) depended on rainwater as their principal water source while 3 families drew their water from the nearest river/creek. Only 2 families obtained their water from treated PWD supplies.

There were no water samplings for either chemical or bacteriological sampling done by the Rewa sub divisional office.

5.6.5 Incidence of diarrhoea
There was no data submitted from the Rewa Health office.
5.7 Rakiraki Subdivision

5.7.1 Farming types

There were 62.8% of respondents from Rakiraki were sugarcane farmers, followed by root crop farmers (32.2%), fruit farmers made up 2.8%, other crops (0.8%) and 0.4% rice farmers (Fig 1.27).

5.7.2 Fertilizer usage

156 respondents from Rakiraki said they depended on NPK for fertilizer and they used an estimated total of 877kg per month. 13 farmers do not use artificial fertilizer.
5.7.3 Pesticide/weedicide usage

The majority of respondents from Rakiraki preferred E40 using an estimated amount of 780L/mnth (Fig 1.29). This was followed by RoundUp with 670L/mnth, Rambo with 388L/mnth, Diuron 80(150L/mnth), Paraquat (128L/mnth) and Argozone (67L/mnth). Quite a significant amount of unknown formulations were recorded at an estimated quantity of 606L/month.

For a comparison in the quantity and users of specific pesticides/weedicides refer to the following Figures:( Fig 1.3 for Grammaxone; Fig 1.10 (Attack); Fig 1.20 (Argozone); Fig 1.23 (Other Pesticides/weedicides); Fig 1.35 (RoundUp); Fig 1.46 (Rambo); Fig 1.51 (Diuron80). Respondents in Rakiraki did not use Malthion.

5.7.4 Water sources and quality
The majority of respondent from Rakiraki (111 families) obtained their water from treated PWD supplies. 48 families depended on obtaining water from the nearest river/creek, 27 families obtained their water supply from springs and 12 families depended solely on wells. There were 3 families who relied solely on rainwater as their principal source.

All the individual spring sources for the villages of Vaidoko, Nakorokula, Narewa, Narara, Drana and Vunitogoloa settlement were all grossly polluted with *F. coli* and
other coliforms. Except for Drana village, all the others are untreated and therefore need sanitary survey to ensure their protection. The treated supplies at Rewasa village and Qalau settlement satisfied the WHO guideline for drinking water. It is significant to note that 2 other sampling points for the Rakiraki treated water supply did not meet the minimum standard of drinking water quality.

The well water supplies at Vunitogoloa settlement, Rewasa settlement as well as the boreholes at Naria settlement and Wananavu were both polluted with *F[coli]* and other coliforms. Consumers drawing water from any of the above water sources with *F[coli]* are at risk of suffering from a range of gastrointestinal diseases.

The results of chemical analysis of the treated water sources at Drana and Waimari as well as the untreated sources at Vaidoko and Naria springs, showed relatively high ammonia and nitrate levels ranging from 1-1.2mg/L indicating possible pollution from animal or human origin (Fig 1.30). The untreated sources at the other locations had low ammonia and nitrate readings of below 0.4mg/L.

Chloride levels range from 500 to 800 mg/L, which is well above the acceptable level of 250mg/L. This could be an indication of salt-water intrusion or from fertilisers. Chloride content in unpolluted waters are often below 10mg/L (WHO guideline). All the sources would be expected to have high corrosive ability. Sulfate levels are also very high at 650-850mg/L (Fig 1.31)
Iron and Manganese levels were 0.3mg/L below the 0.5mg/L recommended by WHO. Copper and Zinc were well below their respective safe levels of 1mg/L and 3mg/L.

5.7.5 Incidence of diarrhoea
Rakiraki had the highest number of diarrhoea with 80 cases during the period January to March 2003.
In the 0-5 age group, 50% of the total cases for Rakiraki were from the study areas. However, in the 5-14 age group, 10% of the cases for the subdivision were from the same study areas. For the above 45-age group there were more from the areas surveyed compared to the rest of Rakiraki subdivision (Fig 1.32)

5.8 Savusavu Subdivision
5.8.1 Farming types
Root crop farmers made up 74% of the respondents followed by 24% farming other crops. Fruit and sugarcane farmers were 1% each (Fig 1.33)
5.8.2 Fertilizer usage
47 respondents from Savusavu said they depended on NPK for fertilizer and used an estimated total of 2615kg per month.

5.8.3 Pesticide/weedicide usage

Most respondents from Savusavu prefer Paraquat using a total of 400L/mnth. Argozone was next with 371L/mnth, followed by Rambo at 218L/mnth. Quantity of RoundUp was 146L/mnth, Other formulations made a total of 88L/mnth and Attack was 8L/mnth.
For similar comparison in the quantity and users of specific pesticides/weedicides refer to the following Figures: (Fig 1.3 for Grammaxone; Fig 1.10 (Attack); Fig 1.20 (Argozone) Fig 1.23 (Other Pesticides/weedicides); and Fig 1.46 (Rambo). Respondents in Savusavu did not use Diuron80, E40 or Malthion.

5.8.4 Water sources and quality

The majority of respondents from Savusavu (36 families) obtained their water from treated PWD supplies. 14 families depended on obtaining water from the nearest river/creek while 13 families obtained their water supply from privately owned springs. There were 2 families who relied solely on rainwater as their principal source.

None of the respondents used well as a source of water supply.

There were no water samplings for either chemical or bacteriological analysis from Savusavu during the period.

5.8.5 Incidence of diarrhoea

Savusavu Hospital reported 16 cases of diarrhoea during the period.

5.9 Sigatoka Subdivision

5.9.1 Farming types

The survey revealed that 65% of respondents were root crop farmers and 22% were cane farmers. Farmers who planted fruits totaled 6% while those who farmed other crops and rice made up 4% and 3% respectively (Fig 1.36).
5.9.2 Fertilizer usage

Respondents from Sigatoka used a lot more fertilizers. 106 farmers amongst themselves used a total of 8095kg per month. 18 farmers said they did not use artificial fertilizer but rather depended on the natural fertility of the soil.

5.9.3 Pesticide/ weedicide usage

Sigatoka subdivision used the most pesticides/weedicides both in quantity and variety. The majority of respondents’ from Sigatoka preferred Paraquat but according to the quantity used, Malthion was highest at 1146L/mnth followed by Parquet (618L/mnth), Attack (462L/mnth), E40 (338L/mnth), Diuron80 (354L/mnth), Rambo (336L/mnth), RoundUp (154L/mnth), and Argozone (106L/mnth). Quite a significant amount of unknown formulations were recorded at an estimated quantity of 272L/month.
For similar comparison in the quantity and users of specific pesticides/weedicides refer to the following Figures:( Fig 1.3 for Grammaxone; Fig1.10 (Attack); Fig 1.20 (Argozone); Fig1.23 (Other Pesticides/weedicides); Fig 1.35 (RoundUp); Fig 1.46 (Rambo); Fig 1.51 (Diuron80)

5.9.4 Water sources and quality
The majority of respondent from Sigatoka (123 families) obtained their water from the nearest river/creek while 105 families were connected to the PWD supply. 27 families obtained their water supply from privately owned wells and 11 families depended solely on spring. There were 54 families who relied solely on rainwater as their principal source.

The treated supply at Sigatoka which was sampled from points at Malevu, Nawamagi and Nasama villages were all satisfactory with 0 E.coli/100ml and <3 coliforms. However, the untreated supplies at Kavanagasau Borehole, Narata, Raiwaqa, Barara, Nadrala and Semo all showed gross contamination with F.coli during the period. These supplies were either from wells or piped from creeks.

In addition, Kavanagasau borehole, Nadrala and Narata had significantly very high Chloride content and Conductivity compared to the WHO guideline.

Levels of Nitrite, Sulfates, Copper, Zinc, Potassium and Sodium were all acceptable and safe. The levels of pH, Ammonia, Calcium and Magnesium were also satisfactory. However, one farm Well near Sigatoka Town showed very high ammonia level indicating pollution from animal or human origin.

5.9.5 Incidence of diarrhoea
Verification with the Hospital and Health center data showed that there were a total of 22 diarrhoea cases reported from the survey area. Of these, there were 6 cases in the 0-5 age group who were all Fijian children. This was significant compared to 20 cases for the rest of Sigatoka. Between 5-14 age group, there were also 6 cases of diarrhoea, and all were Fijians. There were 15 other cases of diarrhoea for the rest of Sigatoka subdivision for the same age group. The number of diarrhoea cases who were above 15 years were not significantly different between races with 6 Fijians and 4 Indians.
5.10 Suva Subdivision

5.10.1 Farming types
The majority of respondents in the Suva area farmed root crops (93%). Rice, fruit and other crops made up the balance (Fig 1.40).

5.10.2 Fertilizer usage
29 respondents from Suva said they used NPK as fertilizer using an estimated total of 1688kg per month. 74 farmers however, did not use any artificial fertilizer.

5.10.3 Pesticide/ weedicide usage
Most respondents from Suva prefer Paraquat using a total of 1028L/mnth. This was followed by Rambo (224L/mnth) and RoundUp with 232L/mnth, other formulations made a total of 90L/mnth and Malthion was 62L/mnth. Respondents also used Argozone but at rate of 10L/mnth and Attack at 2L/mnth.

For comparison in the quantity and users of specific pesticides/weedicides refer to the following Figures:( Fig 1.3 for Grammaxone; Fig1.10 (Attack); Fig 1.20 (Argozone); Fig 1.23 (Other Pesticides/weedicides); Fig 1.35 (RoundUp); Fig 1.38 (Malthion) and Fig 1.46 (Rambo). Respondents in Suva do not use Diuron80.

5.10.4 Water sources and quality
The majority of respondent from Suva (58 families) obtained their water from the nearest river/creek while 47 families relied solely on rainwater as their principal source. 27 families were connected to the treated PWD supply and 44-used spring as their main source.

The treated drinking water supply for Suva was sampled over a period of 2 weeks from 14 schools. All of the 14 sampling points showed levels of <0.1ug/L of Cadmium which were below the guideline value of 0.003mg/L. The level of Lead at all the sites were within the safe level of <1.0ug/L. With exception of a few sites, there were no variations in the levels of Arsenic from <0.5ug/L. ColoiSuva (0.68ug/L), Kalabu primary (2.16ug/L), Makoi Muslim (4.39ug/L) and Tamavua Primary (5.30ug/L) were the exceptions but these levels were still safe for drinking.

The levels of Nitrates in the Suva water supply ranged from <0.034 to 1.4mg/L and these were still safe for human consumption (Fig 4.42). There were very little variations in Phosphate levels and all the sites recorded <0.018mg/L with exception of Kalabu Primary, which was 0.1mg/L, and Nasinu secondary, which had 0.09mg/L.
The Potassium levels were highest at Tamavua Primary (2.55mg/L) followed by 2.25mg/L at Kalabu District School. All the other sites had less than 0.9mg/L. Bacteriological samples taken in March 2003 from Tamavua Primary School showed contamination with E.coli while all the other regular sampling points were satisfactory. Repeat sampling in April showed that the same point at Tamavua Primary was still not satisfactory. The untreated drinking water catchments at Vacoko settlement, Kalokolevu, Wainawa and Muanaicake spring were all contaminated with E.coli.

The receiving waters of Cina River, Matainaborosisi catchment, Wailoku River and Waikalou River, Waibura Creek were all grossly contaminated with both coliforms and E.coli.

5.10.5 Incidence of diarrhoea

Suva subdivision included Lami and Valelevu Health centers. The total number of cases was 62 during the 3-month period of the survey. Within the last 5 days of the survey, Suva recorded the highest number with 14 cases. It is significant to note that for all the three racial groups, there were a big number of infantile diarrhoea cases.
5.11 Tailevu Subdivision
5.11.1 Farming types

Korovou includes a total of 14,000 ha of farmland under crops. There are a total of 2863 farmers who live in rural, 74 villages and 570 small farming settlements. The majority of the farms are small-scale individual farms. The major crops of dalo and yaqona are grown for local consumption and for the export markets.

The major crops for local market and export are *Dalo* and *Yaqona*. 71% of the respondents’ plant root crops such as dalo compared to 16% who planted other crops. Fruit farmers make up 11%. There were only 1% of respondents who planted Sugarcane and rice (Fig 1.44).

![Fig 1.44 Type of farms practised by respondents from Korovou, Tailevu](image)

5.11.2 Fertilizer usage

There were 60 farmers in Korovou who used NPK manure with a combined total of 3672 kg/month. Lesser number of farmers did not use artificial manure.

5.11.3 Pesticide/weedicide usage

![Fig 1.45 Comparison in users of Pesticides and Weedicides by respondents in Korovou subdivision](image)
Judging by the number of users from Korovou, Rambo was the preferred choice of weedicide. By quantity Rambo also topped the list (518L/month), followed by Paraquat (484L), RoundUp (226L), Argozone (156L/month), malthion (106L/mnth) and Attack (46L), Diuron80 (22L/mnth). The quantity of other pesticides was made up of 28L/mnth.

![Graph showing Rambo use by subdivision](image)

**Fig 1.46 Comparison in number of users and quantity of use of Rambo by Districts**

Korovou used the highest quantity of Rambo per month compared to other districts. For similar comparison in the quantity and users of specific pesticides/weedicides refer to the following Figures: (Fig 1.3 for Grammaxone; Fig1.10 (Attack); Fig 1.20 (Argozone); Fig 1.23 (Other Pesticides/weedicides); Fig 1.35 (RoundUp); Fig 1.38 (Malthion); Fig 1.51 (Diuron80)

### 5.11.4 Water sources and quality

The majority of respondent from Korovou (63 families) relied on rainwater while 48 families were connected to treated PWD supplies. 42 families depended on obtaining water from the nearest river/creek while, 13 families obtained their water supply from privately owned wells and 12 families depended solely on spring.

The results of water sampling surveys in January and February, 2003 revealed that 5 of the six sampling points for the treated water from *Waibula River*, which is the main source for Korovou Town, were polluted with < 3 coliform. The other sampling point, an outside standpipe, was grossly polluted with coliform in excess of 2400/100ml. *Waibula River* has several dairy farms located upstream. There were no *E.coli* reported from all the sampling points during the period.

The repeat sampling in March 2003 showed that Korovou treated supply satisfied the WHO guideline of NIL *E.coli* c.f.u/100ml.

*Sawani River* which is the source for 3 nearby villages was grossly polluted with >2400 coliform/100ml. This is an untreated source with farming activities located upstream. *Delasui River*, another untreated source of drinking water was also sampled and showed levels of more than 2400 coliforms/100ml. The supply for Wailotua, which is untreated, also showed an unsatisfactory result of 23 *E.coli*/100ml.
Ciociorati creek, the source for two nearby communities had coliform levels of 2400/100ml. Samples taken from the water tanks showed levels between 240-460 coliforms/100ml. The E.coli readings from both source and tank were between 5-23/100ml. Roof water catchment also showed presence of coliforms. Naveicovatu water tank and Naivicula School both showed gross contamination with 240 E.coli/100ml. Wailotua piped water was also contaminated with 1100 E.coli/100ml. All the above untreated drinking water sources presented a high risk of transmission of gastrointestinal tract diseases to those who depend on them.

A 3-monthly monitoring in Jan - March 2003 of the following major River systems in Tailevu showed gross contamination with Faecal coliforms. Wainivesi River, Waimaro River, Wainibuka River, Wailotua River and Wainivilimi creek were all found to be grossly contaminated with high numbers of E.coli /100ml. These receiving waters are therefore unsafe for drinking or swimming purposes. Nearby villagers who consume freshwater mussels and fish obtained from the same rivers will also be at risk of contracting some gastrointestinal infections.

The results for chemical analysis in February showed levels of Copper, Zinc, Potassium, sodium, Conductivity and Sulphates for Sawani River, Wainivesi River and Dakuivuna Creek were all below their respective WHO guideline values and therefore not of concern.

![Fig 1.47 Levels of Ammonia and suspended solids at Korovou receiving waters](image)

Ammonia levels from the same rivers were about 1.9 mg/L, which slightly exceeded the WHO Criteria for drinking water of 1.5mg/L (). This again coincided with the organic pollution from either animal or human sewage.

5.11.5 Incidence of diarrhoea

The very poor bacteriological and chemical water quality results are reflected somewhat in the number of cases of diarrhoea that were reported from the Korovou subdivision. It is to be noted that this is not the true picture because diarrhoea is usually grossly under reported.
Of the cases of Diarrhoea reported in January and February from the survey area, there was a very high number of Infantile diarrhoea cases between the critical ages of 0-4yrs. Of the total of 23 cases, there were 15 Fijians and 8 Indo-Fijians. The cases were spread out from all over the subdivision and not confined to any particular locality.

In the 5-14 age group, there were 3 Fijians and 1 Indo-Fijians while the 15-44 age group showed a total of 5 Indians and 14 Fijians had diarrhoea. There were only 2 Fijians and 1 Indo-Fijians above the age of 44 who suffered from the disease in January and February.

Within the last 5 days of the survey, Korovou recorded 10 cases of diarrhoea.

The comparatively high number of Fijians is related to the high number of Fijian respondents in the survey compared to Indo-Fijians. It also points to the fact that a greater number of Fijians are drinking from untreated village water supplies whereas Indo-Fijians are generally concentrated close to the Korovou town, which has treated water.
5.12 Tavua Subdivision

5.12.1 Farming types
Root crop farmers made up 54.8% followed by 38.1% cane farmers. Fruit farmers made up 6.7% and there was a low 0.4% rice farmers (Fig 1.49).

Fig 1.49. Type of farming practised by respondents from Tavua

5.12.2 Fertilizer usage
24 farmers from Tavua said they used NPK at an estimate total of 2370kg per month.

5.12.3 Pesticide/ weedicide usage

According to the number of users, E40 was the preferred choice and it also topped the list as far as quantity at 340L/mnth. This was followed by Paraqua (290L/mnth) then Diuron80 (112L/mnth) and Rambo at 30L/mnth. RoundUp was 12L/mnth and Attack was 4L/mnth. Tavua respondents do not use Argozone, Malthion and Other formulations.
Fig 1.51 Comparison of No. of users and quantity of Diuron 80 by subdivision

For similar comparison in the quantity and users of specific pesticides/weedicides refer to the following Figures: Fig 1.3 for Grammaxone; Fig1.10 (Attack); Fig 1.20 (Argozone); Fig 1.23 (Other Pesticides/weedicides); Fig 1.35 (RoundUp); Fig 1.38 (Malthion); Fig 1.46 (Rambo)

5.12.4 Water sources and quality
The majority of respondent from Tavua (86 families) obtained their water from spring/borehole. 42 were connected to treated PWD supplies while 30 families depended on privately owned wells. 4 families depended solely on the nearby river or creek.

The untreated borehole sources at Vatutavui and Koro were all polluted with coliforms. Spring sources at Nasomo, Nadelei, Waikubukubu and Nagatagata also had very high levels of E. coli.

However, the PWD supply for Rukuruku and Lomalagi were free of coliforms.

Cadmium, Lead and Zinc for all the sources were all less than 0.01ppm pH was within the neutral range for all the sources. Nitrogen ranged from 4.52mg/L at Nasomo spring and Malele well to 5.65 at Vatutavui Borehole (Fig 1.52)

Fig 1.52 Nitrogen and pH levels from Tavua water sources
Conductivity for Nasomo spring was 142.8uS/cm; Vatutavui Borehole had 337uS/cm while the well supply at Malele showed a high conductivity of 602uS/cm.

5.12.5 Incidence of diarrhoea

There were 131 patients from all racial groups and age groups with diarrhoea seen during the period (Fig 4.53). Infantile diarrhoea cases for the age group 0-5 years totaled 55 cases. In the same age group (0-5), there were 31 Indo-Fijians compared to 24 Fijians. Of the 55 cases, there were 29 females and 26 males.

![Tavua Hospital Diarrhoea Cases September 2002-March 2003](image)

*Fig 1.53 Incidence of diarrhoea at Tavua during the period Jan-March, 2003*
6  Discussion

6.1  Farming types

There was a wide variation in farming types by districts depending on a whole range of factors such as soil types, topography, water retention levels, climate and demand. It was found that 58% of the 1622 respondents planted root crops, 26% were cane farmers, 4% planted fruits and 2% were rice farmers. 10% of the respondents planted crops other than the ones already mentioned (Fig 5.1).

![Types of Farming](image1.png)

*Fig 1.54 Comparison between different crops planted by the 1622 respondents from the 12 Medical subdivisions surveyed*

The districts with high number of respondents who were canefarmers were Rakiraki (159), Nadi (81), Sigatoka (69) and Tavua (91) and Lautoka with 45 (Fig 5.2).

These districts are all located on the western side of Viti Levu where sugarcane is the principal crop.

![Sugarcane](image2.png)

*Fig 1.55 Districts with number of cane farmers who were interviewed in the survey.*

Root crops were planted by farmers in all the subdivisions for local consumption and export (Fig 1.56).
There were more respondents who planted rice in Navua, Ba, Nausori and Sigatoka (Fig 1.57).

Sigatoka, Korovou and Tavua had more fruit farmers in comparison to the other subdivisions (Fig 1.58).

By being located on the border between the dry western side and the wet eastern side of Vitilevu, the climate for Sigatoka is ideal for a wide variety of farm types. Sigatoka is also known as the “salad bowl” of Fiji from the variety of crops and vegetables grown along the river valley.
Under the banner of “Other crops” is included Yaqona (Fijian name for kava) or *(Piper methysticum)* which has gained international prominence as an export crop for manufacturing medicinal drugs.

### 6.2 Fertiliser use

N PK was the preferred fertilizer at all the subdivisions. The greatest number of users of N PK was found in Rakiraki (156 farmers) followed by Sigatoka (106) then Nadi (81).

However, according to the estimated amount of N PK used in a month, Navua had surprisingly the highest with 14,715kg/month followed by Sigatoka (8095kg) then Levuka with 8100kg (Fig 1.60).
other hand respondents from Ba were mainly Fijian subsistence farmers who do not use use fertilizers.

6.3 Usage and Quantity of Pesticides/Weedicides

![Pie chart showing pesticide use](image)

**Fig 1.62 Comparison of percentage of farmers using particular brand of pesticide/weedicide**

The survey showed that the weedicide/pesticide which majority of farmers used was Grammaxone (29%). It was followed by Rambo (16%) then E 40 (13%), Round Up (10%), Agrozone (8%), Diuron 80 (6%), Attack (4%), Malthion (3%) (Fig 1.63)

![Pie chart showing pesticide use](image)

**Fig 1.63 Comparison by quantity of pesticide used by all respondents.**

Of the total of 15434 Litres of pesticides/weedicides used per month, the highest amount used was Grammaxone (27%) followed by Rambo (15%), Round-up (11%), E40 (10%), Argrozone (8%) then Attack(8%), Diuron (6%) and Attack (5%).
**Grammaxone** was the most popular weedicide used in all the subdivisions (Fig 1.3).

Suva appeared to be the area that uses the most with an estimate of 1028 L/month followed by Sigatoka at 618 L/month then Navua at 522 L/month. Suva and Navua use greater amounts of weedicides to control the rapid growth of weeds on the wetter side of Vitilevu.

The pesticide **Attack** was most popular with Sigatoka farmers who use an estimated 462L/month. Ba farmers were the closest with an estimate of 96L/month, then Nadi with 72 L/month (Fig 1.10).

**Agrozone** appeared to be widely used in most of the subdivisions (Fig 1.20). It is more popular with Savusavu farmers who use an estimated 371L/month followed by Nadi with 344L/month, then Korovou (156L) and Sigatoka (106L).

It was found that 10% of farmers interviewed, used other pesticides/weedicides whose brands were not included in the survey form. Other pesticides could include some, which are highly toxic. This may also include farmers who do not follow recommendations and concocted their own “backyard mixture” using several chemical pesticides. The impact on their health and the environment through tampering with unknowns can be lethal especially because of the real possibility of synergistic effects resulting from such mixtures. Rakiraki had the most number of farmers who concocted their own mixture of chemicals followed by Sigatoka (Fig 1.23).

This practice is not confined to Fiji as even in the Carribean, it was found that some farmers combined a cocktail of systemic pesticide, contact pesticide and fertilizer. Some insecticide and fumigant can be combined with success, however the majority cannot.

**E40** was more popular at Rakiraki where an estimated amount of 780L/month is used. Sigatoka and Tavua follow with an estimated 340L/month each (Fig 1.29).

**Roundup** was used in all the subdivisions with Rakiraki farmers using the most at an estimate of 670L/month. Farmers in other areas however, used very minimal amounts as shown in Fig 1.35

**Malthion** was a more popular brand of pesticide in Sigatoka, Navua, Suva and Korovou. Sigatoka uses the most malthion with an estimated 1146L/month followed by Korovou with 106L (Fig 1.38).

**Rambo** was found to have the greatest number of users in Korovou with an estimated quantity of 518L/month followed by Rakiraki (388L/month) and Sigatoka with 336L/month (Fig 1.46).

**Diuron 80** was found to be used mainly by farmers in Tavua, Nadi and Sigatoka. However, the most amount of Diuron was used in Sigatoka with an estimate of 354L/month followed by Nadi with 252L/month (Fig 1.51)
It was significant to note that farmers in the different farming districts had preference for different brands of agrochemicals. For example, Levuka farmers had significantly greater preference for Gramoxone alone. Sigatoka farmers had greater preference for Malthion pesticide followed by the weedicides Gramoxone, Rambo, Attack and Diuron 80.

The Subdivision, which had the most number of farmers using agrochemicals, was Sigatoka. This was not surprising because Sigatoka is known for being the greatest producer of vegetables in Fiji and is also a cane-farming area. Rakiraki subdivision was the second greatest user (by number of farmers) followed by Korovou. They were followed in order of use by Nadi, Tavua, Lautoka, Suva and other subdivisions. Ba subdivision is one of the biggest producers of cane but had a significantly low level of pesticide use. This was most probably because majority of the respondents were from the subsistence Fijian villagers rather than the Indo-Fijian canefarmers.

A significant number of mainly Fijian farmers in the villages did not use any pesticide on their farms. This was related to the subsistence type of farming of mainly traditional crops such as dalo and yaqona.

There is high usage of agrochemicals in cane farming. Approximately 40% of sugarcane farmers in Fiji rely on herbicides for weed control in their farms. The survey showed that they used very low amounts of insecticides or fungicides, thus probably lessening the health impacts because the most acutely toxic pesticides are, generally insecticides. However, there are number of herbicides found in the survey to be common throughout the subdivisions are classified by the World Health Organization (WHO) as toxicity level II (moderately hazardous) or III (slightly hazardous). These would be expected to negatively affect the health of those exposed either directly or indirectly. Included among these materials are Paraquat (Class II), and Diuron (Class III).

2,4-D 40% (Weedkiller E40) is selective and systemic herbicides. 2,4-D has been implicated as a causal factor in the development of certain cancers in agricultural workers in Northern Europe and USA (Hardell et al, 1979; 1988);(Hoar et al, 1986). Diuron 80 is a residual herbicide and has been classified as having low to medium acute toxicity, while exhibiting carcinogenic, mutagenic, and growth inhibiting long-term effects (Council on Scientific Affairs, 1988).

Szmedra, 2002 in his study of cane farmers in Fiji found that when compared with the control group, cane farmers who used pesticides experienced significant eye problems, (49.3%), skin problems (31.3%), problems associated with the respiratory tract(37%) nervous system (26%). Of lower significance were gastrointestinal problems amongst users of pesticides.

Farmers in Fiji are generally unaware of the actual short term or long-term exposure hazards associated with many pesticides, which are in common use. Technologies
such as chemical pesticides require some minimal level of knowledge that goes beyond traditional agricultural practices.

Farmers do not recognize health impairment as one of the chronic effects of pesticide exposure. This situation may lead to negative health impacts which in turn hinder the productivity of the farmer, farm worker and farm family members, leading to overall diminished farm productivity (Szmedra, 2002).

6.4 Water Sources and Quality

This study revealed that each Medical subdivision had a variety of sources of water supply. Of the 1618 households surveyed, the majority (69%) drew their water from untreated sources and only 475 households or 31% received their supplies from treated PWD supplies. Amongst the respondents, river was the main source (31%) followed by rainwater (17%) then spring (14%) and the least was using wells (7%) (Fig 5.9). Since the survey was carried out in the rural areas, the distribution of population to respective sources was different from the data available for the whole country (Fig 1 C)

![Water source distribution by types in the study](image)

The subdivisions, which depended a lot on the nearby rivers were; Ba, Sigatoka, Rakiraki, Korovou, Levuka, Suva, Navua and Lautoka.

Rainwater was the major source for farmers in Nadi and Nausori. Some farmers in the wet zones of Vitilevu such as in Korovou, Sigatoka, Suva, and Levuka also depended on rainwater to supplement other sources. There was also reliance on Wells by some farmers in Ba, Korovou, Rakiraki, Sigatoka and Tavua.

Spring was another drinking water source for farmers in Tavua, Sigatoka, Rakiraki and Korovou.

The survey revealed that with the exception of a few sources, all of the untreated supplies had unsatisfactory levels of coliforms of both Faecal and E.coli. The vulnerable populations drawing water from those sources are at risk of contracting diarrhoea and a whole range of other more serious gastro intestinal diseases.
It is a matter of concern also that even some treated water supplies had unsatisfactory levels of E. coli which means there are distinct possibilities of the presence of more serious pathogens.

Due to the high amount of agrochemical usage by farmers in some districts, there is distinct possibility of chemicals getting into the waterways. It has been found that even pesticides that are applied correctly on land may wash away from the application site. Rain falling on a treated area before the pesticide binds or degrades may carry the chemical to surface waters. Pesticides can also seep into and through the soil during recharge of groundwater and get into aquifers. Some pesticides can also move in air from the application site to surface waters used in a drinking system (Walker et al, 1995).

Pesticides can also get into waterways from spillages from washing or when mixing near waterways. Pesticides found in drinking water can negatively affect human health and environment depending on how much chemical is present, the length and frequency of exposure, and the toxicity of the pesticide (USEPA, 1990). There are also variations in the toxicity and the sensitivity of humans to specific pesticides.

6.5 Incidence of Diarrhoea

![Diagram showing incidence of diarrhoea by subdivision](image)

*Fig 1.65 No. of cases of diarrhoea by subdivision during the period January-March 2003 from Questionnaire survey.*

The highest numbers of cases were recorded in Rakiraki. This however should be seen in the right context because it could indicate better reporting in Rakiraki compared to other Districts rather than relate to poor water quality alone. By assessing the water quality results and diarrhoea incidences, there did appear to be some link. The majority of the untreated water sources in Rakiraki had gross contamination with F. coli while other water sources had high ammonia and Nitrate levels which indicate pollution from either animal or human origin. It is to be noted that 2 sampling points from the treated water supply at Rakiraki had unsatisfactory results. Most of the water sources sampled were from underground and had very high Chloride levels and Sulfates. The high salt content could be from fertilizers or salt-water intrusion and
maybe a contributor to incidence of diarrhoea. It is also a matter of concern that the study sites had higher cases of diarrhoea compared to the rest of the Rakiraki area, and especially within the vulnerable age group (Fig 1.32)

### 6.6 Agrochemicals and Diarrhoea

There was no correlation found between Incidence of diarrhoea in the family of respondents with use of any of the pesticides, weedicides or even fertilizers. It was found that even in areas with low usage of pesticides there were diarrhoea cases because of the presence of other risk factors.

### 6.7 Water sources and diarrhoea

Although there was zero correlation between water sources and diarrhoea, matching the two variables and using the water sample results, there did appear to be some link between cases of diarrhoea to several water sources.

Analysis of the questionnaire survey from Ba showed there were 5 cases of diarrhoea from people who drink from well water supply and 6 cases from those who depended on the nearby river/creek as a source of supply.

In Lautoka subdivision, the only cases recorded were 7 from those drinking from treated PWD supply and 3 cases from those using the nearby river or creek.

Levuka subdivision had one (1) case of diarrhoea related to those drinking from rainwater and seven (7) cases of those drinking from the nearby creek or river.

Analysis of questionnaire from Nadi subdivision showed there were only 2 cases of diarrhoea related to those who used wells as a source of water supply during the survey period while Navua subdivision had 2 cases related to those who used river or creek as a source of water supply.

Rewa subdivision showed there were no cases amongst the respondent families during the survey period, which was questionable.

Rakiraki subdivision had 19 cases of diarrhoea related to those who used wells as a source of water supply and 24 cases traced to those who were drinking from treated PWD supply. Out of those drinking from spring, there were 11 cases of diarrhoea. The highest numbers of incidence were from those families who depended on the nearby river or creek, which recorded 26 cases.

Savusavu subdivision had 2 cases of diarrhoea related to those who were connected to the PWD supply and 1 case of diarrhoea from those who depended on the river or nearby creek.

According to the survey, Sigatoka had 8 cases from those who used the river for drinking. One (1) case of diarrhoea was related to those connected to the PWD supply and 1 case related to those drawing from springs.
Suva results showed there were 2 cases of diarrhoea related to those who used treated PWD supply and 8 cases from those who used spring water for drinking. There was no case of diarrhoea related to those who used wells in Suva.

Tailevu had 5 cases of diarrhoea related to those drinking from treated PWD supply and 3 cases from those using the nearby river or creek. 1 case was related to those drawing from rainwater. There were no cases of diarrhoea in Tailevu related to those drinking from well or spring.

Analysis of the Tavua survey showed there were 15 cases of diarrhoea related to those who used spring water for drinking and 1 case related to those drinking from river or creek. Of those drinking from well, there were 2 cases noted.

<table>
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<th>Spring/Bhole</th>
<th>Rainwater</th>
<th>River/creek</th>
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Table No of Cases of diarrhoea for families using the respective water sources
River and creek appear to be the water source with highest incidence of diarrhoea when compared to the other water sources. However, by matching all the respondents whose families depended on the river for water, revealed that only 14.4% had cases of diarrhoea recorded. This showed that there was not a very close link between creek/river in the number of cases of diarrhoea. This points to the fact that probably there are other risk factors involved.

There was very low incidence of diarrhoea recorded from the survey and this definitely was not due to absence of risk factors. On the contrary, the sanitation standard in most of the rural communities surveyed was well below standard. The poor response to the question on diarrhoea from majority of respondents was probably due to cultural factors in that people were not forthcoming in admitting to having diarrhoea, a disease that is usually looked down upon and regarded as a very personal subject. Another reason could be the interviewers were not properly trained in the art of tactfully using culturally acceptable words and language when asking a very personal question.

Fig 1.66 Cases of diarrhoea related to type of water sources.
7 Health Effects of Pesticides/weedicides

7.1 Paraquat

Also known, as Gramaxone is a major cause of pesticide poisoning in the country. According to WHO, every year some 220,000 people around the world die of pesticide poisoning, while another three million suffer acute pesticide poisoning. Although 80% of the pesticides produced are used in developed countries, poisoning cases are proportionally higher in developing countries (Philippe Descamps- The Profile of Toxic Danger).

In Costa Rica for example, 827 or 23% of the total of acute pesticide poisoning cases were reported in 1997 due to Paraquat. The data for Fiji in 1999 had a total of 99 incidents of poisoning with a combination of pesticides (Fiji Ministry of Health Statistics Dept). Unfortunately there are no specific records for Paraquat, which is the usual “poison of choice” for majority of suicide cases in Fiji. One of the reasons could be its ready availability.

Paraquat is one of a list of dangerous pesticides whose use should be prohibited according to WHO and the Pesticide Action Network (PAN). The pesticide is prohibited in various Scandinavian countries, and its use is restricted in the United States where the Environmental Protection Agency (EPA) has classified it among the products that are possibly carcinogenic to humans.

It is a highly toxic product for human beings. There is proof that in the long term it has negative health effects, especially on the lungs. When ingested, burns are produced in the mouth and throat; this is followed by a serious irritation of the gastro-intestinal tract, which provokes abdominal pain, nausea, vomiting and diarrhea. Other symptoms are thirst, shortness of breath, an accelerated heart rate, lesions in the kidneys, liver, and heart and bleeding in the lungs. Generally, healthy skin doesn’t absorb this product, but bruised or irritated skin can absorb it very easily.

Poisonings from Paraquat are very serious because firstly, there is no known antidote or effective treatment and secondly, some symptoms can appear a number of days after contact with the pesticide.

In spite of the statistics, the product’s manufacturer, agrochemical distributors, as well as many agronomists and other scientists continue to say that Paraquat isn’t dangerous if it is used correctly. They affirm that due to Paraquat’s blue color, its unpleasant odor and the additive, which provokes vomiting when swallowed, that accidental poisoning with the product is impossible.

Investigations into accidental poisonings caused by this herbicide has revealed that slight wounds to the skin, including those that are barely perceptible, can allow for penetration of the pesticide into the body, which can cause grave consequences, including death. Another important observation from these studies is that protective clothing does not impede contact between the pesticides being applied on the skin. Even diluted in solution, Paraquat can cause fatal accidental poisonings. (Katherina Wesseling, Regional Institute for Research on Toxic Substances (IRET), of the National Autonomous University (UNA) in Costa Rica).
Thousands of organic and traditional producers farm effectively without the use of herbicides since simple and inexpensive weed control alternatives already exist. As far as conventional agriculture is concerned, this product may be substituted by others that are less dangerous although, always representing a danger to health. Compared to other agrochemicals, poisonings by Paraquat causes death after an agony that is sometimes long and always painful and require long and very costly medical service.

Paraquat that is absorbed into the soil has a very long half-life. Due to the manner that Paraquat is used in agriculture, it can cause death even when used in small doses and low concentrations. The difficulty is that symptoms are difficult to pinpoint, and are easily confused with benign symptoms making its treatment difficult. The medical establishment has found it difficult to diagnose these accidents due to the limited data about poisoning with Paraquat in small doses and low concentrations.

The survey in Fiji revealed that 29% of the respondents use Paraquat as a preferred herbicide. These were mainly small and medium producers. This is the sector of the population that is most vulnerable because they have the least information about the dangers of Paraquat and also has the least access to training about agrochemicals. Even when they receive training, they often lack the resources to purchase the recommended protective equipment.
8 Recommendations

8.1 To upgrade Agro-Chemical waste management capacity, it is recommended that

- Fiji to develop and implement regional hazardous waste strategies and waste chemicals to be disposed off at a Hazardous waste facility
- The old disused agrochemicals, which are stored or buried at the MAFF Research Stations around the country to be properly disposed off, and the contaminated sites remediated.
- A “Biomonitoring study” to be done on workers and farmers exposed to specific pesticides and other chemicals. This involves the analysis of urine, blood and faecal samples to find specific chemicals or trace chemicals. This will obtain a more accurate assessment of workers’ exposure to specific chemicals. The concentration of the chemicals in the specimen can then be compared with biological exposure indices (BEIs) for that chemical
- EHOs and MAFF to organise local training for farmers and families on safe use, storage and disposal of pesticides/weedicides

8.2 Recommendation for Improvement of Drinking water quality

To protect health of populations at risk, strategies must be set to ensure that all communities are accessible to an improved water supply that is sufficient and safe for human consumption. Strategies are recommended to be approached from two levels and include:

8.2.1 At the District Level:

- EHOs to ensure proactive and systematic approaches in monitoring water quality and safety
- EHOs to undertake water quality monitoring and surveillance on all types of water supply system in the district especially in ‘high’ risk areas where coverage is at its lowest. The monitoring should include the use of sanitary surveys. They should be undertaken during regular visits to all facilities.
- EHOs to create data collection system on water-borne diseases and contaminants and use data to estimate health burdens.
• EHOs to organise local training on requirements for safe water supply.

• EHOs to follow-up monitoring, surveillance and re-sampling of all the water sources that were identified to be polluted in the study.

• EHOs to network with key stakeholders including the communities affected regarding improvements to be done to water sources.

8.2.2 At the National Level:
• CBH to create an inventory of national capabilities in monitoring water quality and safety, and the protection and control of water sources.

• CBH to design a protocol to strengthen networking through regular weekly/monthly meetings with key stakeholders to discuss and disseminate information on water quality and health data.

8.2.3 Immediate Actions:

There are a number of priority tasks, which the CBH can carry out currently.

• Begin the process of developing a Standard sampling protocol for drinking water in the light of existing pollutant sources in each district

• Begin process of developing a Standard sampling protocol for major receiving waters in each district in view of existing pollutant sources.

• CBH to strengthen network with approved laboratories for proper analysis of water samples for important pollutants

• Enlist the support of key stakeholders in developing a practical manual for the improvement in installation and maintenance of private and community rural water systems

• CBH to submit annual budget for chemicals to treat rural water systems and design manual on appropriate treatment regime for different rural water systems

8.2.4 Second priority actions:

• CBH to prepare an instruction manual for monitoring and surveillance of the different varieties of water supply systems in the country.

• Update and distribute information on the existing sewage disposal system and appropriate improvements
- Encourage formation of Provincial Water Committees to comprise members of the community, NGOs and relevant government departments. Committee could be the driving force behind a “Water watch” movement. Core members of the committee could be an Environmental Health Inspector and Water Engineer.

In spite of limitations the study provides a window of opportunity for further exploration and research.

It is recommended that 2 subdivisions be selected randomly and the study methodology and selection of samples to be improved. Samples should also be collected for pesticide/weedicide and fertilizers.

The research is to include medical examination of farmers and their families to assess the actual health impacts related to use of agrochemicals. At the same time, the management of the agrochemicals could also be looked at.
9 Limitations

a) A major problem with the survey was encountered with the question on diarrhoea. The questions were:

“Whether any member of the family had ever suffered from diarrhoea?”

“If so, whether anyone had suffered from diarrhoea within last 3 days?” “and last 3 months?”

The survey relied on the assumption that family members would share with one another their state of health including diarrhoea. In practice this was not so, and the subject of diarrhoea in fact was found to be a “taboo” topic amongst in-laws and other special relationships in the Fijian family. It was also culturally unacceptable to ask a member of the opposite sex the same question. These were some of the factors that contributed to the high number of “false negative cases”.

b) There were inconsistencies in advice and guidance offered to personnel in the field. This resulted in different subdivisions requesting for different analysis from the laboratories for water quality samples.

c) Inadequate follow-up and meetings with field officers. Perhaps fortnightly meeting or even regular phone calls to assess progress and problems on the ground. This would have ensured that problems were addressed earlier. Through regular meetings, officers could also learn from one another and there would have been better coordination of sampling so that the laboratories would not have been overloaded.

d) Poor supervision resulting in Field officers failing to meet the timeline for sampling, survey, submission of data, maps by the district Programme officers.

e) Cyclone rehabilitation work was more of a priority during the early part of the year and survey work for the study was set aside. There were also transfers and deployment of some staff to other districts or programmes even though they were initially trained to carry out the survey. This resulted in further delays. In one subdivision, all the officers who were part of the original survey team were either transferred or went for study leave and there were no records or mapped areas to demarcate the exact areas that were surveyed.

f) The sites selected depended entirely on the district programme officer. Hence some while some districts tried to include a cross-section of the whole, others only selected convenient samples. Therefore, the results of the study which should provide an important picture of what might be happening suffers from a serious defect because of the biased selection of respondents.
10 Lessons Learned

a) Similar studies that involve field officers should require closer supervision, and better coordination.

b) Divisional EH Officers and Sub divisional EHOs and immediate supervisors should be adequately briefed on the objectives of any programme or study to solicit their support. In the study, Programme officers were often put in a difficult situation when instructed to do other work by their immediate supervisors because the latter were inadequately informed. In such situation, the priority needs of the study were relegated to second place, which was one reason for the delay.

c) Supervisors should ensure that before staff are transferred, proper handing overs of ongoing programmes are done to avoid duplication of efforts, confusion and passing of responsibilities.

d) Stratified sampling of farming units and farm types would have perhaps yielded better representation of the situation with respect to quantity and type of agro-chemicals being used.

e) District offices should improve on information database and strengthen network with members of the District team to facilitate sharing of information and data.

f) Research coordinators should ensure that proper and adequate training to be given to personnel involved in questionnaire surveys in order to adduce the information tactfully from respondents and minimise errors.

g) EHOs to be encouraged to carry out EHIA research in their districts and to build their capacity, undergo training in EpiInfo and other statistical techniques.

h) In future, more stringent selection of sample to ensure samples are more representative.
11 References


5. Institute of Marine Resources (2003) Paper Prepared for the International Waters Programme – Fiji to Assist the National Taskforce to Identify a Focal Area for IWP’s Pilot Project in Fiji.


