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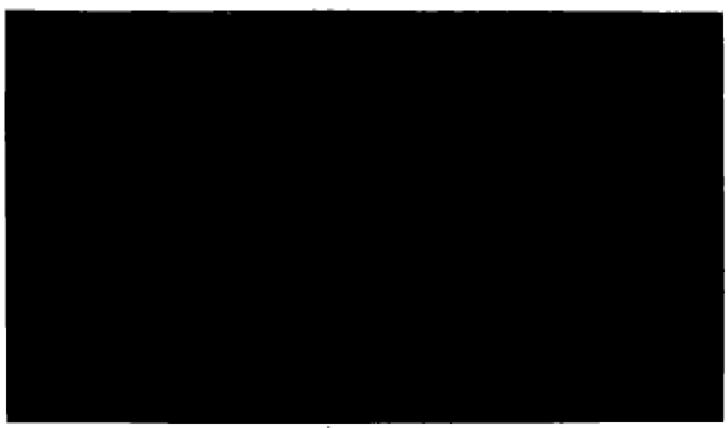

ENVIRONMENTAL HEALTH PROJECT

WASH Reprint: Field Report No. 354

Surface and Groundwater Contamination
in Selected Watersheds
in Southwestern El Salvador

L Fernando Requena
Becky A. Myton

December 1991

Prepared for the USAID Mission to El Salvador
under WASH Task No 265

Environmental Health Project
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WASH and EHP

With the launching of the United Nations International Drinking Water Supply and Sanitation Decade in 1979, the United States Agency for International Development (USAID) decided to augment and streamline its technical assistance capability in water and sanitation and, in 1980, funded the Water and Sanitation for Health Project (WASH) The funding mechanism was a multiyear, multimillion-dollar contract, secured through competitive bidding The first WASH contract was awarded to a consortium of organizations headed by Camp Dresser & McKee International Inc (CDM), an international consulting firm specializing in environmental engineering services Through two other bid proceedings, CDM continued as the prime contractor through 1994

Working under the direction of USAID's Bureau for Global Programs, Field Support and Research, Office of Health and Nutrition, the WASH Project provided technical assistance to USAID missions and bureaus, other U.S agencies (such as the Peace Corps), host governments, and nongovernmental organizations WASH technical assistance was multidisciplinary, drawing on experts in environmental health, training, finance, epidemiology, anthropology, institutional development, engineering, community organization, environmental management, pollution control, and other specialties.

At the end of December 1994, the WASH Project closed its doors Work formerly carried out by WASH is now subsumed within the broader Environmental Health Project (EHP), inaugurated in April 1994 The new project provides technical assistance to address a wide range of health problems brought about by environmental pollution and the negative effects of development These are not restricted to the water-and-sanitation-related diseases of concern to WASH but include tropical diseases, respiratory diseases caused and aggravated by ambient and indoor air pollution, and a range of worsening health problems attributable to industrial and chemical wastes and pesticide residues

WASH reports and publications continue to be available through the Environmental Health Project Direct all requests to the Environmental Health Project, 1611 North Kent Street, Suite 300, Arlington, Virginia 22209-2111, U S A Telephone (703) 247-8730 Facsimile (703) 243-9004 Internet EHP@ACCESS DIGEX.COM

WASH Field Report No 354

SURFACE AND GROUNDWATER CONTAMINATION IN SELECTED WATERSHEDS IN SOUTHWESTERN EL SALVADOR

Prepared for the USAID Mission to El Salvador
under WASH Task No. 265

by
L. Fernando Requena
and
Becky A Myton

December 1991

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ACRONYMS

A I.D.	U.S Agency for International Development (Washington)
AMAR	Amigos del Arbol (environmental group)
ANDA	Administración Nacional de Acueductos y Alcantarillados (national water and sewer authority)
ANR	Agriculture and Natural Resources (A.I.D.)
BOD	Biological oxygen demand
CEL	Compañiá Electrica de Rio Lempo (hydroelectric power utility)
CENDEPESCA	Centro de Desarrollo Pesquero (Fishing Development Center)
CENTA	Centro de Tecnologia Agricola (Center for Agricultural Technology, Ministry of Agriculture)
EPA	U S Environmental Protection Agency
FUSADES	Fundación Salvadoreña para el Desarrollo Economico y Social (Salvadorean Foundation for Economic and Social Development)
GOES	Government of El Salvador
ICAITI	Instituto Centroamericano de Investigacion y Tecnologia (Central American Research Institute for Trade and Industry)
MAG	Ministerio de Agricultura (Ministry of Agriculture)
MHN	Museo de Historia Natural (Museum of Natural History)
MI	Ministerio del Interior (Ministry of Interior)
MOP	Ministerio de Obras Publicas (Ministry of Public Works)
MSPAS	Ministerio de Salud y Asistencia Social (Ministry of Health and Social Assistance)

OPS	Organización Panamericana de Salud (Pan American Health Organization)
PLANSABAR	Plan Nacional de Saneamineto Básico Rural (National Agency for Rural Sanitation)
PROMESA	Proteccion del Medio Ambiente Salvadoreno
UEDA	Unidad Especializada del Agua, Dependiente de ANDA (Specialized Office on Water, a branch of ANDA)
UNICO	Universidad Católica del Occidente (Catholic University of the West)
USAID	United States Agency for International Development (overseas mission)
WASH	Water and Sanitation for Health Project
WHO	World Health Organization

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EXECUTIVE SUMMARY

Background

The government of El Salvador recognizes the environmental contamination that has taken place in the last decade and that threatens the poor with increased living costs through a preventable scarcity of clean water. Further, it believes that important collateral benefits (e.g., reduced morbidity) could be obtained by the rational management of existing sources of water and by reversing long-standing sources of contamination.

One component of the Proteccion del Medio Ambiente Salvadoreno (PROMESA) Project involves the formulation of a national strategy for natural resource management. This strategy is being formulated but is constrained by a lack of clear data

The Water and Sanitation for Health (WASH) Project was asked to collect and evaluate data on water, soil, and organism contamination in the watershed draining to the Barra de Santiago In addition, sediment and organism samples were obtained from the Barra Salada, La Herradura, Jiquilisco, and Puerto Parada, and analyzed to compare levels of contamination with those in the Barra de Santiago.

Sampling Program

In the study the following samples were analyzed:

- 30 water samples (19 surface water and 11 wells)
- 9 soil samples
- 10 sediment samples
- 40 aquatic organisms, including fish, mussels, crabs, freshwater shrimp and saltwater shrimp

All of the water and soil samples were taken from the Barra de Santiago watershed area For this area and each of the other four areas used for comparison, sediment and organism samples were taken.

The water samples were analyzed for coliform bacteria; chemical parameters, including dissolved oxygen, biological oxygen demand (BOD), pH, conductivity, sediment, ammonia, nitrites, nitrates, phosphates, detergent, zinc, boron, and copper; and organochloride and organophosphate pesticides.

Soils were analyzed for pH, boron, and pesticides Soil samples near the geothermal discharge canal were also analyzed for arsenic. Sediments were analyzed for boron and pesticides. Sediments of the Barra de Santiago near the geothermal discharge were also analyzed for arsenic.

Aquatic organisms were analyzed for pesticides.

The soil and water samples were collected by staff from the Catholic University of the West (UNICO), who were also responsible for the chemical and microbiological analyses The sediment and organism samples were collected by inspectors from the Fishing Development Center (CENDEPESCA) who took the samples to the Center for Agricultural Technology, Ministry of Agriculture (CENTA) for pesticide analysis.

The laboratory at UNICO is relatively well equipped and the people involved in the analyses were very competent CENTA's equipment for pesticide analysis is old but still produces reliable results. The center is understaffed and hampered by the rationing of electricity, which limits the number of analyses it can perform

Results

The results from the microbiological analyses were alarming. All of the surface water and the wells tested were extremely contaminated, with many samples having more than 24,000 fecal coliforms/100 ml of water (potable water should contain 0 fecal coliforms/100 ml of water) It is important to note that people interviewed in the study area claim that well water is of good quality and, therefore, they generally do not treat it before use.

Conductivity is a measure of the total dissolved ions in a solution and therefore gives a good idea of the general degree of contamination of the water. In uncontaminated tropical waters values range from 0 to 30 uhoms. Most of the values from the study ranged from 100 to 500 uhoms, indicating that contamination is present.

Relatively high concentrations of ammonia were found in the water, indicating that fresh fecal contamination is present, confirming the microbiological results.

High concentrations of boron were found in some of the water and soil samples. Very high concentrations were found in the sediments.

High arsenic levels were found in the two soil samples analyzed for this metal (59 ppm and 79 ppm) The arsenic probably comes from leakage from the geothermal canal

Pesticide analysis revealed that concentrations are higher in organisms than in water, soil and sediments, but residue levels do not excede the limits established by the EPA and WHO

A CENTA official informed us that recently all of the shrimp larvae in the Chinese shrimp project near Cóbanos died It was discovered that the well being used as their source of water was contaminated with tamaron.

In the El Imposible Reserve, pesticides, including decis, dieldrin, folidol, and lannate are being used to kill freshwater shrimp, which are later sold. Not only the shrimp die, however; other fish and aquatic organisms are also being killed.

As noted above, a geothermal canal goes through the study area It has a length of 77 kms and a capacity of 1m/seg, and its discharge ends in the sea approximately 200 m from the coast. Boron and arsenic are found in the water and, due to leakage, can contaminate the surrounding area. Heat contamination can also affect the marine life near the discharge area in the sea (Marroquin 1986). The canal, however, was not in use during the visits conducted by the WASH team and UNICO's sampling crew According to a verbal communication with a CEL official, the discharge from the thermal plant is being deep-well-injected on an experimental basis, with the eventual goal of eliminating the discharge to the sea

In the area of the Barra de Santiago a type of gar, *Apraprosteus tropicus*, is found. This is the only area of El Salvador where the species is found, and it is endangered.

Estuaries are one of the most productive ecosystems in the world and serve as nurseries for many species of fish, shrimp, crustaceans, and molluscs. The larval stages of these organisms are more sensitive to contamination than the adults; therefore, it is important to maintain an uncontaminated estuarine environment. Sediment resulting from the deforestation in the whole watershed is also carried to the estuary, bringing contamination and altering the bottom fauna

Conclusions

1 Fecal contamination of surface water and wells in the study area is extremely high, with 13 of the 30 sources (45 percent) containing more than 9,000 fecal coliforms/100 ml of water.

2 People interviewed who had wells thought the water was of good quality. This is alarming, especially with the presence of the cholera bacteria, *Vibrio cholerae*, in El Salvador

3. The rivers sampled, in general, cannot be considered healthy based on the fact that the dissolved oxygen contents are lower than 7 mg/l and the Biological Oxygen Demands excede 6 mg/l

4 High ammonia concentrations, compared with nitrites and nitrates, are another indication of fecal contamination.

5 Pesticide residues in water, soil, and sediment were lower (measured in parts per billion) than in organisms (measured in parts per million) due to the process of biomagnification in which each link in the food chain concentrates up to several thousand times the contaminants found in the preceding link.

6. In general, pesticide concentrations were low, due, in the case of organochlorides (used widely during the cotton growing years), to the fact that cotton was never planted extensively in the study area

7 Low concentrations of rapidly degrading pesticides were found, probably due to the fact that the sampling period was not during a period of high pesticide application

8 High concentrations of tamaron metamidophos were found in some of the samples Its use could result in further shrimp larvae, fish, and other fauna die-offs in the region.

9. High concentrations of boron were found in the soil and some of the water samples Many of the concentrations exceed threshold limits.

Recommendations

According to the Pan American Health Organization, the quality and quantity of the water in a country are the two most important parameters in the determination of the health of its inhabitants Health, in turn, affects the education level and the productivity of the country. Sick children and their teachers miss school and unhealthy workers and farmers are less productive than healthy ones

Because of the poor quality of surface and well water found in the study area, the team recommends the following actions

- Because the incidence of diarrhea increases at the beginning of the rainy season, simple rainwater catchments should be experimented with within the area. Gutters could be used to catch the rainwater from the roofs, and the water could be stored in clean containers. A study done in Tegucigalpa, Honduras, (Brand and Bradford

1991) shows that the quality of rainwater is relatively good and could be a useful alternative to the contaminated river and well water in the study area. At the present time, due to the presence of cholera in the study area, a noncontaminated source of water is especially important.

- Alternatives to tamaron should be used in the study area. The German Development Agency (GTZ) is working in this field and is a good source of information.

- Biological control of crop pests should be implemented in the area, using natural enemies and naturally occurring pesticides (Hesse-Rodriguez 1991)

- A sanitation program including latrines and sewerage should be initiated to address the fecal contamination problems affecting the water sources. Sewerage works may be the most appropriate sanitation solution in population centers such as Cara Sucia, San Francisco Menendez, San Jose El Naranjo, and possibly the Barra de Santiago Sewerage should be coupled with a wastewater treatment process, such as oxidation ponds or trickling filters.

- To control and prevent sedimentation due to erosion caused by deforestation, agroforestry should be promoted in the upper watershed area

- To decrease deforestation, and consequently siltation, due to firewood demand, fuel-efficient stoves should be encouraged in the area These could include LORENA, ceramic, or Chinese kerosene stoves.

- Composting on both small and large scales (households and farms) should be promoted using household and farm organic wastes. This would increase the soil's fertility and, at the same time, reduce the contamination of the rivers and wells from solid waste.

- To reduce the use of pesticides in rivers to kill shrimp and fish for human consumption, other food sources should be promoted, such as iguana and agouti farming.

- A short video (10 to 15 minutes) could be made to illustrate the problems of contamination in the area; it could be shown in schools, community groups, and cooperatives and on national television

- A contest among school children in Ahuachapán could be promoted to name a department tree, flower, fish, bird, and mammal to promote interest in the natural resources of the area

- A monitoring program should be established that takes into account

  — The agricultural cycle The sampling program should be carried out during the fertilizer, pesticide, and herbicide application periods
  — The rainy and dry seasons. The rainy season is the most appropriate time to detect pollutants in streams and wells, because at that time runoff will contaminate surface and groundwater.

- Silt and sediment carried by the streams should be sampled and analyzed during the rainy season to get an idea of the magnitude of the problem.

- Levels of pesticides and components of fertilizers such as nitrates should be monitored immediately after their application and for a period thereafter to verify degradation time.

- Flows should be measured with appropriate instruments, and loads of contaminants should be calculated to check the validity of the results

- Further studies of phytoplankton and zooplankton in estuary areas should be carried out, as species composition and abundance indicate water quality.

- The relationship of wells to latrines and other sources of contamination should be studied, and an educational campaign aimed at well owners should be undertaken

- Programs such as the marine turtle project at the Barra de Santiago should be supported

- Thesis research by university students should be encouraged within the study area, with orientations to include ecology, biology, chemistry, sociology, economics, education, agriculture, and so on.

- An environmental education campaign should be undertaken to inform inhabitants of the causes of contamination and how to lessen or avoid them.

- Support should be given to existing labs such as those at CENTA, UNICO, and other universities so as to increase their capabilities and ensure their capacity to undertake regular monitoring programs.

- A detailed study of the geothermal canal should be made and should include the effects of water discharge on marine life

Chapter 1

INTRODUCTION

1.1 Purpose and Objectives

The purpose of the present study was to prepare a report on the status of surface and groundwater contamination in selected waterways in southwestern El Salvador

1.2 Scope of Work and Scoping Process

After a preliminary determination of the scope of work to be included in this contamination assessment, the Water and Sanitation for Health (WASH) Project team held a series of meetings with personnel from USAID/El Salvador, which is summarized in Appendix B The purpose of these meetings was to further define the scope of work This scoping process concluded that the contamination assessment should undertake the following tasks

- Review existing data from the defined area to determine past levels of contamination and possible sources of contamination
- Delineate a sampling program designed to determine contamination in surface and groundwater, soil, sediment, and aquatic organisms.
- Hire local personnel crews to do the sampling and analysis.
- Compare contamination levels with Environmental Protection Agency (EPA) and World Health Organization (WHO) standards
- Identify sources of contamination and describe how the contamination of the water source occurs.
- Analyze the data and put them on diskettes.
- Prepare a report outlining major findings.

1.3 General Description of the Project

The government of El Salvador recognizes the environmental contamination that has taken place in the last decade, and that threatens the poor with increased living costs through a preventable scarcity of clean water. Further, it believes that important collateral benefits (e g , reduced morbidity) could be obtained by the rational management of existing sources of water and by reversing long-standing sources of contamination

One component of the Proteccion del Medio Ambiente Salvadoreno (PROMESA) Project involves the formulation of a national strategy for natural resource management. This strategy is being formulated but is constrained by a lack of clear data.

The WASH Project was asked to collect and evaluate data on water, soil, and organism contamination in the watershed draining to the Barra de Santiago. In addition, sediment and organism samples were obtained from the Barra Salada, La Herradura, Jiquilisco, and Puerto Parada, and analyzed to compare levels of contamination with those in the Barra de Santiago.

Chapter 2

DATA REVIEW

2.1 Introduction

The two most important environmental problems in El Salvador and in all Central America are deforestation and contamination of water and soil.

The two problems are intimately related in that deforestation causes erosion and resultant sedimentation in lakes, dams, rivers and estuaries, as well as changes in climate that generally are difficult to predict and result in less overall rainfall, which decreases agricultural productivity and raises the concentration of contaminants in bodies of water.

In El Salvador several species of freshwater fish, including the much sought after tepemechin, *Agonostomus monticola*, have become scarce due to as yet undetermined causes. It is suspected, however, that the scarcity is caused by chemical contamination and sedimentation plus the instability of the small rivers during the dry season caused by deforestation (USAID 1985)

Unfortunately, in El Salvador, no long-term data-gathering studies have been performed with respect to contamination of water, soil, and fauna. Baseline data are urgently needed in order to plan and monitor future programs and actions

Fortunately, there are active environmental groups in El Salvador that are working with environmental education and environmental projects in communities and parks and preserved areas Also there seems to be a public awareness campaign in the newspapers, as environmental articles appear nearly every day (see Appendix C for examples)

2.2 National Data Bank on Water Quality

ANDA, the National Water and Sewer Authority, has a computerized data bank with water quality data from the country's most important rivers, as well as from groundwater and springs As of September 1991, the agency had 1,558 registered data points and is adding new data as they become available ANDA's data are physical, chemical, and biological. An example of its data sheets is found in Appendix D.

2.3 National Fishing Data

Due to the importance of fishing in the coastal economy of both large and artisanal operations, some relevant data from the three areas west of the Lempa River included in the study are presented below (Table 1)

Table 1

Fishing Data from El Salvador, 1989

	Weight		Value	
Place	%	Kilograms	%	Colones
Barra de Santiago	1.4	26,019	0 7	97,064
Los Cóbanos	2 3	40,961	1.2	162,129
La Herradura	0.6	11,296	0.5	77,024
12 other sites	95 7	1,722,117	97.6	13,744,211
Total	100 0	1,800,393	100.0	14,080,428

Source: CENDEPESCA, 1990.

These data show that although the bulk of the fishing is done in the conflictive areas east of the Lempa River, fishing is the main economic activity of many people living in the coastal area

2.4 Shrimp and Aquaculture Potential

Shrimp farming can be a profitable investment if managed correctly. However, the construction of shrimp farms is traditionally done in mangrove areas, and the destruction of this diverse ecosystem can be extensive and very damaging to the fishing industry in the area

As of 1988 there were seven existing shrimp culture projects in El Salvador with a total of fewer than 200 hectares It has been estimated that there are 8,000 hectares suitable for shrimp farming in the country, 6,000 of which are owned by the government. The rest are privately owned. Water quality is very important in shrimp culture because shrimp are very sensitive to contamination and a lack of dissolved oxygen. In addition, shrimp for export to the United States and other countries must not exceed given limits of pesticide concentration (FUSADES, 1988).

According to A.I.D. (Environmental and Natural Resource Management in Central America), "The degradation of these coastal areas is occurring at a time when many Central American governments are becoming more and more dependent on coastal production as a source of non-traditional exports, especially shrimp, conch, spiny lobster, etc , to bring in much needed foreign exchange. In addition, the coastal zone contains much of the region's best agricultural lands and is home for a growing percent of Central America's burgeoning population "

2.5 Pesticide Use and Contamination

2.5.1 Pesticide Imports

Despite the fact that El Salvador has a total area of only 21,000 square kilometers and an area of 12,000 square kilometers under cultivation, pesticide imports have generally been high, especially in the cotton growing areas.

Before political unrest caused a large decrease in cotton acreage (150,000 manzanas in 1978 versus only 18,000 in 1988), 60 to 70 percent of imported pesticides were used for cotton In fact, during the cotton growing years, the load of pesticides in El Salvador was the highest in Central America, with a high in 1973 of 593.5 kg/km of organochlorides and parathion Organochlorides, which accumulate in the food chain, were widely used in controlling pests in cotton (Arreaga et al., 1988). Map 1 shows the cotton growing zones in El Salvador. It can be seen that the largest cotton growing area is found in the coastal zone east of the Lempa River.

Appendix E presents pesticides available and registered in El Salvador and the crops on which they are used.

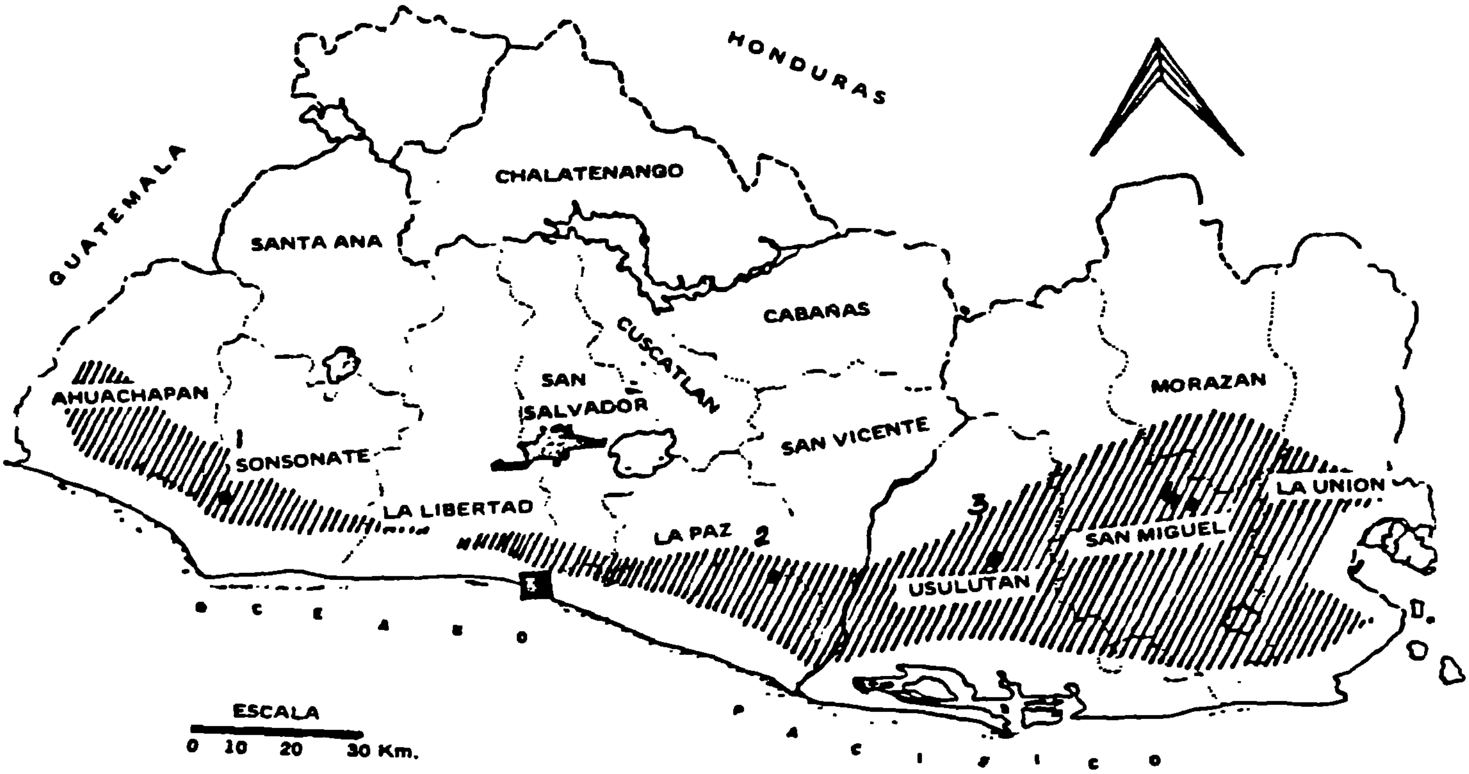
2.5.2 Contamination of Water, Sediments, and Aquatic and Terrestrial Organisms

Several studies have been done on contamination of water, sediments, and aquatic and terrestrial organisms by pesticides

In 1977 the Central American Research Institute for Trade and Industry conducted a study on pesticide concentration in cotton growing areas It found that concentrations of contaminants were lowest in water and soil and highest in organisms in which there was a bioaccumulation Appendix F (Tables F.1 and F.2) presents data of pesticide residues in beef in 1980 and 1988. It is interesting to note that pesticide concentrations are much lower in 1988 due probably to a decline in cotton production (Arreaga et al., 1988)

Map 1

Zones Adequate for the Cultivation of Cotton in El Salvador
and Production Locations of the Cotton Cooperative of El Salvador Ltd
(Cotton Cooperative, 1984)



* Plantel

	No. de beneficios
1 Atalaya	1
2 Entre Ríos	6
3 La Carrera	4
4 El Papalón	3

Source· Lopez Zepeda, 1986

A study performed by Mendez Flamenco, Miranda Cormejo, and Ramirez Molina (1989) compared concentrations of nitrates, nitrites, ammonia, and phosphates in 187 superficial sources of water and in 48 subterranean sources. The study was carried out from September 1988 to March 1989. The authors found that for superficial waters 27 9 percent of the samples exceeded the acceptable level of nitrates for potable water, 68 9 percent exceeded acceptable table levels of nitrites, and 48 7 percent exceeded acceptable levels of ammonia For underground water the percentages were 31 3 percent for nitrates, 70.8 percent for nitrites, and 35.4 percent for ammonia.

Lopez Zepeda (1977) did a study of soil contamination (see Appendix F, Table F.3 for data) Data from his study are graphed (Figure 1) to show the relationship between the use of DDT and approximate years of cultivation It can be seen that there is a positive relationship between the number of years under cultivation and the concentration of DDT.

Another soil analysis study was realized in 1983 by the Ministerio de Planificación (1983 in USAID, 1985) These data are presented in Appendix F, Table F.4. These concentrations are high and show the persistence of organochlorines in the environment.

A thesis study from the University of El Salvador (Alvarenga and Cardenas German, 1990) concerning paraquat residues in agricultural soils from the western part of the country revealed that the highest concentrations were found after 9 to 12 years of use of paraquat in the area. The study also found that the degradation of paraquat is slower than thought and that the highest concentrations of it were found in organic soils The following are representative concentrations of paraquat (ppm) in Ahuachapán· 4.82, 7 38, 16 47, 6 63, 2.32, 3 431, and 1.92.

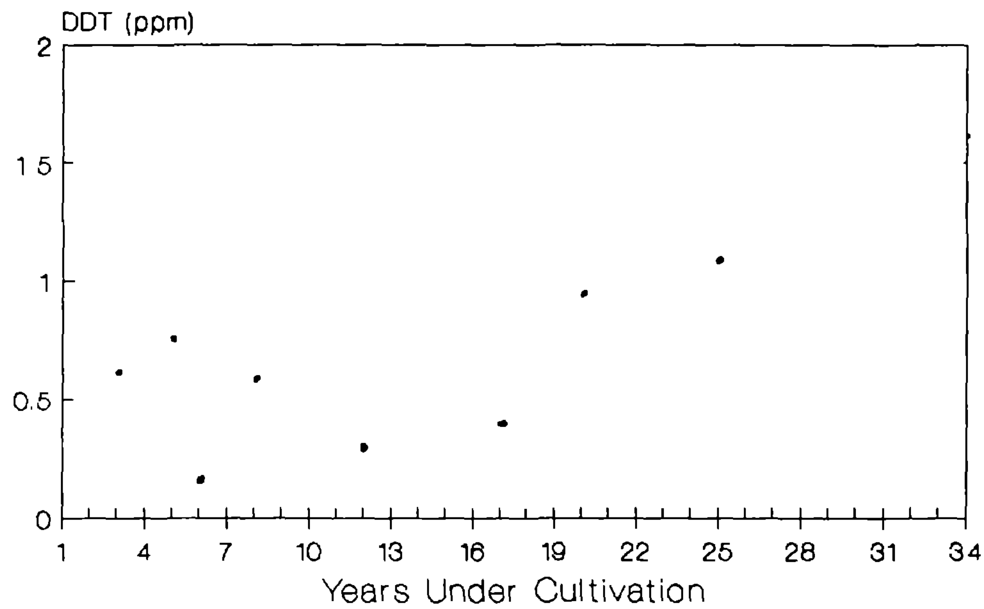
In 1977, Lopez Zepeda also performed a study of organochloride pesticide residues in aquatic organisms. His data are presented in Appendix F, Table F.5. He studied three species of fish, and one each of shrimp, mussels, clams, and starfish. His results showed the highest concentrations of organochloride pesticide residues in fish, followed by clams and mussels, which live in the sediment. Lower concentrations were found in shrimp and starfish, which live on the bottom surface.

Frances (1980, in Arreaga et al., 1988) found small quantities of organochloride pesticides in water in several coastal areas of El Salvador (Appendix F, Table F.6) Low levels were found in Ahuachapán in 1980, reflecting the low acreage of cotton traditionally planted in that area (Cotton is the crop that has traditionally used the highest levels of organochloride pesticides)

There are not many data available on organophosphate residues in water, soil, and aquatic organisms. One of the only studies of this type is a 1988 thesis written by two students at the University of El Salvador, Dominguez Pantoja and Paz Quevedo, in the

Figure 1

Relationship between Years under Cultivation and Concentration of DDT in Cotton Growing Areas



Source of data Lopez Zapeda, 1977

Estero de Jaltepeque They studied residues of methyl (MtPt) and ethyl parathion (EtPt) and ortho-paraoxon (metabolite) in water, sediment, and estuary organisms. They attempted to relate the concentrations to microhabitat and feeding behavior using the following organisms

Table 2

Feeding Behavior and Microhabits of Various Estuary Organisms, 1988

Organism	Type of Feeder	Microhabitat
Shrimp (*Penaeus*)	Herbivore/detritivore	Benthic
Crab (*Callinectes*)	Detritivore	Benthic
Mussel (*Anadara*)	Filter-feeder	Benthic
Fish (*Pomodasys*)	Detritivore/carnivore	Benthic
Fish (*Caranx*)	Predator	Pelagic
Fish (*Arius*)	Omnivore	Benthic

This study showed that during the first sampling period, when there was not much pesticide application, there was little evidence of MtPt or EtPt in the organisms Following the application of pesticides, residues were found in all of the organisms sampled, with the highest concentrations occurring in Anadara and Pomodasys Appendix F, Table F 7 presents the dates of pesticide application during the study and Tables F 8, F 9, and F 10 present the results for three different dates

More data are needed to determine if there is a direct detrimental effect of pesticides on aquatic organisms, but existing evidence supports this supposition. During the cotton growing era there was a decline in fish and clam harvesting in Jiquilisco Bay, which has been attributed to contamination and habitat destruction Declines in the population were most notable during the cotton growing season (Arreaga et al., 1988)

2.5.3 Effects of Pesticides on Human Health

There have been many cases of pesticide poisoning in El Salvador. From 1971-76. 8,917 cases of pesticide poisoning were reported in the country (Hall and Faber, 1989) Between 1980 and 1987, a yearly average of 1,176 cases was reported. These data include only people sick enough or fortunate enough to visit hospitals (Arreaga et al , 1988) In one hospital in San Salvador 50 children died of pesticide poisoning in 1987 (Hall and Faber, 1989).

In a study carried out by the El Salvador Ministry of Health and Social Assistance (MSPAS) in 1987 (Arreaga et al , 1988), it was found that the most frequent cause of death for females age 15-40 treated in hospitals was intoxication by organophosphates and carbamates This was the second highest cause of death for males, the first being traumatism

A study carried out by Mendez Lecha, Henriquez Fernandez, and Ojeda Rivera (1989) revealed that after 13 years of prohibiting the use of DDT in El Salvador, residues are still present in fatty tissues of humans. Of 60 samples, 13 exceeded 5.0 ppm, the criterion used in the study. For the other pesticide residues tested—lindane, dieldrin, heptachlor—none of the samples exceeded its criterion levels.

Barrera and Ponce (1988) connected the use of pesticides with health problems in El Salvador They found a positive correlation between the time of pesticide application and the incidence of pesticide poisoning. They found most problems were caused by tamaron, metamidophos, lannate, and phostoxin. As it would be expected, most cases of pesticide contamination were found in agricultural workers.

2.5.4 Agricultural and Livestock Activity in the Department of Ahuachapán, Santa Ana and Sonsonate

The following data are taken from the "Anuario de Estadisticas Agropecuarias, MAG, 1988-89." Crop data are given for the three departments in the MAG (Ministry of Agriculture) Region I, which includes Ahuachapán

Table 3

Various Crops Planted in the Ministry of Agriculture Region I, 1988-89

Crop	Number of Manzanas Planted
Beans	35,500
Corn	115,100
Rice	1,400
Sorghum	59,000
Cotton	380

The following animal data are taken from the Department of Ahuachapán.

Table 4

Various Animal Production in Ahuachapán, 1988-89

Animal	Number of Units	
Chickens for meat	7,848,584	pounds
Chickens for egg production	2,898,998	individuals
Pigs	4,761	individuals
Beef cattle	3,560	individuals

Chapter 3

ECOLOGICAL DESCRIPTION OF EL SALVADOR

3.1 Physical Characteristics

One of the smallest countries in Central America, El Salvador covers a total surface of 21,000 km^2 It drains toward the Pacific Ocean with no access to the Atlantic Although its highest peak does not surpass 2,730 m, El Salvador's topography is considered abrupt due to recent tectonic and volcanic activity.

3.1.1 Climate

El Salvador has three climatic zones, which depend on the elevation above sea level. According to classifications by Koppen, Sapper, and Lauer, the zones are as follows·

- "Hot tropical sabanas" or "hot": These range from 0 to 800 m above sea level, with dry winters (from November through April) and a maximum temperature of 22 degrees Celsius or more just prior to the rainy season (March or April). Annual temperatures range from 22 to 28 degrees Celsius, depending on the elevation. Annual precipitation in these areas is 1,900 to 2,300 mm, or 75 to 90 inches

- "Warm tropical sabanas" or "temperate": These range from 800 to 1,200 m above sea level, with the dry season being the same time span and temperature range as in the hot region The temperature during the warmest month is below 22 degrees Celsius, but there are at least four months during the year when temperatures rise above 10 degrees Celsius. The annual temperature range, depending on elevation, is between 19 and 22 degrees Celsius Annual recorded precipitation is 2,400 mm, or 94 inches.

- "High tropics"· These range from 1,200 m to 2,700 m above sea level and include two zones.

  - From 1,200 to 1,800 m above sea level, still temperate weather, with annual temperatures ranging between 16 and 20 degrees Celsius, and no frost. The annual precipitation is 1,800 mm, or 70 inches, in some areas and as high as 2,700 mm, or 106 inches, close to the border with Honduras

— From 1,800 to 2,700 m above sea level, cold temperatures ranging from 10 degrees to 16 degrees Celsius, with frost conditions during parts of the year in the valleys. The dry season is reduced to three or four months in the sierra zones near the border with Honduras; annual precipitation reaches 2,700 mm, or 106 inches

3.1.2 Soils and Geology

El Salvador is located on the Pacific Ocean slope of the Central American complex, between the Brazilian and the Canadian plates. It emerged at the end of the Mesozoic Era, when the convulsions of these plates lifted Mesozoic sediments and Paleozoic rocks to the sea surface Periodic seismic activity and recurrent volcanic eruptions are proof of the persistent instability of this zone

With respect to soils, there are 15 different types altogether, divided mainly into 4 groups that represent 89 percent of the country's soil types. This classification is in accordance with that used by the U.S. Soil Conservation Service

The most frequently occurring type of soils is the red clay *latosoles* (35 percent), derived from volcanic lavas blended with piroclasts. The second most abundant type of soils is the *regosoles* (20 percent), darker-looking red clays originating from piroclastic materials and occurring in the central-strip portion of the country, predominantly to the east The *litosoles* are the third most abundant soil type (19 percent). These are soils that were formed under great pressures and show frequent outcrops of lava. They are very shallow in depth and therefore are not very productive. The fourth most abundant soil type is *alluvial* (15 percent), located in flatlands and areas close to rivers and floodplains. These soils are very productive and are generally located in the coastal plains and dispersed throughout the interior valleys Other soil types include the *grumosoles*, black clayish soils with surprisingly low organic content. These too can be found in the interior valleys of the country

3.1.3 Hydrology

El Salvador is divided into 10 watersheds, which are namely 1) Lempa River, 2) Paz River, 3) Paz and Sonsonate rivers (from the San Francisco River to the Copinula), 4) Bandera, Sensunapán, and San Pedro rivers, 5) Pululuga and Compalapa rivers, 6) Jiboa River, 7) between the Jiboa and the Lempa, 8) between the Lempa and the Grande de San Miguel rivers (from the El Progreso River to the Molino River), 9) the Grande de San Miguel River, and 10) the Goascorán River and others. The largest of these watersheds is the Lempa River watershed, with 18,240 km^2, of which 10,255 km^2 are within El Salvador

The main natural lakes in the country cover 146 km^2, divided into Lake Guija, with 44 km^2, of which 32 km^2 are in El Salvador; Lake Ilopango, which occupies 71 km^2; Lake Coatepeque, 25 km^2; and Lake Olomega, 18 km^2. The artificial lakes in the country add up to a total extension of 190 km^2 and include the reservoirs behind Cerrón Grande (135 km^2), 5 de Noviembre (20 km^2), and 15 de Septiembre (35 km^2) dams.

Groundwater availability totals 76 8 m^3 per second. The Lempa River watershed includes 48.9 m^3 per second, but due to the hydrogeology of the basin, only 53 percent can be drafted in a cost effective manner The Grande de San Miguel River basin provides 12.52 m^3 per second, with the remaining basins supplying less than 4 m^3 per second each, although exploitation of the coastal basins is limited by saltwater intrusion.

Water quality is generally poor, mainly because of untreated wastewater discharges, uncontrolled use of fertilizers and pesticides in agriculture, waste discharges from agro-industrial plants such as those for coffee and sugar cane, and improper disposal of solid wastes

3.2 Land Use

Of the country's 21,000 km^2 (or 2 1 million hectares), an estimated 1.1 million hectares or more contain cattle and agricultural activities of some sort. In 1983, 592,700 hectares (28 2 percent of the nation's total) were dedicated to agriculture in annual, semipermanent, and permanent crops, and 522,400 hectares (24.8 percent) were dedicated to cattle grazing and other cattle activities. Forest areas totaled 265,500 hectares (12 6 percent) and chaparral 628,100 hectares (29.9 percent). According to the Office of Agricultural Economic Policy of the GOES, 95,400 hectares were "without agricultural possibilities," of which 77,515 hectares were occupied by water bodies, urban areas, and roadways

3.3 Endangered Species

The endangered species list of El Salvador is lengthy considering the size of the country Altogether there are 65 species of trees, 17 of which are concentrated in and endemic to the area known as El Imposible-San Benito Of these the Rubiaceae, the Capparidaceae, the Malvaceae, and the Celestraceae families are the most numerous. Thirteen other endangered species are also endemic to another area called Montecristo, while 5 more species are in the San Salvador area. The list also includes 61 different species of flowers and 128 of animals, including 5 freshwater fish, 3 amphibians, 21 reptiles, 78 birds, and 21 mammals

3.4 Natural Areas

Map 2 shows the natural areas of El Salvador Three of the most important areas in terms of the present study are discussed below.

- El Imposible· The most important natural area is "El Imposible," The Impossible. It is located in the Department of Ahuachapán in the Apaneca mountain range. It is the most representative broadleaf forest and has the highest diversity of flora and fauna in the country.

- Barra de Santiago: Barra de Santiago is located along the coast in the Department of Ahuachapán, and is an area with a very diverse fauna, including many species of fish, molluscs, crustaceans, and the crocodile and caiman

- Los Cóbanos Los Cóbanos includes the only coral reef in El Salvador. It is southeast of the Port of Acajutla in the Department of Sonsonate. It includes an area of at least 8,000 hectares.

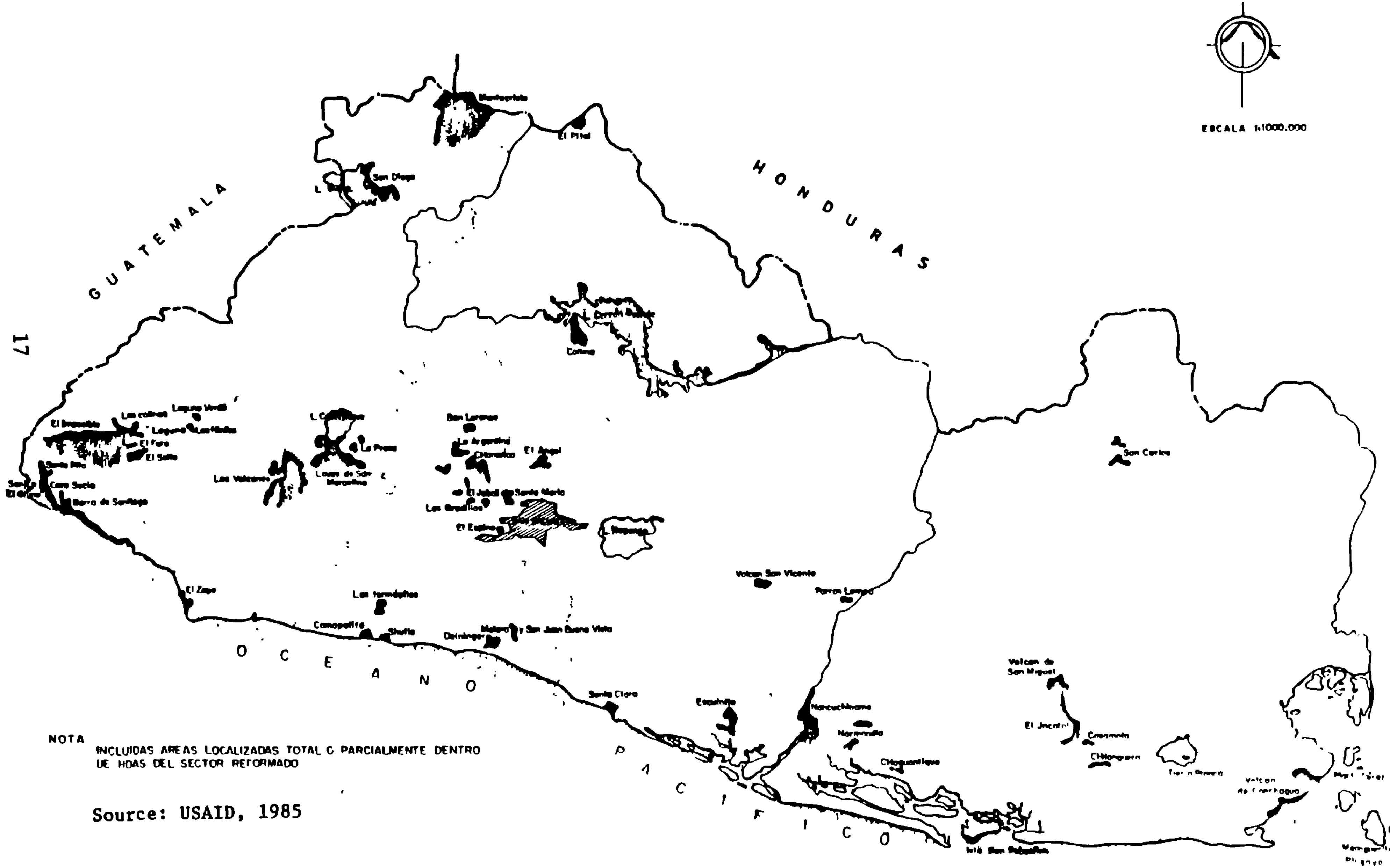
3.5 Mangroves

Although the total area of mangroves in El Salvador is only 2 percent of the total area (45,000 hectares), these areas are very important both socially and economically. As one of the most diverse ecosystems in the world, they are home to a very diverse fauna, which is exploited by the local population.

The species of mangrove found include the red mangrove, *Rhizophora mangle*, which is the first species to invade and is the one that is found in the water. As its leaves mature and die they form detritus in the water, which is food for many small and larval organisms These mangroves have been called the "nursery" because of the large larval populations of fish, shrimp, and molluscs found there. Other species of mangrove include the black mangroves, *Avicennia nitida* and *A. bicolor*; the white mangrove, *Laguncularia racemosa*; and the little button mangrove, *Conocarpus erectus*.

Map 2

Location of Natural Areas to be Preserved



Source: USAID, 1985

3.6 Environmental Contamination in El Salvador

3.6.1 Air Contamination

Air contamination is becoming more of a problem, but there are not many studies on it. Important sources of air contamination include exhaust from cars, buses, and trucks; industry; and open burning of trash and garbage

3.6.2 Soil Contamination

The three principal sources of soil contamination are domestic, industrial, and agricultural wastes Garbage collection and disposal are inadequate and lead to soil contamination.

Industrial waste is estimated at 1,646 m^3/month; this includes organic material, leather, glass, plastic, paper, metals, and so on (USAID 1985). Some of these materials could be used to produce energy, especially biogas, thus reducing contamination and providing a low-cost energy source

Probably the most important sources of soil contamination are from agricultural products, including insecticides, herbicides, and fungicides. The indiscriminate use in the past of organochlorine pesticides has left pesticide residues in the soil. Because of bioaccumulation, these residues can be up to 500,000 times more concentrated in organisms high up on the food chain than they are in the soil.

3.6.3 Water Contamination

The most important sources of water contamination include domestic, industrial, and agricultural wastes, which, without being treated, are discharged into streams and rivers. Raw sewage enters the rivers and streams directly, without treatment. The Acelhuate River passes through the capital, San Salvador, where it receives raw sewage. Not too far downstream, water from the same river is used to irrigate land where many of the locally consumed vegetables are grown (Gutierrez 1991). The spread of many diseases, including cholera, which has now reached El Salvador, is favored by these unsanitary conditions.

The main industrial wastes that contaminate the water are organic in origin and mostly come from agroindustry The most important sources are, in order, coffee processing plants, sugar processing plants, kemp processing plants, distilleries, tanneries, milk plants, textile factories, and slaughterhouses.

Probably the most important source of water contamination comes from the use of pesticides. Traditionally, the heaviest use has been in the cotton growing areas. According to Mckee and Wolf (1976, in USAID, 1985) concentrations of DDT of 1 mg/l during 12 hours is enough to kill all the fish in a body of water In the Grande de San Miguel concentrations of 3.15 mg/l of DDT have been found. These, of course, exceed many times the lethal limit. It should be remembered that the rivers end in the sea or estuaries, where these pesticide residues become concentrated in aquatic organisms

A very interesting example of water contamination is the result of a canal constructed to take geothermal water from the electric plant to the sea. The water is contaminated with boron and arsenic and also presents heat contamination due to the high temperature of the water (USAID, 1985)

Chapter 4

LOCATION OF STUDY AREA

In the scope of work, USAID had defined the study area as a "coastal area west of the Lempa River " A USAID official later defined the study area more completely to the team in El Salvador (Map 3).

The six areas of interest included the following.

1 The watershed area of the Barra de Santiago· The Barra de Santiago was, until recently, the most intact mangrove area with the most diverse fauna in El Salvador. The recent cyclone destroyed much of the area, but a mangrove reforestation program has been initiated to repair the damage Several studies have been done in this region, including a fish inventory and an ecological study being carried out by the Museum of Natural History (MHN).

This was the most important area in the study due, in part, to the fact that it is bordered on the north by El Imposible, the largest and most diverse protected area in El Salvador

2 Barra Salada This area is located in the Department of Sonsonate east of Los Cóbanos. It is important for its mangrove swamps and the presence of several shrimp farming operations near the mangrove forest The Banderas River ends in this area.

3. La Herradura (Jaltepeque Estuary)· This area is a large mangrove area in the Department of La Paz Several important rivers are located here, including El Amate, Camopa, Jalponga, and Guiscoyolapa

4., 5 Puerto Triunfo and Puerto Parada· Both are located in the Jiquilisco Estuary east of the Lempa River in important cotton growing areas. They have been subjected to heavy pesticide use.

6 Manzanilla Estuary: Located on the Goascorán and Siram rivers, this area borders the Golfo de Fonseca. This area includes mangroves and important fishing resources near the border with Honduras

Chapter 5

SAMPLING PROGRAM

5.1 Description of Sampling Program

The budget and schedule determined the number of samples that could be analyzed within this project. As a result, samples were as follows:

- 30 water samples
- 9 soil samples
- 10 sediment samples
- 40 aquatic organisms

Water and soil samples were collected for the Barra de Santiago watershed only, while sediment and aquatic organism samples were taken in all five major estuaries.

The water samples included samples taken from rivers, streams, and wells. Soil samples were taken in the agricultural areas of the watershed and near the geothermal canal. Sediment samples were taken from the banks of the estuaries

Considering the limited capacity and other work being carried out in CENTA and UNICO, the following timetable was prepared. It should be noted that it was suggested by a CENTA official that the organism samples in areas 4 and 5 be taken in October and the beginning of November, which corresponds to the heaviest pesticide application period in those areas

The water and soil samples were taken in September and October of 1991

The sediment and organisms were collected according to the following schedule·

Sept. 2	Site 2 3 organisms and 2 sediment
Sept 23	Site 1: 7 organisms and 2 sediment
Oct. 14	Site 2: 11 organisms and 2 sediment
Oct 21	Site 3. 10 organisms and 2 sediment
Oct 28	Site 4: 6 organisms and 2 sediment
Nov. 4	Site 5· 6 organisms and 2 sediment

No organism or sediment samples were obtained from site 6 because of its location in a conflictive area and because the Fishing Development Center (CENDEPESCA) did not have the capability to reach that area.

5.2 Parameters of Concern, EPA and WHO Standards

The following parameters were considered to be the most important for the present study Tables for these and other parameters are presented in Appendix G. Tables G.1 and G.2 present the national primary and secondary drinking water standards from EPA Table G.3 shows the EPA standards for organic and inorganic chemicals. Table G.4 presents the WHO drinking water standards. Below is information condensed from Tables G 1, G 2, and G.4

Table 5

EPA and WHO Drinking Water Standards for Various Parameters

Parameter	EPA Drinking Water Standards	WHO Drinking Water Standards	Other
pH	6 5-8.5	6 5-8.5	
Total dissolved solids	500	1,000	
Conductivity			0-30 (clean water)
Nitrates	10 mg/l	10 mg/l	
Arsenic	05 mg/l	.05 mg/l	
Zinc	5.0 mg/l	5.0 mg/l	
Copper	1.0 mg/l	1 0 mg/l	
Total coliforms	1/100 ml	10/100 ml (unpiped water source)	
Fecal coliforms	0/100 ml	0/100 ml	

Pesticide	WHO Drinking Water Standards (microg/l)
Aldrin	0.03
Dieldrin	0 03
DDT	1 00
Heptachlor	0.10
Heptachlor epoxide	0 10

Source Van Der Leedn, Troise, and Todd, 1990

In addition to drinking water standards, one must consider the effects of contamination on aquatic life Table G 5 presents guidelines for evaluating the quality of water for aquatic life, and Table G.6 shows lethal concentrations of chemicals in aquatic environments

5.3 Sampling Locations and Methodology

For each of the five study areas, two representative sampling points were located At each point aquatic organisms and sediment were collected

5.3.1 Sampling Points in Area 1, the Barra de Santiago

Map 4 presents the location of the sampling points for the water analysis in the principal area of study, area 1, the Barra de Santiago These points were picked to represent upstream areas with less possible pollution, areas in the middle of the watershed with more possible contamination, and areas downstream from populated areas or agricultural areas with the highest chance of being contaminated

The following points include 19 river sampling points and 11 wells.

RIVERS

Site number	Location
1	Rio Cara Sucia, upstream
2.	Rio Cara Sucia, downstream
3.	Zanjón La Danta

4.	Rio Aguachapio, downstream
5	Rio Guayapa, downstream
6	Canal Embarcadero de Guayapa
7.	Rio Cuilapa
8.	Rio Naranjo, downstream
9.	Rio El Rosario
10.	Rio Naranjo, upstream
11.	Rio El Izcanal
12	Rio San Francisco o de la Soledad, downstream
13.	Rio Guayapa, upstream
14.	Rio Aguachapio, upstream
15	Rio San Francisco, upstream
16	Zanjón Madre Vieja
17	Zanjón Aguachapio (El Zapote)
18	Rio La Palma
28	Rio Hacienda Izcanal

WELLS

19	Hacienda Cara Sucia
20.	Near geothermal discharge canal
21.	Guayapa
22.	Hacienda La Danta
23	Water supply for the town of Cara Sucia
24.	San José El Naranjo
25	Hacienda Santa Rita
26	Santa Virginia (El Achiotal)
27.	Hacienda El Camalote
29.	El Porvenir
30	Embarcadero de Guayapa

In addition, nine soil samples were collected in area 1. Sampling sites were located in agricultural areas and along the geothermal wastewater canal

5.3.2 Sampling Methodology

The soil and water samples were collected by investigators from UNICO. Soil samples were taken from the first 5 cm Water for pesticide analysis was put into 2 liter opaque bottles and transported to CENTA the same day The routine water analysis was done in the UNICO laboratories. The methods of analysis for pesticides and routine water, and soil analyses are presented in Appendix G

The sediment and aquatic organism samples were taken by the inspectors of CENDEPESCA For pesticide analysis at least 250 grams of tissue are needed; consequently, for fish, samples of 1 pound were taken, while for the other organisms, sample weights were about 2 pounds, including shells. The samples were put into coolers with ice and transported to CENTA the same day. Approximately two pounds of sediment were taken from each sampling point. Half went to CENTA for pesticide and arsenic analysis and half to UNICO for boron analysis

Chapter 6

RESULTS AND DISCUSSION

6.1 Introduction

UNICO performed the bacteriological and chemical analyses of the soil and water. For each sample point a data sheet was made that included a description of each point, including possible sources of contamination; in most cases a photo; and other data A summary of the results is presented in separate data sheets. All of the above sheets are found in Appendix H.

CENDEPESCA inspectors took the organisms and sediment to CENTA for pesticide analysis Descriptions of each area were made and are included in Appendix I

6.2 Bacteriological Analysis of Water

Table 6 presents the results of the bacteriological analysis. All of the surface water and wells tested were extremely contaminated, with many samples having more than 24,000 fecal coliforms/100 ml of water (drinking water should contain 0 fecal coliforms/100 ml of water). This is even more alarming when it is considered that most of the people with wells think their water is uncontaminated. The well at the Hacienda El Camalote (sample 27) is chlorinated and the owner is confident that it is potable.

Fecal contamination of water is probably the most critical type of contamination in the study area.

6.3 Chemical Analysis of Water

Tables 7 to 9 present the results of the chemical analyses

The pH is a measure of the acidity of a solution, where 7 is neutral, values below 7 are increasingly acidic, and values from 7 to 14 are increasingly more alkaline The pH values from the study area were all within the normal range for water.

Conductivity is a measure of the total dissolved ions in a solution and therefore gives a good idea of the general degree of contamination in water. In natural uncontaminated tropical streams and rivers, normal values of conductivity range from 0 to 30 uhoms. Salt and brackish water have higher values due to the presence of salt. It can be seen that all the conductivity values measured in this study exceed this norm, indicating at first glance

Table 6

Microbiological Analysis of Water

Normal Values		10/100ml	10/100ml
No Sample	Date	Total Coliforms MPN/100ml	Fecal Coliforms MPN/100 ml
1	30-09-91	>24,000	>24,000
2	30-09-91	>24,000	>24,000
3	30-09-91	>24,000	>24,000
4	07-10-91	>24,000	1,609
5	09-10-91	>24,000	9,180
6	09-10-91	>24,000	3,450
7	11-09-91	>24,000	330
8	11-09-91	>24,000	390
9	11-09-91	>24,000	3,450
10	11-09-91	>24,000	3,450
11	07-10-91	16,090	2,210
12	17-09-91	>24,000	16,090
13	09-10-91	>24,000	16,090
14	07-10-91	5,420	1,720
15	17-09-91	9,180	9,180
16	23-09-91	>24,000	>24,000
17	23-09-91	5,420	360
18	17-09-91	>24,000	16,090
19	30-09-91	16,090	16,090
20	23-09-91	>24,000	>24,000
21	09-10-91	16,090	1,720

No Sample	Date	Total Coliforms MPN/100ml	Fecal Coliforms MPN/100 ml
22	23-09-91	>24,000	>24,000
23	30-09-91	>24,000	>24,000
24	11-09-91	16,090	2,210
25	17-09-91	2,400	2,400
26	17-09-91	1,300	490
27	07-09-91	2,400	220
28	07-09-91	16,090	390
29	23-09-91	5,420	5,420
30	09-10-91	230	230

MPN = Most Probable Number

Interpretation

According to the microbiological results found, which are higher than those established by WHO, the water of these sources is not fit for human consumption

Table 7

Chemical Analyses of Water

Normal Values	6.5-8 5	0-30 µs	<0 01mg/l**	<1 0mg/l***	10 mg/l***	****
No. W.S *	6 5-8 5 pH	Conduc. µS	NH4 mg/l	NO2 mg/l	10 mg/l NO3 mg/L	PO4 mg/L
1	7 79	143	0 15	0.013	0 3	0 153
2	7 71	141	0 6	0.024	0 5	0 325
3	7 32	216	0 26	0.015	0 3	0 634
4	7.61	146	0.31	0.012	0.9	0 565
5	7 61	113	0.21	0.007	0 3	0 163
6	7.29	172	0.28	0.01	0.3	0.132
7	7 26	186	1.38	0.02	1 2	0.905
8	7.55	115	0 815	0.015	0.8	0.143
9	7 50	138	0 988	0.015	0.9	0.147
10	7 61	110	0.44	0.011	0.7	0.071
11	7.65	123	0 27	0.013	0.7	0 105
12	7 82	180	0.365	0.014	0.1	0 090
13	7 46	106	0.11	0.01	0 1	0 165
14	7.59	116	0.19	0.011	0.1	0 113
15	7 93	159	0.25	0.018	0.0	0 103
16	7.20	550	0 781	0.007	0.2	6.628
17	7.60	26000	8 504	0.012	0.4	0.200
18	7 67	206	0.885	0 015	0.4	0.122
19	7.3	360	0	0.016	3	0.296
20	7.60	1020	0.84	0.068	3.5	0.592
21	7.21	5420	0 5	0.012	19.3	1.741

No W S.*	6.5-8.5 pH	Conduc µS	NH4 mg/l	NO2 mg/l	10 mg/l NO3 mg/L	PO4 mg/L
22	7 20	5430	8 908	0 344	6 0	2.900
23	6 99	461	0 03	0 01	3	0 197
24	7.30	349	0.4	0 01	0 9	0 170
25	7.82	364	0.315	0 012	0 1	0 087
26	7.40	294	0 23	0.016	0.1	0.120
27	6.92	350	0.08	0.013	6.7	0.437
28	7.56	127	0.16	0.011	5.1	0.398
29	7 87	1001	0 587	0 053	23 5	0 3
30	8.05	570	0.81	0.084	12 3	0.275

METHODOLOGY FOR THE ANALYSIS

Settleable solids	Imhoff Cone Method
Ammonia Nitrogen	Nessler Method
Nitrates·	Cadmium Reduction Method (according to Hach Co)
Nitrites·	Diazotization with cromotropic acid and sulfanilic acid method (according to Hach Co)
Phosphates	Ammonium Molibdate and Ascorbic Acid Method (according to Hach Co.)

* W.S . Water Sample
** In natural waters
*** Potable water standard
**** No standard available

Table 8

Flows and Loads for Nitrates, Phosphates, and Boron

No.	Location	Flow m /seg	Load (kg/day) Nitrate	Phosphate	Boron
1	Rio Cara Sucia, upstream	2.11	54 6		0 0
2	Rio Cara Sucia, downstream	6.78	292 3		58 6
3	Zanja La Danta	0 69	18.0		6 0
4	Rio Aguachapio, downstream	4 9	381 0	232.9	0 0
5	Rio Guayapa, downstream	3.6	93.3	50.7	0 0
6	Canal Embarcadero de Guayapa	10.4	269.6	118.6	0.0
7	Rio Cuilapa	0.13	13.5	10.2	10 1
8	Rio Naranjo, downstream	1 91	132 0	23.6	33 0
9	Rio El Rosario	3 6	280 0	45 7	62.2
10	Rio El Naranjo, upstream	2 62	158 5	16 1	45 3
11	Rio El Izcanal	2 6	157.2	23 6	0 0
12	Rio San Francisco o de la Soledad, downstream	0.53	4 6	4 1	0 0
13	Rio Guayapa, upstream	3 52	30 4	50 2	0 0
14	Rio Aguachapio, upstream	1.14	9.8	11.1	0 0
15	Rio San Francisco, upstream	0.98	0 0	8.7	8.5
16	Zanjón Madre Vieja	0.0	—	—	—
17	Zanjón Aguachapio (El Zapate)	4.5	155.5	77.8	1,049.8
18	Rio La Palma	0.4	13.8	4.2	0 0
28	Rio Hacienda Izcanal	1 6	705.0	55 0	0 0

Table 9

Additional Chemical Analyses of Water

Normal Values	>7 mg/l	<3 mg/l	2 mg/l	5 mg/l	2.0 mg/l**	1 mg/l
No. W.S *	O2 DIS. mg/l	B O D mg/l	DETERG mg/l	Zn mg/l	B mg/l	Cu mg/l
1	4 1	20.5	0.012	0.000	0.0	0 0
2	4 3	20	0.013	0.000	0.1	0.0
3	3.9	13.6	0.008	0.000	0.1	0 0
4	6.3	6 8	0.007	0.000	0 0	0 0
5	6.3	6 9	0.012	0.000	0.0	0 0
6	6 2	7.2	0.013	0.000	0 0	0 0
7	3 6	13	0.031	0.000	0 9	0 0
8	4 5	14.5	0.017	0 000	0.2	0 0
9	4.3	12 2	0.007	0.000	0.2	0.0
10	4.3	12.1	0.023	0.000	0 2	0 0
11	6.5	8.1	0.016	0.000	0.0	0 0
12	4.2	16.6	0.014	0 000	0.0	0 0
13	6.1	7.3	0.013	0 000	0 0	0 0
14	6.5	6.7	0.015	0.000	0 0	0 0
15	4.4	23.3	0.002	0.000	0 1	0 0
16	3.9	17 7	0.012	0.000	0.2	0 0
17	4.2	25 9	0 011	0 000	2 7	0.0
18	4 1	8.5	0.007	0 000	0 0	0 0
19	4 2	17.7	0.016	0.000	0.1	0 0
20	4	28	0.022	0.000	0.5	0 0
21	5.8	6.5	0.015	0.000	0.0	0 0
22	2 9	14 4	0.022	0.000	1.7	0.0

No. W S *	O2 DIS. mg/l	B O D mg/l	DETERG mg/l	Zn mg/l	B mg/l	Cu mg/l
23	3.9	16.4	0.015	0.000	0.1	0 0
24	4 2	13.2	0 037	0.000	0.0	0 0
25	2 4	12.2	0.006	0.000	0.0	0 0
26	2 9	10.5	0.011	0.000	0.0	0 0
27	6 1	9	0.009	0.000	0.0	0 0
28	7 8	7.4	0.025	0.000	0.0	0 0
29	3 9	16 6	0.016	0.000	0 6	0 0
30	6 3	6.3	0 022	0.000	0.6	0.0

METHODOLOGY FOR THE ANALYSIS:

Dissolved Oxygen.	Wheaton System (electrod for O^2)
BOD (Biological Oxygen Demand:)	Winkler Method
Anionic Detergents	Violet Crystal Method (according to Hach Co)
Copper.	Flame Photometry
Boron:	Carminic Acid Method
Zinc	Flame Photometry

* W.S Water Sample
** For irrigation waters

that all the samples contain some kind of contaminant. Samples 17, 21, and 29 have extremely high values due to their proximity to the sea. It is much harder to explain the very high values in samples 20 and 22. These two wells are located along the geothermal canal and could possibly be receiving contaminants from that source.

The quantity of suspended solids is a measure of erosion in that silt and soil are washed into the rivers and streams mostly during the rainy season. High concentrations are found after rains, while much lower values are found during the dry season The low values found in the WASH study are due to the lack of rain during the period of the study

Suspended solids should be measured during the rainy season in order to get a better idea of the quantity of sediment that would eventually reach the coastal mangrove areas Sediment carries nutrients and contaminants that settle on the bottom, where organisms can absorb them Due to the process of "biomagnification," the concentration of contaminants can be thousands of times more concentrated in organisms than in the water

Also, sediment can cover the bottom, altering the bottom ecosystem and, therefore, the bottom fauna. This, in turn, alters the composition of the pelagic fauna Finally, over time, sediments can slowly fill out the manglares.

The components of nitrogen, ammonia, nitrites, and nitrates are cyclical. In the presence of oxygen, ammonia is transformed into the unstable nitrite, which is then transformed into nitrate A high concentration of ammonia usually indicates the presence of fresh fecal contamination.

High concentrations of nitrates are found in agricultural areas, as they are one of the main components of fertilizers

The results of these parameters (Table 7) indicate that ammonia concentrations are much higher than those of nitrite and nitrate These high values indicate that most of the sites, including surface and groundwater, present fresh fecal contamination that could come from human or animal sources. These results are consistent with the high fecal coliform counts previously cited.

High concentrations of phosphates were found in the Zanjón Madre Vieja, and two wells near Guayapa and La Danta Phosphate contamination is usually a result of fertilizer or detergent use.

In streams and rivers, low concentrations of phosphates and nitrogen compounds are considered nutrients and can actually improve the quality of water for the fauna. However, at higher concentrations, eutrophication, a process by which too many nutrients cause the death of higher faunal forms due to oxygen depletion, occurs. The initial influx of nutrients produces an algal bloom and proliferation of other aquatic plants, such as water lilies and water hyacinths. These plants cover the surface and prevent light from penetrating the water and keep phytoplankton from photosynthesizing. The lack of photosynthesis deprives the stream of an important source of oxygen, which results in the dying off of fish and other fauna.

The load (quantity passing a given point) of a contaminant, in kg/day, can be calculated by multiplying the flow (m /seg) x concentration (mg/l) x 86.4 This gives an idea of the magnitude of the contamination and is useful in predicting the effects on water organisms. The loads in this study were calculated for nitrates, phosphates, and boron in water (Table 8)

The quantity of dissolved oxygen is a measure of the health of a stream or river. A minimum of 5 mg/l is needed to be considered relatively healthy, and 7 mg/l are needed to categorize the ecosystem as healthy. Below 4 mg/l fish life is threatened. The data presented in Table 9 reveal that 1 of the 19 surface waters sampled can be considered healthy, 7 relatively healthy, and the other 11 of poor quality.

It should be noted that the concentration of dissolved oxygen follows a diurnal curve, with higher concentrations during the day (due to photosynthesis) and lower ones at night (due to depletion by respiration). Also it should be remembered that there is a negative correlation between water temperature and capacity to retain dissolved oxygen. This means that the higher the water temperature, the less dissolved oxygen the water can retain.

The BOD, or biological oxygen demand, is a measure of the amount of oxygen required to stabilize by biological oxidation the organic matter in the water. If the BOD is higher than the quantity of dissolved oxygen, and the natural re-aeration of the stream is relatively low, there will be a deficit of dissolved oxygen, and the fish, shrimp, and other fauna will begin to die In all of the surface waters sampled except one (sample 28) the BOD exceeds the quantity of dissolved oxygen, indicating that the fauna probably do not have enough oxygen available and the river is considered unhealthy

The concentrations of detergents are not high, but they have been diluted by the water in the river Most of the people living along the rivers and streams in El Salvador wash their clothes in the river No threshold for the concentration of detergents in water has been set

It was also considered important in this study to measure metal concentrations. Zinc, boron, copper, and arsenic were chosen as important. Unfortunately, UNICO was unable to measure the concentrations of arsenic. No traces of zinc or copper were found, but in some of the samples unusually high concentrations of boron were found (Table 9). For potable water ANDA has established a threshold concentration of 1.5

mg/l. Two of the samples exceeded this level, sample 17 (Zanjón Aguachapio) and sample 22 (a well in the Hacienda La Danta)

6.4 Chemical Analyses of Soils and Sediments

Table 10 presents the results of the soil analysis done at UNICO

The pH values are all within the values needed for agricultural purposes, although some crops have specific requirements

Unusually high concentrations of boron were found in soils and sediments Sediment samples showed high boron concentrations in the Barra de Santiago, Barra Salada, La Herradura (Jaltepeque), and Puerto Triunfo (Jiquilisco).

Soil samples also showed high concentrations of boron, considering that the upper limit for agricultural purposes is 75 mg/l in El Salvador (Calderon 1991). Only one of the nine soil samples is below this value

High boron concentration in the soil can adversely affect crops grown there, causing chlorosis and lowering the germination of seeds.

Two samples near the geothermal canal were analyzed for arsenic High arsenic levels were found in both samples (59 ppm and 79 ppm) (Table 10). The presence of arsenic probably is due to leakage of the geothermal canal

Arsenic concentrations were also measured in sediment samples from each of the five sites (Table 11) Very high levels were found in all of the samples with the two highest concentrations found in the samples from sites 2 and 5, Barra Salada and Puerto Parada respectively. Further investigations are warrented due to the high concentations found in all of the coastal areas studied

Table 10

Chemical Analysis of Soils

Normal		0 75 ppm		
No S S *	pH	Boron ppm	ARSENIC ppm	Apparent Texture
S1	7.70	2 2		Coarse sand
S2	6.60	1.0		Sandy
S3	6 56	1.4		Clayey silt
S4	6 80	1.4		Clayey sand
S5	5 70	1 2		Clayey sand
S6	6.24	1.2		Clay
S7	6 52	0.6		Clay
S8	6.02	1.6	59	Clay
S9	5 91	0 8	79	Clay

* S.S . Soil Sample

METHODOLOGY FOR THE ANALYSIS·

Boron· Carminic Acid Method (according to Hach Co)
Texture By touch

Table 11

Results of Sediment Analysis for Arsenic in the Five Study Sites

Site	Localization	Arsenic Concentration (ppm)
1	Barra de Santiago	54.8
2	Barra Salada	74 7
3	La Herradura	54.6
4	Puerto El Triunfo	41.1
5	Puerto Parada	74 9

6.5 Results of Pesticide Analysis

The results of the pesticide analyses are presented in Tables 12 to 15. The only organophosphate found in surface and well water was metamidophos (tamaron) Low concentrations of organochlorides were also found in the water samples (Tables 12 and 13) The concentrations of pesticides found in soil and sediments were also low (Table 14)

Due to biomagnification, higher concentrations of pesticides were found in organisms, but none was excessive (Table 15) However, relatively high concentrations of metamidophos were found and should be noted

Table 12

Pesticides in Surface Water
(in ppb)

NO	IDENTIFICATION	PARAQUAT	META-MIDOPHOS	αBHC	γBHC	HEPTA-CHLORO	ALDRIN	HEPTA-CHLORO EPOXIDO	DDE	DIELDRIN	OpDDT	DDD	pp'DDT	METHYL PARATHION	ETHYL PARATHION	ATRAZINA
1	Rio Cara Sucia arriba	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	Rio Cara Sucia abajo	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	Zanjon La Danta	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	Trace
4	Rio Aguachapio abajo	ND	ND	0 01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	Rio Guayapa abajo	ND	ND	0 01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	Canal Embarcadero Guayapa	ND	ND	0 05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7	Rio Culapa	ND	0.34	0 33	0 01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8	Rio Naranjo abajo	ND	ND	0 33	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9	Rio El Rosario	ND	ND	0 07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10	Rio Naranjo arriba	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11	Rio Izcanal arriba	ND	ND	0 01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12	Rio San Francisco abajo	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13	Rio Aguayapa arriba	ND	ND	0 09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
14	Rio Aguachapio arriba	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15	Rio San Francisco arriba	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16	Zanjon Madre Vieja	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
17	Zanjon Aguachapio	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
18	Rio La Palma	ND	ND	0 07	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
28	Rio Izcanal abajo	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND= Not Detected

Table 13

Pesticides in Wells
(in ppb)

NO	IDENTIFICATION	PARAQUAT	META-MIDOPHOS	@BHC	YBHC	HEPTA-CHLORO	ALDRIN	HEPTA-CHLORO EPOXIDO	DDE	DIELDRIN	OpDDT	DDD	pp'DDT	METHYL PARATHION	ETHYL PARATHION	ATRAZINA
19	Hacienda Cara Sucia	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
20	Near Geotheramal Canal	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
21	Guayapa abajo	ND	ND	0 01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
22	Hacienda La Danta	ND	ND	0 10	0 10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
23	Town Cara Sucia	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
24	San Jose El Naranjo	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
25	Hacienda Santa Rita	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
26	Santa Virginia El Achiotal	ND	0 27	0 09	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
27	Hacienda El Camalote	ND	0 01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
29	El Porvenir	ND	0 10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
30	Embarcadero de Guayapa	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND= Not Detected

Table 14

Pesticides in Soils and Sediments
(in ppb)

NO	IDENTIFICATION	PARAQUAT mg/kg	META-MIDOPHOS	@BHC	YBHC	HEPTA-CHLORO	ALDRIN	HEPTA-CHLORO EPOXIDO	DDE	DIELDRIN	OpDDT	DDD	pp'DDT	METHYL PARATHION	ETHYL PARATHION	ATRAZINA
	SOILS															
1	Camino Rio El Rosario	NT	NT	ND	ND	0 01	ND	ND	ND	ND	ND	ND	ND	ND	ND	NT
2	Camino San Jose El Naranjo	NT	NT	0 01	0 01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NT
3	Camino Rio Cuilapa	NT	NT	ND	0 01	ND	ND	ND	0 05	ND	ND	ND	ND	ND	ND	NT
4	Camino Lomas de Guayapa	10 25	ND	ND	ND	ND	ND	18	ND	ND	ND	ND	ND	ND	ND	NT
5	Camino Rio de Faya	8 67	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NT
6	Hacienda El Camalote	11 89	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NT
7	Zanjon El Chino	5 91	ND	ND	ND	ND	ND	12	ND	ND	ND	ND	ND	ND	ND	NT
8	Tuberia La Cabana	5 91	ND	ND	ND	ND	ND	ND	18	ND	ND	ND	ND	ND	ND	NT
9	Santa Teresa	5 86	ND	ND	ND	ND	ND	17	ND	ND	ND	ND	ND	ND	ND	NT
	SEDIMENTS															
1	Barra de Santiago	3 4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NT
2	Barra de Santiago	4 1	ND	05	ND	ND	ND	ND	07	53	ND	06	ND	ND	ND	NT
3	Barra Salada	1.3	ND	0 10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NT
4	Barra Salada	1 5	ND	ND	ND	ND	ND	ND	0 01	ND	ND	ND	ND	ND	0 01	NT
5	La Herradura	4 6	ND	ND	ND	ND	ND	ND	20	ND	ND	ND	ND	ND	ND	NT
6	Jiquilisco	6 21	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NT
7	Puerto Parada	5 42	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NT

ND = Not Detected

NT = Not Tested

Table 15

PESTICIDES IN AQUATIC ORGANISMS
(in ppm)

NO	IDENTIFICATION	PARAQUAT	METAMIDOPHOS	αBHC	γBHC	HEPTACHLORO	ALDRIN	HEPTACHLORO EPOXIDO	DDE	DIELDRIN	OpDDT	DDD	pp'DDT	METHYL PARATHION	ETHYL PARATHION	ATRAZINA
SITIO 1	BARRA DE SANTIAGO															
1	Curil Andara Sp	ND	ND	0 01	0 01	ND	ND	ND	0 01	ND	ND	ND	ND	ND	NT	ND
2	Curil Andara Sp	ND	ND	0 03	ND	ND	ND	0 01	0 01	ND	ND	ND	ND	ND	NT	ND
3	Jaiba Callinectes sp	ND	ND	ND	ND	ND	0 01	ND	ND	ND	ND	ND	ND	ND	NT	ND
4	Punche Ucides sp.	ND	ND	0 10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NT	ND
5	Punche Ucides sp	ND	ND	ND	ND	ND	ND	ND	0 01	ND	ND	0 01	ND	ND	NT	ND
6	Pez Lisa Mugil sp	004	ND	ND	ND	ND	ND	ND	0 03	ND	0 01	ND	ND	ND	NT	ND
7	Pez Bagre Bagre sp	ND	ND	0 01	0 03	ND	ND	ND	0 09	ND	ND	ND	ND	ND	NT	ND
SITIO 2	BARRA SALADA															
1	Jaiba Callinectes sp	NT	0 16	0 01	ND	ND	0 01	ND	ND	0 01	0 01	0 01	0 01	NT	NT	NT
2	Jaiba Callinectes sp	NT	0 15	0 01	0 01	ND	ND	ND	0 01	0 01	ND	ND	ND	NT	NT	NT
3	Chimberra Mugil sp	NT	NT	ND	0 01	ND	ND	ND	0 08	ND	ND	ND	ND	NT	NT	NT
4	Punche Ucides sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	03	ND	ND	< 01	NT	NT.
5	Jaiba Callinectes sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	< 01	NT	NT
6	Jaiba Callinectes sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	< 01	ND	ND	< 01	NT	NT
7	Almeja	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NT	ND

ND= Not Detected
NT= Not Tested

Table 15 (continued)

NO	IDENTIFICATION	PARAQUAT	META-MIDOPHOS	αBHC	γBHC	HEPTA-CHLORO	ALDRIN	HEPTA-CHLORO EPOXIDO	DDE	DIELDRIN	OpDDT	DDD	pp'DDT	METHYL PARATHION	ETHYL PARATHION	ATRAZINA
8	Almeja	NT	ND	ND	ND	ND	ND	ND	< 01	ND	ND	ND	ND	ND	NT	ND
9	Camaron de Mar Penneaus sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	< 01	ND	ND	ND	NT	ND
10	Camaron de Mar Penneaus sp.	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	< 01	ND	NT	ND
11	Camaron de Rio Macrobrochium sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NT	ND
12	Bagre	NT	ND	ND	ND	ND	ND	ND	13	ND	ND	ND	ND	ND	NT	ND
13	Pargo	NT	ND	ND	ND	ND	ND	ND	047	ND	ND	ND	ND	ND	NT	ND
14	Punche Uades sp	NT	ND	ND	ND	09	ND	07	ND	ND	ND	ND	ND	< 01	NT	ND

ND= Not Detected
NT= Not Tested

Table 15 (continued)

NO	IDENTIFICATION	PARAQUAT	META-MIDOPHOS	@BHC	YBHC	HEPTA-CHLORO	ALDRIN	HEPTA-CHLORO EPOXIDO	DDE	DIELDRIN	OpDDT	DDD	pp'DDT	METHYL PARATHION	ETHYL PARATHION	ATRAZINA
SITIO 3	JALTEPEQUE LA HERRADURA															
1	Chimbera Mugil sp	NT	NT	ND	ND	ND	ND	ND	ND	ND	06	ND	ND	ND	ND	ND
2	Conchas Andara sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	Conchas Andara sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	Punche Ucides sp	NT	TRACES	ND	ND	ND	ND	09	ND	ND	ND	ND	ND	ND	ND	ND
5	Camaron de Rio Macrobrachium sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	Camaron de Mar Penneaus sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SITIO 4	JIQUILISCO PUERTO TRIUNFO															
1	Chimbera Mugil sp	NT	ND	ND	ND	ND	ND	ND	063	ND	ND	ND	ND	025	ND	ND
2	Chimbera Mugil sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	013	ND	< 01	ND	ND	ND
3	Conchas Andara sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	Conchas Andara sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	Camaron de Mar Penneaus sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 15 (continued)

NO	IDENTIFICATION	PARAQUAT	META-MIDOPHOS	@BHC	YBHC	HEPTA-CHLORO	ALDRIN	HEPTA-CHLORO EPOXIDO	DDE	DIELDRIN	OpDDT	DDD	pp'DDT	METHYL PARATHION	ETHYL PARATHION	ATRAZINA
SITIO 5	JIQUILISCO PUERTO PARADA															
1	Punche Ucides sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	01	ND	ND	ND	ND
2	Conchas Andara sp	NT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND= Not Detected
NT= Not Tested

6.6 Sources of Contamination within the Study Area

As part of the study UNICO prepared a map indicating sources of contamination within the study area (Map 4)

Agricultural activities are common in the area and are a main source of contaminants, as is cattle raising Fecal contamination, resulting from poor sanitary conditions, is the main source of contamination and the results indicate that this is the main problem in the watershed Also, most people wash their clothes in the river, thereby contaminating the water with soap and detergent. In general, garbage and trash are not disposed of properly and it is suspected that much of such waste ends up in the rivers There is no real industry in the area.

A geothermal canal goes through the study area. It has a length of 77 kms and a capacity of 1 m^3 per second. The discharge ends in the sea approximately 200 m from the coast Boron and arsenic are found in this water and due to leakage can contaminate the surrounding area Heat contamination can also affect the marine life near the discharge area in the sea (Marroquin, 1986) The canal, however, was not in use during WASH and UNICO's visits According to a verbal communication with a CEL representative, the discharge from the thermal plant is being deep-well-injected on an experimental basis, with the eventual goal of eliminating the discharge to the sea.

6.7 Other Pertinent Findings

6.7.1 Endangered Fish

In the area of Barra de Santiago, a gar, *Apraprosteus tropicus*, is found. This is the only area of El Salvador in which the species is located. An ichthyologist working with the Natural History Museum (see Chapter 4) has found this species in El Zalte, Gloria Linda, El Roble, and Zanj6n el Chino It is a species under pressure from the local population; the MHN ichthyologist feels it is endangered in El Salvador.

6.7.2 Turtle Project in the Barra de Santiago

Two AMAR representatives are coordinating a marine turtle project in the Barra de Santiago (Hasbun and Vasquez, 1991). In the project, eggs are bought from turtle egg collectors and are then incubated in enclosures. After hatching, the young turtles are returned to the sea

6.7.3 Fish Studies in the Barra de Santiago

The ichthyologist cited above is also doing a survey of fish species that includes their ecology in the Barra de Santiago. He spends one week in the Barra and one week in the museum in El Salvador. His results have not been published yet, but will be an important source of information when compiled.

6.7.4 Phytoplankton Studies in the Barra de Santiago

Studies of phytoplankton are important because the species composition and abundance can give an indication of the quality of water. A study of species composition and abundance done by Rodriguez (1989) is a significant start. Phytoplankton are sensitive to contamination, and changes in species composition indicate changes in water quality.

6.7.5 Shrimp Larvae Die-off in the Chinese Project

Recently all of the shrimp larvae in the Chinese project near Cóbanos died. The cause of the die-off was found to be well water contaminated with tamaron or metamidophos.

6.7.6 Use of Pesticides in El Imposible to Kill Shrimp

A representative of the Natural History Museum who is working in El Imposible indicates that people are using pesticides to kill river shrimp which are then sold locally. Of course, not only shrimp are killed and, according to the quantity of pesticides used, aquatic life can be destroyed for 1 or more kilometers Pesticides used include decis, dieldrin, folidol, and lannate.

6.8 General Overview of Water Contamination

Table 16 presents a summary of causes and effects of different types of contaminants in water resources. In the present study, all types of waste except radioactive materials were found. These produce health hazards and reduce light penetration in water, with subsequent deoxygenation and toxicity problems for agricultural crops, aquatic fauna, and humans. These problems are interrelated and, by negatively affecting the quality of the environment, affect the quality of human life.

The PROMESA project is an excellent opportunity to reverse the effects of contamination, better the quality of the environment, and improve the state of the natural resources of El Salvador for the benefit of all Salvadoreans.

Table 16

Causes of Damage to the Quality of Water Resources

Type of Waste	Wastewater Sources	Water Quality Measures	Effects on Water Quality	Effects on Aquatic Life	Effects on Recreation
Disease-carrying agents—human feces, warm blooded animal feces	Municipal discharges, watercraft discharges, urban runoff, agricultural runoff, feedlot wastes, combined sewer overflows, industrial discharges	Fecal coliform, fecal streptococcus, other microbes	Health hazard for human consumption and contact	Inedibility of shellfish for humans	Reduced contact recreation
Oxygen-demanding wastes—high concentrations of biodegradable organic matter	Municipal discharges, industrial discharges, combined sewer overflows, watercraft discharges, urban runoff, agricultural runoff, feedlot wastes, natural sources	Biochemical oxygen demand, dissolved oxygen, volatile solids, sulfides	Deoxygenation, potential for septic conditions	Fish kills	If severe, eliminated recreation
Suspended organic and inorganic material	Mining discharges, municipal discharges, industrial discharges, construction runoff, agricultural runoff, urban runoff, silvicultural runoff, natural sources, combined sewer overflows	Suspended solids, turbidity, biochemical oxygen demand, sulfides	Reduced light penetration, deposition on bottom, benthic deoxygenation	Reduced photosynthesis, changed bottom organism population, reduced fish production, reduced sport fish population, increased non-sport fish population	Reduced game fishing, aesthetic appreciation
Inorganic materials, mineral substances—metal, salts, acids, solid matter, other chemicals, oil	Mining discharges, acid mine drainage, industrial discharges, municipal discharges, combined sewer overflows, urban runoff, oil fields, agricultural runoff, irrigation return flow, natural sources, cooling tower blowdown, transportation spills, coal gasification	pH, acidity, alkalinity, dissolved solids, chlorides, sulfates, sodium, specific metals, toxicity bioassay, visual (oil spills)	Acidity, salination, toxicity of heavy metals, floating oils	Reduced biological productivity, reduced flow, fish kills, reduced production, tainted fish	Reduced recreational use, fishing, aesthetic appreciation
Synthetic organic chemicals—dissolved organic material, e g . detergents, household aids, pesticides	Industrial discharges, urban runoff, municipal discharges, combined sewer overflow, agricultural runoff, silvicultural runoff, transportation spills, mining discharges	Cyanides, phenols, toxicity bioassay	Toxicity of natural organics, biodegradable or persistent synthetic organics	Fish kills, tainted fish, reduced reproduction, skeletal development	Reduced fishing, inedible fish for humans
Nutrients—nitrogen, phosphorus	Municipal discharges, agricultural runoff, combined sewer overflows, industrial discharges, urban runoff, natural sources	Nitrogen, phosphorus	Increased algal growth, dissolved oxygen reduction	Increased production, reduced sport fish population, increased non-sport fish population	Tainted drinking water, reduced fishing and aesthetic appreciation
Radioactive materials	Industrial discharges, mining	Radioactivity	Increased radioactivity	Altered natural rate of genetic mutation	Reduced opportunities
Heat	Cooling water discharges, industrial discharges, municipal discharges, cooling tower blowdown	Temperature	Increased temperature, reduced capacity to absorb oxygen	Fish kills, altered species composition	Possible increased sport fishing by extended season for fish which might otherwise migrate

Source Council of Environmental Quality, 1981, Environmental Trends in Van Der Leeden, Troise and Todd, 1990

Chapter 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

- Fecal contamination of surface water and wells in the study area is extremely high, with 13 of the 30 sources (45 percent) containing more than 9,000 fecal coliforms/100 ml of water.

- People interviewed who had wells thought the water was of good quality. This is alarming, especially with the presence of the cholera bacteria, *Vibrio cholerae*, in El Salvador

- Based on low dissolved oxygen content and high biological oxygen demand, the rivers, in general, cannot be considered healthy.

- High ammonia concentrations compared with those of nitrites and nitrates is another indication of fecal contamination.

- Pesticide residues in water, soil, and sediment were lower than in organisms, due to biomagnification.

- In general, pesticide concentrations were low, due, in the case of organochlorides (used widely during the cotton growing years), to the fact that cotton was never planted extensively in the study area

- Low concentrations of rapidly degrading pesticides were found, probably due to the fact that the sampling period was not one of high pesticide application

- High concentrations of tamaron (metamidophos) were found in some of the samples. Its use could result in further shrimp larvae, fish, and other fauna die-offs in the region.

- High concentrations of boron were found in the soil and some of the water samples. Many of the concentrations exceed threshold limits.

- High concentrations of arsenic were found in soil samples taken near the geothermal canal.

7.2 Recommendations

According to the Pan American Health Organization, the quality and quantity of the water in a country are the two most important parameters in the determination of the health of its inhabitants. Health, in turn, affects the education level and the productivity of the country. Sick children and their teachers miss school and unhealthy workers and farmers are less productive than healthy ones.

Because of the poor quality of surface and well water found in the study area, the team recommends the following actions.

- Because the incidence of diarrhea increases at the beginning of the rainy season, simple rainwater catchments should be experimented with within the area. Roof gutters could be used to catch the rainwater from the roofs The rainwater then could be stored in clean containers A study done in Tegucigalpa, Honduras (Brand and Bradford, 1991) shows that the quality of rainwater is relatively good and could be a useful alternative to the contaminated river and well water in the study area. At the present time, due to the presence of cholera in the study area, a noncontaminated source of water is especially important

- Alternatives to tamaron, such as *Bacillus thuringiensis*, should be used in the study area GTZ is working in this field and is a good source of information

- Biological control of crop pests should be implemented within the area, using natural enemies and naturally occurring pesticides (Hesse-Rodriguez, 1991)

- A sanitation program including latrines and sewerage should be initiated to address the fecal contamination problems affecting the water sources Some recommendations for latrines follow.

  — Community latrines should be double pit vented type when groundwater conditions are favorable (greater than 1.80 m below the ground surface in the wet season). A typical design of this type of latrine is included in Appendix J.

  — Household latrines should be single pit vented when groundwater conditions are favorable (greater than 1.80 m below ground surface in the wet season). A typical design of this type of latrine is included in Appendix J.

- Compost latrines or elevated latrines should be used when groundwater is less than 1.80 m below ground surface during the wet season. If elevated latrines are used, the bottom of the pit should be at least 0.6m above the highest elevation of the groundwater. A typical design of a compost latrine is included in Appendix J.

- The location of latrines should observe the minimum distances required from wells or any other water source. The minimum distance from any water source should be 20 m

- Sewerage works may be the most appropriate sanitation solution in population centers such as Cara Sucia, San Francisco Menendez, San Jose El Naranjo, and possibly the Barra de Santiago Sewerage should be coupled with a wastewater treatment process, such as oxidation ponds or trickling filters. Both of these processes are relatively cheap to build if local labor and materials are used

- Oxidation ponds could be used in the flat areas while trickling filters could be used in mountain locations Oxidation ponds should be the facultative type, which do not require separate sludge treatment Sludge that drops to the bottom is anaerobically digested, and the ponds need to be cleaned every few years. The design should include at least two cells so that one cell can be operating while the other is cleaned

- Trickling filters require small settling ponds ahead of the filters to settle the solids and avoid filter clogging. Trickling filters are well suited to mountain locations because they do not require a large area, and need a hydraulic head of about 2 m. They can be built using local materials such as stone and require very little maintenance. The settling ponds should be designed with at least two cells so they can be cleaned easily.

• To control and prevent sedimentation due to erosion caused by deforestation, agroforestry should be promoted in the upper watershed area

- To decrease deforestation, and consequently siltation, due to demand of firewood, fuel-efficient stoves should be encouraged in the area These could include LORENA, ceramic, or Chinese kerosene stoves.

- Composting on both a small and large scale (households and farms) should be promoted using household and farm organic waste. This would increase the fertility of the soil and, at the same time, reduce the contamination of the rivers and wells from solid wastes. Also, by reducing the amount of fertilizers required, this could be an economical method of organic solid waste disposal.

- To reduce the use of pesticides in rivers used to kill shrimp and fish used for human consumption, other food sources should be promoted, such as iguana and agouti farming.

- A short video (10 to 15 minutes) could be made to illustrate the problems of contamination in the area; it could be shown in schools, community groups, and cooperatives and on national television

- A contest among school children in Ahuachapán could be promoted to name a department tree, flower, fish, bird, and mammal to promote interest in the natural resources of the area.

- A monitoring program that considers the following should be established:

    — the agricultural cycle—the sampling program should be carried out during the fertilizer, pesticide, and herbicide application periods.

    — the rainy and dry seasons—the rainy season is the most appropriate time to detect pollutants in the streams and wells, because at that time runoff will contaminate surface and groundwater

- Silt and sediment carried by the streams should be sampled and analyzed during the rainy season to get an idea of the magnitude of the problem.

- Levels of pesticides and components of fertilizers, such as nitrates, should be monitored immediately after their application for a period of up to three weeks to verify degradation time.

- Flows should be measured with appropriate field instruments, in order to calculate the loads of contaminants to check the validity of the results

- Further studies of phytoplankton and zooplankton in estuary areas should be carried out since species composition and abundance indicate the quality of water.

- The relationship of wells to latrines and other sources of contamination should be studied and an educational campaign aimed at well owners should be undertaken. Portable field kits (by Millipore) should be introduced to do bacteriological analyses of well water, either by health promoters or by the well owners themselves

- Programs such as the marine turtle project at the Barra de Santiago should be supported

- Thesis research by university students should be encouraged within the study area, with orientations to include ecology, biology, chemistry, sociology, economics, education, agriculture, and so on.

- An environmental education campaign should be undertaken to inform inhabitants of the causes of contamination and how to lessen or avoid them.

- Support should be given to existing labs such as those at CENTA, UNICO, and other universities so as to increase their capabilities and ensure their capacity to undertake regular monitoring programs

- A detailed study of the geothermal canal should be made and should include the effects of water discharge on marine life.

- Because of the high concentration of arsenic in the soil near the geothermal canal and the close proximity of local inhabitants' wells, a detailed study of arsenic in well water and human hair should be carried out

Appendix A

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Appendix B

SUMMARY OF INTERVIEWS AND FIELD TRIPS

1 USAID Mission employees interviewed:

- Peter Gore
- Ross Wherry
- Mark Scott
- Kevin Armstrong
- Christine Adamczyk

2. Laboratories visited·

Laboratory	Person Interviewed	Capacity
SERTESA 3rd Ave N 27 and 29 Calle Poniente 25-9811, 25-9222	Flora Espinosa	Routine chemical analyses (mostly agricultural). Microbiological analyses.
CENTA Km 33, Careterra a Santa Ana 28-2066, 28-2255	Glona Calderon	Pesticide analyses.
UNICO 1st Calle Poniente, Santa Ana	Jose Antonio Puig	Routine chemical and microbiological analyses. (They are hard working and have had experience in agriculture but were willing to branch out and collaborate with WASH team's water analysis.)
Ministry of Agriculture Environmental Lab Santa Tecla	Nelson Martinez	Some routine chemical analyses; they hope to get more equipment soon.
University of El Salvador (Biology Department)	E. Lopez Zepeda Lila Gutierrez	Some chemical and biological analysis of water, hampered by lack of equipment

University of El Salvador (Chemistry Department)	Lab assistants	Have new AA for heavy metal analysis.
University of El Salvador (Agriculture) 25-2572, 25-1506	Leopoldo Serrano	Working on biological control.

Of the labs visited with capabilities to do routine chemical analyses, UNICO was chosen for the following reasons·

- UNICO is located in Santa Ana, which is close to the study area.
- The lab is well equipped for routine analyses
- The person in charge of the lab, Jose Antonio Puig, and his staff are very professional in their work and most of their results are to be trusted On their own initiative, they took photos of most of the sampling sites and redid some of the analyses that had had doubtful results.

CENTA is the only lab in the country equipped to do pesticide analyses Gloria Ruth Calderon is very capable but is hampered by lack of personnel and lack of electrical power due to the rationing program.

The Head of Inspectors at CENDEPESCA, the biologist Eugenio Palacios, was very cooperative and organized his inspectors to take the sediment and organism samples. By chance, one of the WASH team members was at CENTA the day an inspector arrived with the samples They were properly preserved in ice in a cooler provided by the project

FUSADES is building a new laboratory that will also be able to perform pesticide and herbicide analyses in Santa Tecla This lab should be an alternate to CENTA when it becomes operational

3 Other interviews

A Museum of Natural History

- Celina Duenas (Acting Director, working on herpetology in El Imposible)

- Mauricio Vásquez (working on an inventory of fish in the Barra de Santiago and the turtle project)
- Eunice Echeverria (working on an inventory of insects in El Imposible)

B. ANDA

- Roberto Ochoa, Director of OEAD
- Manuel Merlos, in charge of ANDA data bank on water quality, which has chemical and microbiological data on main rivers and wells

C CENDEPESCA

- Francisco Guevarra, Head of Investigation
- Eugenio Palacios, Head of Inspectors

Eugenio Palacios and his team of inspectors were contracted to take the samples of sediment and organisms at the 5 sampling points.

D Meeting at CENTA

- Ramon Montoya (GTZ)
- Elias Mejia (CENTA)
- Ruth Calderon (CENTA)
- Peter Gore
- Angel Chiri (A I.D , Washington, pesticides)
- Rodolfo Cristales (USAID, El Salvador)
- Fernando Requena
- Becky Myton

This meeting was arranged to explain the PROMESA project to CENTA and GTZ and exchange ideas with respect to a pesticide component of the project.

4 Field trips

A August 27, 1991

Participants Mauricio Salinas (CLUSA)
Fernando Requena
Becky Myton

Site visited· Main study area around Cara Sucia

A visit was made to Cara Sucia and the surrounding area to get a feel for the study area. Team members attended a meeting of the Cara Sucia Cooperative, which is growing marigolds for export. The team also saw rivers and streams in the area and traveled up the geothermal canal. People who lived along the canal were interviewed. The participants visited the Barra de Santiago and traveled by pipante to the sea.

B August 31, 1991

Participants Peter Gore
Ross Wherry
Fernando Requena
Becky Myton

Site visited Area around Cóbanos and Barra Salada

A visit was made to a shrimp farm. The farm's entire operation was explained. Participants also went to Barra Salada and took samples of sediment, crabs, and fish

C. October 3, 1991

Participants Peter Gore
Mark Hardin, Tropical Research and Development, Inc., Gainesville, Fla
David Gibson, AID-LAC Bureau, Washington, D.C.
Becky Myton

Site visited La Herradura mangrove area

A visit was made to La Herradura to visit the mangrove replanting project Participants were escorted by the mayor of La Herradura and some local people involved in the project The people are planting *Rhizophora mangle* as 1 m distances.

D October 5, 1991

Participants: Peter Gore
Jane Gore
Mark Hardin
David Gibson
Becky Myton

Site visited: A trip to El Imposible was attempted to view the Barra de Santiago Turtle Project

The team tried to get to El Imposible but it proved impossible. It was raining very hard and the road soon became too muddy, so participants had to turn back.

In the afternoon a visit to the Barra de Santiago Turtle Project was made. AMAR has a turtle-protecting project that buys eggs from local collectors and transfers them to a hatchery constructed by school children and other local inhabitants. When they hatch, the turtles are returned to the sea.

Appendix C

SELECTED ARTICLES

2 LA PRENSA GRAFICA Miércoles 4 de Septiembre, 1991

1,440 Tons. de basura acumulada aumentan los riesgos del cólera

No se puede negociar con los que juegan con la vida de la gran mayoría, haciendo de San Salvador un gran basurero u aumentando los riesgos de contraer el cólera.

El Lic. Carlos Antonio Mejía Alférez, Gerente General y alcalde en funciones de San Salvador, dijo que mientras dure el paro convocado por la Asociación Salvadoreña de Trabajadores Municipales (ASTRAM), no habrá ningún arreglo.

Mejía Alférez, que sustituye al Dr. Armando Calderón Sol, quien regresa el viernes de su gira por el exterior, manifiesta que los costos de operación por la huelga son mínimos, comparados con los altos costos que en vidas humanas pudiera tener.

Foto de LA PRENSA, por Herrera.

RIESGOS. No se puede negociar con los que juegan con la vida de la gran mayoría, haciendo de San Salvador un gran basurero o aumentando los riesgos de contraer el cólera, dijo ayer el alcalde depositario Lic. Carlos Antonio Mejía Alférez.

San Salvador produce diariamente 480 toneladas de basura. Por los efectos de la huelga, se acumularon durante el sábado, domingo y lunes recién pasados, 1,440 toneladas de basura. Esto ha venido a incrementar las condiciones de insalubridad propicias para la infestación por cólera.

Cooperación

El alcalde en funciones, manifestó que la situación de limpieza se normalizará posiblemente para el fin de semana, gracias a la cooperación que han dado camiones y montacargas del Ministerio de la Dirección General de Caminos, del Ministerio de Obras Públicas y la Fuerza Armada.

El Gerente General de la Alcaldía capitalina, sostiene que son pequeños grupos de perturbadores los que se mantienen en huelga en demanda de aumentos de salarios y otras prestaciones, que las condiciones económicas imperantes en la municipalidad no permiten satisfacer.

Están regresando

Personal de Parques y Jardines, Cementerio, Ingeniería y Recolección de Basuras, que en principio apoyaba la paralización de labores, ahora están regresando a sus puestos de trabajo, convencidos de que dicho movimiento es nocivo para el pueblo.

Finalmente el funcionario, dijo que espera una respuesta más humana de parte de los huelguistas, a fin de que tanto el barrido de calles, la recolección de basura domiciliar, de botaderos y mercados, así como la disposición final de las mismas y la limpieza de quebradas y cañadas, se reinicien normalmente para evitar que el cólera se propague más en nuestro país.

Las islas y manglares del estero de Jaltepeque

Por Enrique S. Castro

En el extremo sur del departamento de La Paz, El Salvador cuenta con uno de los más hermosos parajes marinos que le ha dotado la naturaleza: El estero de Jaltepeque, con sus islas, manglares y canales de apacibles aguas.

El Estero, su flora y su fauna, constituyen un atractivo para los turistas que no se conforman con que el azar les depare este espectáculo cuando incursionan en las anchas avenidas y en las misteriosas y caprichosas raíces que como anacondas sobresalen de los manglares.

La pesca es intensa y mientras en el Estero el anzuelo y la atarraya hieren las aguas, mar afuera los diestros pescadores tienen los trasmallos para sacar la esperanza de los pargos, el boca colorada y los pequeños tiburones que se enhebran como perlas en las redes.

El mundo maravilloso que está bajo las aguas del Estero no es, sin embargo, alumbrado por el ingenio de los buzos. Gracias entonces a la vida porque ha permitido evitar el rompimiento del equilibrio ecológico ya de por sí alterado con el incesante golpear del corvo sobre el manglar.

Más allá en la bahía de Jiquilisco, la punta de San Juan, con su arco o puerta horadada en el horizonte, se sostiene sobre esa movediza sustentación arenosa del fondo. Desde Corral de Mulas y la Isla del Espíritu Santo, se puede apreciar la interminable línea de suciedad de hojas, ramas y palos sueltos que arrastra la corriente marina.

Sin embargo, también en los canales del estero de Jaltepeque el panorama de la tarde muchas veces se oscurece por la terquedad del ser humano de no sólo danzar con máquinas poderosas sobre sus tranquilas aguas, sino que tirar los restos alimenticios, diesel y envases de cerveza y gaseosa.

El Estero se ensucia, se agotan los peces y otras especies marinas y de la misma flora. Los pescadores de San Luis La Herradura encuentran ahora muchas dificultades para obtener una buena pesca. Su alternativa entonces la constituyen los barcos camaroneros que les venden a bajo costo o les regalan la murraya.

Los expertos de CENDEPESCA mediante estudios realizados en la zona costera, en las cuencas marinas y en los manglares del estero de Jaltepeque, han advertido recientemente de los peligros que causa la tala indiscriminada de los manglares, junto con el daño que causa el saqueo sin límites de especies marinas.

En islas como La Canoa el daño es mayor porque los "depredadores humanos" no sólo se limitan a talar los man-

—Pasa a la página 25—

Las islas y...

—Viene de la página 7—

glares, sacar conchas pequeñas, destruir los nichos ecológicos, sino que también se dedican a la caza de armadillos, esos acorazados conocidos como cusucos.

Los diputados de la Asamblea Legislativa, basándose en la Ley Forestal deben aprobar leyes adicionales (el mismo Ejecutivo puede hacerlo con decretos) para declarar zonas de refugio submarino de flora, fauna y condiciones ecológicas de fondo, las ubicadas en las islas El Zapote, La Canoa, El Chingo, Tasajera, Guadalupe la Zorra, San Sebastián la Zorra, La Calzada y otros sitios del estero de Jaltepeque.

Ese decreto del Ejecutivo, a través del Ministerio de Agricultura y Ganadería, o leyes adicionales aprobadas por la Asamblea Legislativa, deben prohibir por tiempos limitados la pesca de algunas especies, el uso de explosivos y abandonar en las playas adyacentes a dicha zona desperdicios de pesca.

Las personas que persistan en su caprichosa necedad, deben recibir las sanciones que dicta la ley. Y éstas deben ser acatadas forzosamente tanto por los pescadores usuales, como por los propietarios de ranchos en las islas o en las orillas de la playa.

La promulgación de un refugio como el apuntado que se extiende hasta las bocana del Río Lempa, en los límites con el departamento de Usulután, debe ser un salvavidas para el mar y las especies, una batalla en la lucha por salvar la naturaleza y su ambiente de la destrucción de quien más las necesita: el hombre.

Comité contra cólera en Barra de Santiago

Con el propósito de habilitar un pequeño hospital de emergencia para atender los posibles casos de cólera que se den en el cantón de la Barra de Santiago, departamento de Ahuachapán, 22 personas de la comunidad han integrado el Comité Pro-Cólera de la Barra de Santiago.

A pesar que aún no se ha presentado ningún caso de cólera en esta comunidad de unos 8 mil habitantes que viven principalmente de la pesca, un hospital provisto del equipo mínimo necesario para tratar a las personas que contraigan la enfermedad, será de mucho beneficio.

Además de ser una comunidad pobre y de pescadores, características que la hacen vulnerable a esta enfermedad, el hospital más cercano queda a unos 50 kilómetros, en la ciudad de Sonsonate.

Los miembros del Comité son voluntarios, y han recibido de parte del Ministerio de Salud, charlas sobre lo que es la enfermedad y las medidas preventivas, a nivel doméstico y comunitario, que se deben practicar.

"Hemos aprendido y visitado las casas para dar orientación, pero también necesitamos saber qué hacer médicamente, para salvar la vida de personas contagiadas", hace ver Alejandra Rivas, secretaria del Comité.

Entre el equipo clínico que se necesita para instalar el mini-hospital y para lo cual los miembros del Comité están realizando actividades, se menciona lo siguiente: Gigantes para sostener suero, tijeras de lona, baldes y barriles plásticos, lejía, botas de hule, sábanas, tela para confeccionar gabachas, bolsas plásticas para basura, platos y vasos desechables y víveres de primera necesidad: maíz, frijoles, arroz y aceite comestible.

Qué son los Bosques Salados

Los bosques salados, también conocidos como manglares en el agro-forestal, se dice estar formados por el conjunto de especies que se desarrollan en los esteros inundados frecuentemente por las aguas oceánicas, al variar éstas su nivel debido a las mareas.

El manglar se desarrolla siempre en condiciones de frecuente inundación y de alta salinidad, lo cual es debido a los diferentes niveles de las mareas y las altas concentraciones de sal, que contienen las aguas marítimas.

En El Salvador se encuentran cinco especies de mangle, todas diferentes, entre las que se mencionan: Rhizophora mangle, conocido como mangle colorado, caracterizado por ser un árbol corpulento que alcanza 30 metros de altura y 60 Cms. de diámetro; Laguncularia racemosa, otro árbol que alcanza hasta 20 metros de altura, de corteza color café, oscuro y escamosa; la Avicennia nitida clasificado como el más pequeño (15 mts. y diámetro de 80 cms.); la Avicennia bicolor y el Conocarpus erecta, son las últimas especies más conocidas y por ende, de mayor utilización forestal en las zonas costeras.

De las especies citadas anteriormente, el mangle y el sincahuite son las de mayor importancia, tanto por ser las que ocupan las mayores extensiones, como por ser las de mayor aplicación.

El Servicio Forestal y de Fauna del CENREN, está encargado de velar por la conservación y la incrementación del bosque salado en el país; actualmente se está llevando a cabo un plan de reforestación de mangle en 80 hectáreas del Estero de Jaltepeque, que se encuentran degradadas y que por consiguiente se pretende restaurar la vegetación del lugar, demostrar las bondades y rentabilidad de la aplicación silvicultural en el manejo de manglares.

Según lo demuestra una investigación realizada recientemente por el Servicio Forestal, en San Luis La Herradura, Departamento de La Paz, revelan que uno de los principales beneficios de la reforestación de mangle es el mantenimiento sostenido del equilibrio ecológico, ya que el ecosistema es una parte de la biosfera definida en función de las interrelaciones entre seres vivientes y su medio ambiente.

En conclusión, los manglares son los ecosistemas naturales productores de alimento, más importantes para el país (moluscos, crustáceos, peces y animales terrestres).

EL DIARIO DE HOY • Martes 27 de Agosto de 1991

SUPLEMENTO
AGROPECUARIO

■ ECOLOGIA

El Jacinto de Agua Disminuye la Captación de los Embalses

Por José Eduardo Cubías Colorado

A los ojos del visitante, la masa vegetal verde-violeta del "Jacinto de agua" que cubre más de la cuarta parte de los embalses, resulta agradable, hasta poético; pero no para los ingenieros y técnicos de las centrales hidroeléctricas del país, quienes ven en esta planta acuática un peligro para la generación de energía, ya que su proliferación hace disminuir el volumen de agua, lo cual se hace más sensible durante los períodos de sequía.

A juicio del Colegio de Biólogos de El Salvador, la presencia de esta planta en los embalses (lagos artificiales formados por las represas) es producto de la disponibilidad de nutriente arrastrados por los ríos que desembocan en los embalses; asimismo del escurrimiento de la cuenca hidrográfica acompañada del arrastre de la tierra (erosión), que se va como sedimento hasta el fondo.

El jacinto de agua y la sedimentación afectan la cantidad de almacenaje de agua; para el caso —explican los biólogos— una superficie limpia de esta planta tiene una evotranspiración de 3.8 litros por metro cuadrado al día, caso contrario aumenta a 29.6 litros. Una estimación proyectada en 50 kilómetros cuadrados da por resultado una pérdida de agua por evotranspiración de 523,328 metros cúbicos al año, que excede en 463,932 metros cúbicos a la evotranspiración de una superficie limpia.

Un problema mayúsculo, si se considera que El Salvador dispone de un área de agua embalsada de aproximadamente 200 kilómetros cuadrados, distribuidos en los embalses de Guajoyo, Cerrón Grande, 5 de Noviembre y 15 de Septiembre; de esa superficie un 25 por ciento (cálculos biológicos) está cubierta de "Eichornia cressipes", o Jacinto de agua, que, tal como se ha explicado, no resulta nada beneficioso para la tecnología hidroeléctrica.

De este análisis se puede deducir que la presencia del Jacinto de agua en los embalses constituye un reto, un problema de carácter técnico-ecológico, para los conservacionistas si se toma en cuenta que los embalses son fuentes de producción de alimentos, ya que en ellos viven diversas especies acuícolas, cuya supervivencia habrá que tomar en cuenta, ya que el Jacinto de agua forma parte del habitat de los embalses.

Lunes 9 de Septiembre, 1991 LA PRENSA GRAFICA 21

Botadero de basura contamina un río

(Sonsonate). Los habitantes de San Antonio del Monte, se quejan de estar siendo envenenados debido a que un predio cercano ha sido seleccionado como botadero de basura, lo cual les contamina el Río Los Milagros.

Dicen que esa práctica les perjudica, porque les envenena dicho río que en algunas vertientes les sirve para abastecerse de agua.

Entre las colonias que se consideran perjudicadas, figuran El Carmen, IVU, Los Milagros, Santa Elena y Las Brisas.

Por ello solicitan al Alcalde de Sonsonate, don Abraham López de León, que busque otra parte donde botar la basura producida en la ciudad.

Aseguran que les asiste la razón al reclamar esta gestión pues no es correcto contaminar dicho río, del cual toman agua cuando hay escasez.

Agregan que "de nada sirve estar combatiendo las enfermedades si nosotros mismos estamos contaminando los ríos".

Asimismo los habitantes de Cuyuapa piden al propietario de la Cooperativa El Castaño que procure un método racional para eliminar los desechos que allí se producen.

Argumentan que las autoridades de Salud Pública, deberían visitar el lugar para resolverles su problema, antes que tenga que lamentarse graves hechos contra la salud colectiva.

Appendix D

SAMPLE DATA SHEET

OEDA/ANDA/PNUD/OPS/OMS

BANCO DE DATOS DE CALIDAD DE AGUA

AGUAS SUPERFICIALES

FECHA DE INVENTARIO : 09/26/87 LABORATORIO : MSPAS

RIO : PAZ

ESTACION DE MUESTREO : GARITA PALMERA

NOMBRE DE LA ESTACION : PAZ-4 DEPARTAMENTOAHUACHAPAN

NUMERO DE LA ESTACION : 65 MUNICIPIO : SAN FRANCISCO MENEND

REGION HIDROGRAFICA : B

FECHA DE MUESTREO : 02/23/78			SOLIDOS TOTALES	(P.P.M.)	740
PH		8.80	SOLIDOS DISUELTOS	(P.P.M.)	733
TEMPERATURA	(ºC)	25.0	SOLIDOS SUSPENDIDOS	(P.P.M.)	7
OXIGENO DISUELTO	(P.P.M.)	10.00	TOTALES FIJOS	(P.P.M.)	608
D. B. O.	(P.P.M.)	1.4	TOTALES VOLATILES	(P.P.M.)	132
ALCALINIDAD	(P.P.M.)	171.3	SOLIDOS SEDIMENTABLES	(ML/L)	0.15
ACIDEZ	(P.P.M.)	0.0	SODIO (Na)	(P.P.M.)	-
NITROGENO TOTAL	(P.P.M.)	-	POTASIO (K)	(P.P.M.)	-
TURBIEDAD SIO2	(P.P.M.)	5.2	INDICE COLIFORME	(N M P)	-
COLOR REAL	(UNIDADES)	3.0	NITRATOS (NO3-)	(P.P.M.)	0.04
CLORUROS	(P.P.M.)	235.0	BORO	(P.P.M.)	-
OLOR		TIERRA MOJADA	ARSENICO	(P.P.M.)	-

Appendix E

PESTICIDES AVAILABLE AND REGISTERED FOR USE IN EL SALVADOR

Table 1. **Pesticides Available and Registered for Use in El Salvador Also Shown are Toxicity Categories of Listed Pesticides (1,2,3,4,5,6,7)**

Source: Arreaga et. al., 1988

Common Name and (Brand Name)	Action	Toxicity Category	TOMATO 1	RICE 2	POTATO 3	SUGAR CANE 4	CHILI 5	CABBAGE 6	CASSAVA 7	BROCOLI 8	EGGPLANT 9	CUCUMBERS 10	RADISH 11	CORN 12	SORGHUM 13	ONIONS 14	CARROTS 15	GARLIC 16	BEANS 17	BEETS 18	MELONS 19	COFFEE 20	COTTON 21
Acephate (ORTHENE)	Insecticide	III																	X				X
Alachor (LASSO)	Herbicide	I			X									X	X				X				
Aluminum Phosphide (PHOSTOXIN)*	Insecticide	I																					
Allethrin (Fynamin I Forte)	Fungicide	III	X											X	X						X		
Ametryn (GESAPAX)	Herbicide	III			X	X			X					X					X				X
Atrazine (AATREX)	Herbicide	III				X								X	X								
Arsenal	Herbicide	III																					
Asulam (ASULOX)	Herbicide	III				X																	
Bacilus thuringiensis (DIPEL)	Insecticide	III	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Baytan (BAYFIDAN)	Fungicide	III																					
Baythion (VOLATON)	Insecticide	II																					
Benomyl (BENLATE)	Fungicide	III	X	X				X		X	X	X					X	X	X				
Bentazon (BASAGRAN)	Herbicide	II		X										X	X				X				
Brodifacoum (KLERAT)* 6	Rodenticide	III																					
Captafol (DIFOLATAN) 8	Fungicide	II	X	X								X		X		X					X		
Carbaryl (SEVIN)	Insecticide	III	X	X	X			X				X	X	X	X		X		X	X	X		X
Carbendazin (BAVISTIN) 2	Fungicide	III																					
Carbofuran (FURADAN)(CURATER)	Insecticide Acaricide Nematocide	II;I		X	X							X		X	X						X		X
Chlorothalonil (DACONIL)	Fungicide	II	X		X			X		X		X		X		X	X		X		X	X	
Chlorpyrifos (LORSBAN)*	Insecticide	II			X			X						X	X	X							X
Copperhydroxide (KOCIDE)	Fungicide	III;I	X		X		X	X		X		X				X			X		X		
Copper oxychloride (CUPRAVIT)	Fungicide	III	X		X		X			X									X				
Ciflluthrin (BAYTHROID)*	Insecticide	I	X	X	X		X	X	X	X	X	X	X	X	X	X	X		X	X	X		X
Cypermethrin (SHARPA, AMMO, SYMBUSH, RIPCORD)*	Insecticide	III																					X
	Herbicide	I;III		X										X	X								
Deconate (MSMA)	Herbicide	III																					X
VP (VAPONA)	Insecticide	I	X									X	X										

Common Name and (Brand Name)	Action	Toxicity Category	TOMATOE 1	RICE 2	POTATO 3	SUGAR CANE 4	CHILI 5	CABBAGE 6	CASSAVA 7	BROCOLI 8	EGGPLANT 9	CUCUMBERS 10	RADISH 11	CORN 12	SORGHUM 13	ONIONS 14	CARROTS 15	GARLIC 16	BEANS 17	BEETS 18	MELONS 19	COFFEE 20	COTTON 21
Deltamethrin (DECIS)[2]	Insecticide	I	?																				X
Diazinon (BASUDIN)	Insecticide	III;I	X		X			X	X			X		X	X	X	X		X	X	X		X
Dicamba	Herbicide	II				X								X	X								
Dichlorvos (VAPONA; DDVP)[4]	Insecticide	I	X																				
Dicrotophos (BIDRIN;CARBICRON)*	Insecticide	I																					X
Dimethametryn (AVIROSAN)	Herbicide	III																					
Disulfoton (SOLVIREX:DISYSTON)*	Insecticide	I	X		X			X						X	X				X				X
Diuron (KARMEX)	Herbicide	III			X									X	X								X
Edifenphos (HINOSAN)[2]	Fungicide	II																					
Endosulfan (THIODAN)	Insecticide	I	X		X			X				X					X		X		X		X
EPTC (ERRADICANE)	Herbicide	III			X									X					X				
Ethoprop (MOCAP)*	Nematocide	II			X			X				X		X									
Fenamiphos (NEMACUR)*	Nematocide	I						X															X
Fenitrothion (FOLITHION)	Insecticide	II																					
Fenthion Lebaycid (BAYTEX)	Insecticide	II																					
Fluzifop-Butyl (FUSILADE)	Herbicide	III																					X
Glyphosate (ROUNDUP)	Herbicide	II		X	X			X			X			X	X	X	X		X	X		X	X
Heptachlor[9]	Insecticide	II																					
Hexazinone (VELPAR)	Herbicide	II				X																	
Isofenphos (OFTANOL)	Insecticide	I																					
Karate	Insecticide	?																					
Kasugamycin (KASUMIN)	Fungicide	IV	X	X																			
Malathion (LUCATION)	Insecticide	III	X	X	X			X		X	X	X	X	X	X	X	X	X	X	X	X		X
Maneb (MANZATE)	Fungicide	III	X		X							X		X		X	X		X		X		X
Metaldehyde	Molluscicide	III																					
Mephosfolan (CYTROLANE)[2]	Insecticide	I		X										X	X								
Metalaxyl (RODOMIL)	Fungicide	II	X		X			X		X	X	X				X					X		X
Methamidophos (TAMARON;MONITOR)*	Insecticide Acaricide	I	X		X			X				X								X	X		X
Methiodathion (SUPRACIDE)*	Insecticide	I													X								X
Methomyl (LANNATE)*	Insecticide	I	X		X			X				X		X	X	X	X		X	X	X		X
Methy Bromide *	Fumigant	I	X	X	X			X			X	X	X	X	X	X	X	X	X	X	X	X	X
Methyl Parathion (FOLIDOL;MITIDOX)*	Insecticide	I	X	X	X			X				X		X		X	X		X	X			X
Methyl Pirimiphos (ACTELLIC)	Insecticide	III												X	X								
Metolachor (DUAL)	Herbicide	II		X										X	X				X				X

Common Name and (Brand Name)	Action	Toxicity Category	TOMATOE 1	RICE 2	POTATO 3	SUGAR CANE 4	CHILI 5	CABBAGE 6	CASSAVA 7	BROCOLI 8	EGGPLANT 9	CUCUMBERS 10	RADISH 11	CORN 12	SORGHUM 13	ONIONS 14	CARROTS 15	GARLIC 16	BEANS 17	BEETS 18	MELONS 19	COFFEE 20	COTTON 21
Metribuzin (SENCOR)	Herbicide	III	X		X									X									
Mirex	Insecticide	II																					
Monocrotophos (NUVACRON);GUSATHON	Insecticide	I																					X
AZODRIN)*																							
Omethoate (FOLIMAT)	Insecticide	II																					
	Acaricide	II																					
Oxadiazon (RONSTAR)	Herbicide	II		X																			
Oxamyl (VYDATE)*	Insecticide	I	X		X							X				X					X		X
	Nematocide																						
Oxifluorfen (GOAL)	Herbicide	II												X		X							X
Oxythioquinox (MORESTAN)	Insecticide	III																					
	Acaricide																						
	Fungicide																						
Paraquat (GRAMESEN;GRAMAXONE;	Herbicide	I	X		X			X	X			X		X	X	X	X		X		X		X
KENOQUAT; PARADOX;GRAMAFIX)*																							
Parathion*	Insecticide	I	X	X	X	X		X			X	X	X	X	X	X	X	X	X	X	X	X	X
Pendimethalin (DRAGON;PROWL)	Herbicide	II		X	X									X	X				X				X
Permethrin (AMBUSH;LORNADA)*	Insecticide	III			X			X						X									X
Phorate (Thimet)*	Insecticide	I	X	X	X	X								X	X				X				X
Phosalone (ZOLANE)	Acaricide	II			X																		
	Insecticide																						
Phoxim (VOLATON;BAYTHION) 2	Insecticide																						
Pichloram (TORDON)	Herbicide	II																					
Profenofos (TAMBO;SELECRON);	Insecticide	II																					X
CURACRON)*	Acaricide																						
Piperophos (AVIRASAN) 2	Herbicide	?																					
Propanil (HERBAX; STAM)	Herbicide	II		X																			
Propineb (ANTRACOL)	Fungicide	II																					
Propoxur (BAYGON)	Insecticide	II																					
Prothiophos (TOKYTHION) 2	Insecticide	?																					
Temephos (ABATE)	Insecticide	III																					
Thiram (THIRAM) 2	Fungicide	III																					
	Animal																						
	Repellant																						

Common Name and (Brand Name)	Action	Toxicity Category	TOMATOE 1	RICE 2	POTATO 3	SUGAR CANE 4	CHILI 5	CABBAGE 6	CASSAVA 7	BROCOLI 8	EGGPLANT 9	CUCUMBERS 10	RADISH 11	CORN 12	SORGHUM 13	ONIONS 14	CARROTS 15	GARLIC 16	BEANS 17	BEETS 18	MELONS 19	COFFEE 20	COTTON 21
Terbufos (Counter)	Insecticide Nematocide	I												X	X								
Terbutryn (ICRAN)	Herbicide	II													X								
Toxaphene (STROBANE, PHENATOX)9	Insecticide	II																					
Triadimefon (BAYLETON)	Fungicide	II										X									X		
Trichlorfon (DIPTEREX; DANEX; DYLOX)	Insecticide	II	X											X						X			X
Tridemorph (CALAXIN)	Fungicide	II																					
Zineb (ZINEB; MANCOZEB)9	Fungicide	III																					

1. Aerial Application Prohibited
2. Not Registered by EPA
* Restricted Use in some if not all formulations
3. Residue tolerance have not been established by EPA or recommended by FAO/WHO
4. Currently under review by EPA
5. Granular formulations of Carbofuran are not restricted, but all concentrate suspensions and wettable powers 40% and greater are. FURADAN 5% granules are proposed here.
6. Restriction can be lifted if labeling modified
7. Use approved subject to adherance to U.S. labelling provisions
8. Voluntary cancellation of all products in U.S.
9. Use suspended in the U.S.

Appendix F

PESTICIDE RESIDUES FOUND IN OTHER STUDIES

Table F.1 Average Pesticide Residues in Fat, Tissue and Blood of Cattle From the Eastern (Zone 1), Central (Zone 2) and Western (Zone 3) Zones of El Salvador (in ppb), 1980

	OC-BHC + r-BHC	Heptachlor + Epoxy Heptachlor	Aldrin & Dieldrin	DDT & Metabolites	Chloradane
Fat					
Z1	68.25	21.87	25.62	85.50	30.25
Z2	85.30	12.30	66.50	57.00	6.10
Z3	38.00	14.00	11.25	80.75	0
Tissue					
Z1	239.62	98.50	97.62	291.37	107.87
Z2	402.90	73.20	368.40	179.50	23.50
Z3	92.50	45.50	70.50	51.50	23.50
Blood					
Z1	10.25	0.12	5.87	22.00	5.00
Z2	13.00	6.80	4.30	13.50	30.60
Z3	6.25	0.25	2.25	80.75	3.00

Source: Zelya + Laxo (1980) in Arreaga, et. al., 1988

Table F.2 Average Pesticide Residues in Fat, Liver and Blood in Beef in Eastern (Zone 1), Central (Zone 2), Western (Zone 3) Zones of El Salvador (in ppb), 1988

	BHC	BHC	Heptachlor + Epoxy Heptachlor	Aldrin & Dieldrin	DDT & Metabolites	Methyl Parathion
Fat						
Z1	0.34	0.23	-	-	0.36	-
Z2	0.29	0.56	-	-	3.024	0.15
Z3	-	1.17	-	-	3.42	0.57
Liver						
Z1	0.19	0.09	-	-	0.03	-
Z2	0.21	0.30	-	0.002	0.33	0.31
Z3	0.06	0.05	-	-	-	-
Blood						
Z1	-	-	0.0046 + 0.001	0.00003	0.142	0.012
Z2	0.011	0.026	0.007	0.997	0.997	0.14
Z3	-	0.13	-	0.0008	0.389	0.0015

Source: Meléndez and Bonilla (1988)

Table F.3 Pesticide Residues in Soil Samples Collected from Cotton Fields (in ppm)

Sample	DDT	Toxaphene	Organo Phosphate	pH	Approximate Years Under Cultivation
1	0.80	1.43	0	5.6	5
2	0.39	2.50	0	5.4	17
3	1.08	4.17	0	5.7	25
4	0.50	1.83	0	5.8	5
5	0.61	1.00	0	5.8	3
6	0.58	1.66	0	6.5	8
7	0.94	5.03	0	6.0	20
8	0.16	0.69	0	5.2	6
9	0.29	1.10	0	6.2	12
10	1.61	7.86	0	6.2	34

Source: Lopez Zepeda (1977) in Arreaga et. al., 1988

Table F.4

CONCENTRACIONES DE PESTICIDAS EN SUELOS CULTIVADOS DE ALGODON
(En partes por millón)

Municipio	No de muestras	CONTENIDO DE DDT			CONTENIDO DE TOXAFENO		
		MAX	MIN	PROM	MAX	MIN	PROM
Jiquilisco	8	1.08	0 39	0.63	4 7	0.69	2 28
Pto. El Triunfo	2	1 61	0 29	0 95	7.86	1.10	4 48
San Dionisio	3	2.52	0 03	1 39	10 87	0	5 86
Usulután	2	1 46	0 96	1.21	10 51	6.53	8 52
Concepción Batres	3	1.39	0 88	1.20	2.53	2.14	2 39
Jucuarán	2	1 74	0 84	1.29	5.84	1.45	3 64

Ministerio de Planificación, Oficina Especializada del Agua, Programa Nacional de Abastecimientos y Saneamiento, 1983 in USAID, 1985

Table F.5 Average Level of Pesticide Residues in Some Fish, Molluscs and Echinoderms in the Jiquilisco Bay (in ppm)

Scientific & Common Name	DDT	Endrin	Dieldrin	Ethyl Parathion
Cynoscion spp. (Curvina) Fish	2.33	0.16	0.04	-
Mugil spp. (lisa) Fish	1.86	0.27	0.05	-
PomadaSys spp. (Ruco) Fish	1.79	0.07	0.52	-
Peneaus spp. (Camaron) Shrimp	0.56	-	-	-
Anadara spp. (Curil) Mussel	0.75	0.05	0.03	-
Mytella spp. (Churria) Clam	0.62	0.03	0.02	0.01
Oreaster spp. (Starfish)	0.35	0.06	0.02	-

Source: Lopez Zepeda (1977)

Table F.6 Residues of Organochlorine Pesticides in the Coastal Zones of El Salvador (in ppm)

Residuos de pesticidas organoclorados expresados en partes por millón (PPM) para granjas avícolas y caseríos de las Zonas Costeras de El -- Salvador (Frances, 1980).

Pesticide / Origin	∝ BHC	γ BHC	Heptacloro	Aldrin	Heptacloro epoxado	PPDDE	Dieldrin	OPDDT	PPDDD	PPDDT	Endrin	Total DDT
Ahuachapan	0.01	0.07	—	0.02	—	0.06	—	—	--	—	—	0.06
La Libertad	0.02	0.34*	—	0.05	—	0.33	0.50	--	—	—	0.04	0.33
San Salvador	0.03	0.23	0.40	0.02	—	0.15	0.03	0.03	—	0.06	—	0.23
Usulután	0.02	0.17	0.35*	0.04	0.02	0.36	0.69*	—	—	0.42	0.02	0.78*
San Miguel	0.03	0.18	0.12	—	—	0.59*	0.02	0.03	—	0.06	—	0.67*
La Unión	0.01	0.15	0.07	0.03	—	0.35	0.05	0.03	—	0.06	—	0.44
Cas. Metalío	0.08	0.03	0.4	0.04	—	0.78*	0.02	0.07	—	0.38	—	1.22*
Cas. El Presidio	0.15	0.40*	—	0.14*	—	0.96*	0.08	—	—	0.56*	—	1.23*
Cas. Entre Ríos	0.02	0.24*	0.04	—	—	1.49*	—	—	--	1.03*	—	2.53*

* Sobre los límites máximos permisibles.

Source: Frances (1980) in Arreaga et. al., 1988

Table F.7 APLICACION DE PLAGUICIDAS DURANTE LA TEMPORADA ALGODONERA 1985-1986
ISLA LA CALZADA (ESTERO DE JALTEPEQUE)

MUESTREO	FECHA DE ROCIADO	PARATION APLICADO	EXTENSION ROCIADA ** (MANZANAS)	VOLUMEN DE ROCIADO* TOTAL (LTS)
I	---------------	----------------	---------------	--------
II	4 septiembre 1985 al 10 noviembre 1985	Supertión Metil-800 (MPT) Etil-Metil 6,3 (EPT)	3,193.0 525.0	1,915.80 1,050.00 2,965.80
III	13 noviembre 1985 al 26 noviembre 1985	Supertión Metil-800 (MPT)	614.0	368.40
			4332.00	3,334.20

* Dosis de Aplicación: Supertión Metil-800 = 0.6 lts/Mz
Etil-Metil 6,3 = 2 lts/Mz

** 1 Manzana es equivalente a: 0.6988 hectáreas

Fuente: Registro de riegos de la División de Control Integrado de Plagas (C.I.P.) del Centro de Tecnologia Agricola (CENTA)

Source: Dominguez and Paz, 1988

Table F.8

RESIDUOS DE METIL PARATION Y PARA-OXON

MUESTREO Nº 1 - ISLA LA CALZADA (ESTERO DE JALTEPEQUE) 22 JUN. 1985

MUESTRAS*		METILPARATION	ETILPARATION	PARAOXON	TOTAL
"camarón"	*Penaeus* sp.**	0.0	0.0	Trazas (0.0168)	0.0168
"jaiba"	*Callinectes* sp.	0.0	0.0	0.0	0.0
"curil"	*Anadara* sp.	0.0	0.0	0.1222	0.1222
"ruco"	*Pomadasys* sp.	0.0	0.0	0.3667	0.3667
"bagre"	*Arius* sp.	0.0	0.0	0.1537	0.1537
"jurel	*Caranx* sp.	0.0	0.0	0.0	0.0
Agua***	Sitio Pacoya	0.2164	0.0	0.7553	0.9717
	El Tempate	0.0	0.0	0.3437	0.3437
	San Lorenzo	0.0	0.0	0.0	0.0
Sedimento**	Sitio Pacoya	0.0	0.0	0.0	0.0
	El Tempate	0.0	0.0	Trazas (0.0134)	Trazas (0.0134)
	San Lorenzo	0.0	0.0	0.0	0.0

* Las muestras de animales provienen del área comprendida por las 3 estaciones.
** Concentraciones expresadas en ppm.
*** Concentraciones expresadas en ppb.

Source: Dominguez and Paz, 1988

Table F.9

RESIDUOS DE METIL-ETIL PARATION Y PARA-OXON

MUESTREO Nº 2 - ISLA LA CALZADA (ESTERO DE JALTEPEQUE) 10 NOV. 1985

MUESTRAS*		METILPARATION	ETILPARATION	PARAOXON	TOTAL
"camarón"	_Penaeus_ sp.**	0.3537	0.0	0.6670	1.0207
"jaiba"	_Callinectes_ sp.	0.2417	0.0	0.0	0.2417
"curil"	_Anadara_ sp.	0.3140	1.5273	1.1293	2.9706
"ruco"	_Pomadasys_ sp.	0.7679	1.8502	0.8727	3.4908
"bagre"	_Arius_ sp.	0.0	0.0	0.2636	0.2636
"jurel	_Caranx_ sp.	0.1505	0.2035	0.0	0.3540
	Sitio Facoya	0.0	0.1272	0.0	0.1272
Agua***	El Tempate	0.0	Trazas (0.0744)	0.0	Trazas (0.0744)
	San Lorenzo	0.0	0.1365	0.0	0.1365
	Sitio Facoya	0.0	0.0	Trazas (0.0402)	Trazas (0.0402)
Sedimento**	El Tempate	0.0	Trazas (0.003)	Trazas (0.0011)	Trazas (0.0041)
	San Lorenzo	0.0	Trazas (0.0085)	Trazas (0.0059)	Trazas (0.0144)

* Las muestras de animales provienen del área comprendida por las 3 estaciones.
** Concentraciones expresadas en ppm.
*** Concentraciones expresadas en ppb.

Source: Dominguez and Paz, 1988

Table F.10

RESIDUOS DE METIL-ETIL - PARATION Y PARA-OXON

MUESTREO Nº 3 - ISLA LA CALZADA (ESTERO DE JALTEPEQUE) 30 NOV. 1985

MUESTRAS*		METILPARATION	ETILPARATION	PARAOXON	TOTAL
"camarón"	*Penaeus* sp.**	0.1356	0.9535	0.0	1.0891
"jaiba"	*Callinectes* sp.	0.0	0.4615	0.0	0.4615
"curil"	*Anadara* sp.	4.2305	0.0	Trazas (0.0581)	4.2886
"ruco"	*Pomadasys* sp.	0.0	1.0899	0.0	1.0899
"bagre"	*Arius* sp.	0.0	0.0	0.0	0.0
"jurel	*Caranx* sp.	0.0	0.1742	0.0	0.1742
	Sitio Pacoya	0.0	0.0	0.0	0.0
Agua***	El Tempate	0.0	0.6710	0.0	0.6710
	San Lorenzo	0.0	0.0	0.2297	0.2297
	Sitio Pacoya	Trazas (0.0093)	0.0	Trazas (0.0066)	Trazas (0.0159)
Sedimento**	El Tempate	0.0	Trazas (0.0027)	0.0	Trazas (0.0027)
	San Lorenzo	Trazas (0.0046)	Trazas (0.0099)	Trazas (0.0053)	Trazas (0.0198)

* Las muestras de animales provienen del área comprendida por las 3 estaciones.

** Concentraciones expresadas en ppm.

*** Concentraciones expresadas en ppb.

Source: Dominguez and Paz, 1988

Appendix G

STANDARDS FOR DRINKING WATER AND AQUATIC ENVIRONMENTS

TABLE G.1 NATIONAL PRIMARY DRINKING WATER STANDARDS

Constituent	MCL mg/L	Constituent	MCL mg/L
INORGANICS		Lindane	0.004
Arsenic (AS)	0.05	Methoxychlor	0 1
Barium (Ba)	1.0	Toxaphene	0.005
Cadmium (Cd)	0.01	Total trihalomethanes	0 10
Chromium (Cr)	0 05	RADIONUCLIDES	
Fluoride (F)	4.0	Beta particle and photon	
Lead (Pb)	0.05	activity, mrem	4 (annual dose equivalent)
Mercury (Hg)	0 002	Gross alpha, pCi/L	15
Nitrate (as N)	10.0	Radium-226 and 228, pCi/L	5
Selenium (Se)	0 01	VOLATILE ORGANIC CHEMICALS	
Silver (Ag)	0.05	Benzene	0.005
MICROBIOLOGICALS		Carbon tetrachloride	0.005
Coliforms	1/100 mL	1,2-Dichloroethane	0.005
PHYSICAL CHARACTERISTICS		1,1-Dichloroethylene	0.007
Turbidity, NTU	1–5	1,1,1-Trichloroethane	0.20
ORGANICS		para-Dichlorobenzene	0.075
2, 4-D	0 1	Trichloroethylene	0.005
2,4,5-TP Silvex	0.01	Vinyl chloride	0.002
Endrin	0 0002		

Source U.S Environmental Protection Agency

Van Der Leedn, Troise and Todd, 1990

TABLE G.2 NATIONAL SECONDARY DRINKING WATER STANDARDS

Constituent	SMCL Level (mg/L)	Constituent	SMCL Level (mg/L)
Chloride (Cl)	250	Manganese (Mn)	0.05
Color, color units	15	Odor, threshold odor number	3
Copper (Cu)	1	pH, pH units	6.5–8.5
Corrosivity	Noncorrosive	Sulfate (SO_4)	250
Fluoride	2.0	Total dissolved solids (TDS)	500
Surfactants (MBAS)	0.5	Zinc (Zn)	5.0
Iron (Fe)	0 3		

HEALTH ADVISORY

Constituent	Level (mg/L)
Sodium	20

Source U.S. Environmental Protection Agency

Van Der Leedn, Troise and Todd, 1990

TABLE G.3 PROPOSED NATIONAL DRINKING WATER STANDARDS FOR ORGANIC AND INORGANIC CHEMICALS

[MCL - Maximum contaminant level, SMCL - Secondary maximum contaminant Level]

Chemical	Level	Chemical	Level
Proposed MCLs for organic chemicals:		**Proposed MCLs for inorganic chemicals:**	
Acrylamide	treatment technique	Arsenic	0.03 mg/L
Alachlor	0.002 mg/L	Asbestos	7 million fibers/L
Aldicarb	0 01 mg/L		(longer than 10 μm)
Aldicarb sulfoxide	0 01 mg/L	Barium	5 mg/L
Aldicarb sulfone	0 04 mg/L	Cadmium	0.005 mg/L
Atrazine	0 003 mg/L	Chromium	0 1 mg/L
Carbofuran	0 04 mg/L	Mercury	0 002 mg/L
Chlordane	0.002 mg/L	Nitrate**	10.0 mg/L (as N)
Dibromochloropropane	0 0002 mg/L	Nitrite	1.0 mg/L (as N)
o-Dichlorobenzene	0 6 mg/L	Selenium	0 05 mg/L
cis-1,2-Dichloroethylene	0 07 mg/L		
trans-1,2-Dichloroethylene	0 1 mg/L	**Proposed SMCLs:**	
1,2-Dichloropropane	0.005 mg/L		
2,4-D	0.07 mg/L	Aluminum	0.05 mg/L
Epichlorohydrin	treatment technique	o-Dichlorobenzene	0.01 mg/L
Ethylbenzene	0 7 mg/L	p-Dichlorobenzene	0.005 mg/L
Ethylene dibromide	0 00005 mg/L	1,2-Dichloropropane	0.005 mg/L
Heptachlor	0 0004 mg/L	Ethylbenzene	0.03 mg/L
Heptachlor epoxide	0 0002 mg/L	Pentachlorophenol	0.03 mg/L
Lindane	0 0002 mg/L	Silver	0.09 mg/L
Methoxychlor	0 4 mg/L	Styrene	0.01 mg/L
Monochlorobenzene	0.1 mg/L	Toluene	0.04 mg/L
PCBs	0 0005 mg/L	Xylene	0.02 mg/L
Pentachlorophenol	0.2 mg/L		
Styrene*	0 005 mg/L/0 1 mg/L		
Tetrachloroethylene	0.005 mg/L		
Toluene	2 mg/L		
Toxaphene	0 005 mg/L		
2,4,5-TP (Silvex)	0 05 mg/L		
Xylene	10 mg/L		

* EPA proposes MCLs of 0 1 mg/L based on a Group C carcinogen classification and .005 mg/L based on a B_2 classification
** In addition, MCL for total nitrate and nitrite = 10 0 mg/L.
Source USEPA Office of Drinking Water, August 1988, amended based on May 22, 1989, Fed Register Vol. 54, No 97, pp. 22062-65

Van Der Leedn, Troise and Todd, 1990

TABLE G.4 WORLD HEALTH ORGANIZATION GUIDELINES FOR DRINKING WATER QUALITY

MICROBIOLOGICAL AND BIOLOGICAL QUALITY

Organism	Unit	Guideline Value	Remarks
I. Microbiological quality			
A Piped water supplies			
A 1 Treated water entering the distribution system			
Faecal coliforms	Number/100 mL	0	Turbidity <1 NTU, for disinfection with chlorine, pH preferably <8 0, free chlorine residual 0 2-0 5 mg/litre following 30 minutes (minimum) contact
Coliform organisms	Number/100 mL	0	
A 2 Untreated water entering the distribution system			
Faecal coliforms	Number/100 mL	0	
Coliform organisms	Number/100 mL	0	In 98% of samples examined throughout the year—in the case of large supplies when sufficient samples are examined
Coliform organisms	Number 100 mL	3	In an occasional sample, but not in consecutive samples
A 3 Water in the distribution system			
Faecal coliforms	Number/100 mL	0	
Coliform organisms	Number/100 mL	0	In 95% of samples examined throughout the year—in the case of large supplies when sufficient samples are examined
Coliform organisms	Number/100 mL	3	In an occasional sample, but not in consecutive samples
B Unpiped water supplies			
Faecal coliforms	Number/100 mL	0	
Coliform organisms	Number/100 mL	10	Should not occur repeatedly, if occurrence is frequent and if sanitary protection cannot be improved, an alternative source must be found if possible
C Bottled drinking-water			
Faecal coliforms	Number/100 mL	0	Source should be free from faecal contamination
Coliform organisms	Number/100 mL	0	
D Emergency water supplies			
Faecal coliforms	Number/100 mL	0	Advise public to boil water in case of failure to meet guideline values
Coliform organisms	Number/100 mL	0	
Enteroviruses		No guideline value set	
II. Biological quality			
Protozoa (pathogenic)	—	No guideline value set	
Helminths (pathogenic)	—	No guideline value set	
Free-living organisms (algae, others)	—	No guideline value set	

TABLE G.4 WORLD HEALTH ORGANIZATION GUIDELINES FOR DRINKING WATER QUALITY (continued)

INORGANIC CONSTITUENTS OF HEALTH SIGNIFICANCE

Constituent	Unit	Guideline Value	Remarks
Arsenic	mg/L	0.05	
Asbestos	—	No guideline value set	
Barium	—	No guideline value set	
Beryllium	—	No guideline value set	
Cadmium	mg/L	0.005	
Chromium	mg/L	0.05	
Cyanide	mg/L	0.1	
Fluoride	mg/L	1.5	Natural or deliberately added local or climatic conditions may necessitate adaptation
Hardness	—	No health-related guideline value set	
Lead	mg/L	0.05	
Mercury	mg/L	0.001	
Nickel	—	No guideline value set	
Nitrate	mg/L (N)	10	
Nitrite	—	No guideline value set	
Selenium	mg/L	0.01	
Silver	—	No guideline value set	
Sodium	—	No guideline value set	

ORGANIC CONSTITUENTS OF HEALTH SIGNIFICANCE

Constituent	Unit	Guideline Value	Remarks
Aldrin and dieldrin	μg/L	0.03	
Benzene	μg/L	10[a]	
Benzo[a]pyrene	μg/L	0.01[a]	
Carbon tetrachloride	μg/L	3[a]	Tentative guideline value[b]
Chlordane	μg/L	0.3	
Chlorobenzenes	μg/L	No health related guideline value set	Odor threshold concentration between 0.1 and 3 μg/L
Chloroform	μg/L	30[a]	Disinfection efficiency must not be compromised when controlling chloroform content
Chlorophenols	μg/L	No health-related guideline value set	Odor threshold concentration 0.1 μg/L
2,4-D	μg/L	100[c]	
DDT	μg/L	1	
1,2-Dichloroethane	μg/L	10[a]	
1,1-Dichloroethene[d]	μg/L	0.3[a]	
Heptachlor and heptachlor epoxide	μg/L	0.1	
Hexachlorobenzene	μg/L	0.01[a]	
Gamma-HCH (lindane)	μg/L	3	
Methoxychlor	μg/L	30	
Pentachlorophenol	μg/L	10	
Tetrachloroethene[d]	μg/L	10[a]	Tentative guideline value[b]
Trichloroethene[d]	μg/L	30[a]	Tentative guideline value[b]
2,4,6-Trichlorophenol	μg/L	10[a,c]	Odor threshold concentration, 0.1 μg/L
Trihalomethanes		No guideline value set	See chloroform

[a] These guideline values were computed from a conservative hypothetical mathematical model which cannot be experimentally verified and values should therefore be interpreted differently. Uncertainties involved may amount to two orders of magnitude (i.e., from 0.1 to 10 times the number).

[b] When the available carcinogenicity data did not support a guideline value, but the compounds were judged to be of importance in drinking-water and guidance was considered essential, a tentative guideline value was set on the basis of the available health-related data.

[c] May be detectable by taste and odor at lower concentrations

[d] These compounds were previously known as 1,1-dichloroethylene, tetrachloroethylene, and trichloroethylene, respectively

TABLE G.4 WORLD HEALTH ORGANIZATION GUIDELINES FOR DRINKING WATER QUALITY (continued)

AESTHETIC QUALITY

Constituent or Characteristic	Unit	Guideline Value	Remarks
Aluminium	mg/L	0.2	
Chloride	mg/L	250	
Chlorobenzenes and chlorophenols	—	No guideline value set	These compounds may affect taste and odor
Color	True color units (TCU)	15	
Copper	mg/L	1 0	
Detergents	—	No guideline value set	There should not be any foaming or taste and odor problems
Hardness	mg/L (as $CaCO_3$)	500	
Hydrogen sulfide	—	Not detectable by consumers	
Iron	mg/L	0.3	
Manganese	mg/L	0.1	
Oxygen—dissolved	—	No guideline value set	
pH	—	6.5–8 5	
Sodium	mg/L	200	
Solids—total dissolved	mg/L	1000	
Sulfate	mg/L	400	
Taste and odor	—	Inoffensive to most consumers	
Temperature	—	No guideline value set	
Turbidity	Nephelometric turbidity units (NTU)	5	Preferably <1 for disinfection efficiency
Zinc	mg/L	5.0	

RADIOACTIVE CONSTITUENTS

Constituent	Unit	Guideline Value	Remarks
Gross alpha activity	Bq/L	0 1	(a) If the levels are exceeded more detailed radionuclide analysis may be necessary (b) Higher levels do not necessarily imply that the water is unsuitable for human consumption
Gross beta activity	Bq/L	1	

Source World Health Organization, 1984, Guidelines for Drinking-Water Quality, Vol. 1, Recommendations

Van Der Leedn, Troise and Todd, 1990

TABLE G.5 GUIDES FOR EVALUATING THE QUALITY OF WATER FOR AQUATIC LIFE

Determination	Threshold Concentration*	
	Freshwater	Saltwater
Total dissolved solids (TDS), mg/liter	2000†	
Electrical conductivity µmhos/cm @ 25°C	3000†	
Temperature, maximum °C	34	34
Maximum for salmonoid fish	23	23
Range of pH	6 5–8 5	6 5–9 0
Dissolved oxygen (D.O), minimum mg/liter	5 0‡	5 0‡
Flotable oil and grease, mg/liter	0	0†
Emulsified oil and grease, mg/liter	10†	10†
Detergent, ABS, mg/liter	2 0	2 0
Ammonia (free), mg/liter	0.5†	
Arsenic, mg/liter	1 0†	1.0†
Barium, mg/liter	5 0†	
Cadmium, mg/liter	0 01†	
Carbon dioxide (free), mg/liter	1.0	
Chlorine (free), mg/liter	0.02	
Chromium, hexavalent, mg/liter	0 05†	0 05†
Copper, mg/liter	0 02†	0 02†
Cyanide, mg/liter	0 02†	0 02†
Fluoride, mg/liter	1 5†	1 5†
Lead, mg/liter	0 1†	0.1†
Mercury, mg/liter	0 01	0 01
Nickel, mg/liter	0 05†	
Phenolic compounds, as phenol, mg/liter	1.0	
Silver, mg/liter	0 01	0 01
Sulfide, dissolved, mg/liter	0.5†	0 5†
Zinc, mg/liter	0 1	

* Threshold concentration is value that normally might not be deleterious to fish life Waters that do not exceed these values should be suitable habitats for mixed fauna and flora

† Values not to be exceeded more than 20 percent of any 20 consecutive samples, nor in any 3 consecutive samples. Other values should never be exceeded Frequency of sampling should be specified

‡ Dissolved oxygen concentrations should not fall below 5.0 mg/liter more than 20 percent of the time and never below 2 0 mg/liter (Note. Recent data indicate also that rate of change of oxygen tension is an important factor, and that diurnal changes in D O may, in sewage-polluted water, render the value of 5 0 of questionable merit)

Source Calif State Water Quality Control Board, 1963

Van Der Leedn, Troise and Todd, 1990

TABLE G.6 OBSERVED LETHAL CONCENTRATION OF SELECTED CHEMICALS IN AQUATIC ENVIRONMENTS

Chemical	Organism Tested	Lethal Concentration, mg/L	Exposure Time, hr
ABS (100 percent)	Fathead minnow	3 5–4 5	96
ABS (100 percent)	Bluegills	4 2–4 4	96
Household syndets	Fathead minnow	39–61	96
Alkyl sulfate	Fathead minnow	5 1-5 9	96
LAS (C12)	Bluegill fingerlings	3	96
LAS (C14)	Bluegill fingerlings	0 6	96
Acetic acid	Goldfish	423	20
Alum	Goldfish	100	12-96
Ammonia	Goldfish	2-2 5 NH_3	24–96
Ammonia	Perch, roach, rainbow trout	3N	2-20
Sodium arsenite	Minnow	17 8 As	36
Sodium arsenate	Minnow	234 As	15
Barium chloride	Goldfish	5000	12-17
Barium chloride	Salmon	158	..
Cadmium chloride	Goldfish	0.017	9–18
Cadmium nitrate	Goldfish	0 3 Cd	190
CO_2	Various species	100–200	..
CO	Various species	1.5	1-10
Chloramine	Brown trout fry	0 06	.
Chlorine	Rainbow trout	0.03–0 08	...
Chromic acid	Goldfish	200	60–84
Copper sulfate	Stickleback	0 03 Cu	160
Copper nitrate	Stickleback	0 02 Cu	192
Cyanogen chloride	Goldfish	1	6–48
H_2S	Goldfish	10	96
HCl	Stickleback	pH 4 8	240
HCl	Goldfish	pH 4 0	4–6
Lead nitrate	Minnow, stickleback, brown trout	0.33 Pb	...
Mercuric chloride	Stickleback	0.01 Hg	204
Nickel nitrate	Stickleback	1 Ni	156
Nitric acid	Minnow	pH 5 0	...
Oxygen	Rainbow trout	3 cc/liter	..
Phenol	Rainbow trout	6	3
Phenol	Perch	9	1
Potassium chromate	Rainbow trout	75	60
Potassium cyanide	Rainbow trout	0 13 Cn	2
Sodium cyanide	Stickleback	1.04 Cn	2
Silver nitrate	Stickleback	70 K	154
Sodium fluoride	Goldfish	1000	60–102
Sodium sulfide	Brown trout	15	...
Zinc sulfate	Stickleback	0.3 Zn	120
Zinc sulfate	Rainbow trout	0.5	64
Pesticides			
1. Chlorinated hydrocarbons			
A Aldrin	Goldfish	0.028	96
DDT	Goldfish	0.027	96
DDT	Rainbow trout	0.5–0.32	24–36
DDT	Salmon	0.08	36
DDT	Brook trout	0.032	36
DDT	Minnow, guppy	0 75 ppb	29
DDT	Stoneflies (species)	0.32–1.8	96
BHC	Goldfish	2.3	96
BHC	Rainbow trout	3	96

TABLE G.6 OBSERVED LETHAL CONCENTRATION OF SELECTED CHEMICALS IN AQUATIC ENVIRONMENTS (continued)

Chemical	Organism Tested	Lethal Concentration, mg/L	Exposure Time, hr
Chlordane	Goldfish	0 082	96
Chlordane	Rainbow trout	0 5	24
Dieldrin	Goldfish	0 037	96
Dieldrin	Bluegill	0 008	96
Dieldrin	Rainbow trout	0 05	24
Endrin	Goldfish	0 0019	96
Endrin	Carp	0 14	48
Endrin	Fathead minnow	0 001	96
Endrin	Various species	0.03–0 05 ppb	...
Endrin	Stoneflies (species)	0.32–2 4 ppb	96
Heptachlor	Rainbow trout	0 25	24
Heptachlor	Goldfish	0.23	96
Heptachlor	Bluegill	0.019	96
Heptachlor	Redear sunfish	0.017	96
Methoxychlor	Rainbow trout	0.05	24
Methoxychlor	Goldfish	0.056	96
Toxaphene	Rainbow trout	0 05	24
Toxaphene	Goldfish	0.0056	96
Toxaphene	Carp	0 1	.
Toxaphene	Goldfish	0.2	24
Toxaphene	Goldfish	0 04	170
Toxaphene	Minnows	0 2	24
2 Organic phosphates			
Chlorothion	Fathead minnow	3 2	96
Dipterex	Fathead minnow	180	96
EPN	Fathead minnow	0 2	96
Guthion	Fathead minnow	0 093	96
Guthion	Bluegill	0.005	96
Malathion	Fathead minnow	12.5	96
Parathion	Fathead minnow	1 4–2.7	96
TEPP	Fathead minnow	1 7	96
3. Herbicides			
Weedex	Young roach and trench	40–80	1 month
Weeda Zol		15–30	1 month
Weeda Zol T L		20–40	1 month
Simazine (no plants present)	Minnow	0 5	< 3 days
Atrazine (A361) (plants present)	Minnow	5 0	24
Atrazine in Gesaprime	Minnow	3 75	24
4. Bactericides			
Algibiol	Minnow	20	24
Soricide tetramino'	Minnow	8	48

Source. McGauhey, Engineering Management of Water Quality, McGraw-Hill, copyright 1968

Van Der Leedn, Troise and Todd, 1990

Appendix H

DATA SHEETS OF SOIL AND WATER SAMPLING

CONTROL PARA MUESTRAS

DE AGUA

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 30 de Septiembre 1991.

LUGAR DE COLECCION: Río Cara Sucia Aguas Arriba

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.33
- ANCHURA (M) 16
- PROFUNDIDAD (M) 0.40

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 1

DESCRIPCION DEL LUGAR DE MUESTREO:

La topografía del lugar es irregular, el camino de acceso se vuelve bastante difícil en invierno. En la zona del muestreo existen caseríos dispersos. Los cultivos en su mayoría son cereales y además existen varios potreros donde pastorea el ganado de haciendas cercanas.
* El río despide malos olores.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 30 de Septiembre 1991.

LUGAR DE COLECCION: Río Cara Sucia Aguas Abajo

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 1.13
- ANCHURA (M) 15
- PROFUNDIDAD (M) 0.4

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 2

DESCRIPCION DEL LUGAR DE MUESTREO:

El río pasa por la población Cara Sucia. El río está contaminado por desechos orgánicos depositados(*) por los pobladores de la zona, así como también por productos químicos, ya que gran cantidad de personas llegan a lavar ropa al mismo.
* Basura y animales muertos. No existe acueducto de agua negras en la población de Cara Sucia.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 30 de Septiembre 1991

LUGAR DE COLECCION: Zanja La Danta

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.33
- ANCHURA (M) 7
- PROFUNDIDAD (M) 3

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 3

DESCRIPCION DEL LUGAR DE MUESTREO:

La muestra tomada en una zanja con abundante flora acuática y bastante pantanosa; aledaño a lugar de la muestra existen varios potreros donde pastorean ganado bovino. El cultivo más predominante en este lugar es caña de azúcar. El agua es bastante turbia.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 7 de Octubre 1991.

LUGAR DE COLECCION: Río Aguachapío Aguas Abajo

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.90
- ANCHURA (M) 9
- PROFUNDIDAD (M) 0.60

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 4

DESCRIPCION DEL LUGAR DE MUESTREO:

La topografía de la zona es plana; la muestra fue tomada a la orilla de la carretera, donde se observó que varias de las familias lavan ropa. El agua era bastante turbia debido a la intensidad de lluvia en estos días. Existen en la zona haciendas destinadas a la crianza de ganado y cultivos.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 9 de Octubre 1991

LUGAR DE COLECCION: Río Guayapa Aguas Abajo

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.5
- ANCHURA (M) 14.5
- PROFUNDIDAD (M) 0.5

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 5

DESCRIPCION DEL LUGAR DE MUESTREO:

En la zona aledaña al río se pudo observar cultivos de caña de azúcar y maíz. Varias de las familias de la zona lavan ropa en este río y además se depósita la basura en este lugar.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 9 de Octubre 1991

LUGAR DE COLECCION: Canal en Embarcadero de Guayapa

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO OTROS: Canal *

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.5
- ANCHURA (M) 16
- PROFUNDIDAD (M) 1.30

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 6

DESCRIPCION DEL LUGAR DE MUESTREO:

En la zona aledaña donde se tomó la muestra no se observaron cultivos, la única vegetación existente eran manglares. El agua era bastante turbia.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 11 de Septiembre 1991

LUGAR DE COLECCION: Río Cuilapa

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.07
- ANCHURA (M) 7.60
- PROFUNDIDAD (M) 0.25

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 7

DESCRIPCION DEL LUGAR DE MUESTREO:

En la zona aledaña al río se visualizan varios potreros en el que se pastorea el ganado y varias de las familias vecinas que crían ganado bovino lo llevan hasta el río a tomar agua. El color del agua es bastante turbia y segú se nos manifestó en los 2 últimos meses ha aumentado la cantidad de personas que llegan a lavar ropa, estos provienen de las zonas aledañas al río Cara Sucia.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sediméntos
Septiembre 1991

FECHA DE MUESTREO: 11 de Septiembre 1991.

LUGAR DE COLECCION: Río El Naranjo Aguas Abajo

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.42
- ANCHURA (M) 13.0
- PROFUNDIDAD (M) 0.35

SUELO _____ SEDIMENTO _____

NUMERO DE IDENTIFICACION DE LA MUESTRA: 8

DESCRIPCION DEL LUGAR DE MUESTREO:

En la zona aledaña al río existen varias familias que crían ganado bovino y otros crían ganado porcino a nivel familiar. El río está ubicado en medio de potreros. La mayoría de las personas cercanas al río se bañan y lavan ropa en el mismo.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 11 de Septiembre 1991

LUGAR DE COLECCION: Río El Rosario (Estación 9)

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.45
- ANCHURA (M) 16
- PROFUNDIDAD (M) 0.50

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 9

DESCRIPCION DEL LUGAR DE MUESTREO:

Los cultivos predominantes en la zona son: caña de azúcar, maíz, frijol y sorgo; varias de las familias aledañas a la zona se dedican a la crianza de ganado vacuno. La mayoría de las familias cercanas a la zona lavan ropa en el río, por lo que se deduce que este tiene un alto grado de contaminación por detergentes.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 11 de Septiembre 1991.

LUGAR DE COLECCION: San José El Naranjo (Río Naranjo Aguas Arriba)

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.45
- ANCHURA (M) 17.10
- PROFUNDIDAD (M) 0.34

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 10

DESCRIPCION DEL LUGAR DE MUESTREO:

La muestra fue tomada en las proximidades de la comunidad San Jose El Naranjo. En esta comunidad existen chorros públicos que abastecen a los pobladores y el servicio de agua lo proporciona PLANSABAR. Pero según vecinos de la comunidad toda la población va a lavar ropa al río. No existen tuberías de aguas negras y las letrinas son de fosa. Los pobladores en su mayoría se dedican a actividades agropecuarias: maíz, maicillo, ganado.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 7 de Octubre 1991.

LUGAR DE COLECCION: Río El Izcanal

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.62
- ANCHURA (M) 14
- PROFUNDIDAD (M) 0.30

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 11

DESCRIPCION DEL LUGAR DE MUESTREO:

La topografía de la zona es bastante irregular y las tierras son destinadas al cultivo de maíz y maicillo, además parte de estas tierras son potreros destinados al pastoreo de ganado. La zona está bastante despoblada.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 9 de Octubre 1991.

LUGAR DE COLECCION: Río Guayapa Aguas Arriba

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 1.1
- ANCHURA (M) 8
- PROFUNDIDAD (M) 0.4

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 13

DESCRIPCION DEL LUGAR DE MUESTREO:

La topografía de la zona era bastante irregular y los cultivos más predominantes son: maíz y maicillo.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 7 de Octubre 1991.

LUGAR DE COLECCION: Río Aguachapío Aguas Arriba

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.38
- ANCHURA (M) 1.5
- PROFUNDIDAD (M) 0.20

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 14

DESCRIPCION DEL LUGAR DE MUESTREO:

La topografía de la zona es bastante irregular y la muestra fue tomada en una zona con vegetación densa y sin cultivos.
La zona es bastante despoblada.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 17 de Septiembre 1991

LUGAR DE COLECCION: San Francisco Menéndez Aguas Arriba

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.34
- ANCHURA (M) 8.60
- PROFUNDIDAD (M) 0.30

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 15

DESCRIPCION DEL LUGAR DE MUESTREO:

Contaminación de lavado de ropa, cultivos cercanos de frijol, maíz para el consumo de los que viven en el caserío cercano.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 19 de Septiembre 1991.

LUGAR DE COLECCION: Zanjón Madre Vieja

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO Agua retenida

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M) 4
- PROFUNDIDAD (M) 1.5

SUELO _____ SEDIMENTO _____

NUMERO DE IDENTIFICACION DE LA MUESTRA: 16

DESCRIPCION DEL LUGAR DE MUESTREO:

La muestra se tomó en una especie de pantano que contenía agua retenida y con mal olor. La vegetación con flora acuática era abundante en el lugar de muestreo. Anteriormente este zanjón era destinado al cultivo de peces de agua dulce.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 19 de Septiembre 1991

LUGAR DE COLECCION: Zanjón Aguachapío (El Zapote)

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.45
- ANCHURA (M) 25
- PROFUNDIDAD (M) 4 (El dato de la profundidad se sacó por entrevistas de los pobladores vecinos del lugar

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 17

DESCRIPCION DEL LUGAR DE MUESTREO:

La zona donde se tomó la muestra es bastante poblada y hay presencia de diversos cultivos como: ajonjolí, maíz, etc. Además esta es una zona rodeada de manglares.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 17 de Septiembre 1991

LUGAR DE COLECCION: Río La Palma

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.1
- ANCHURA (M) 9.80
- PROFUNDIDAD (M) 0.40

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 18

DESCRIPCION DEL LUGAR DE MUESTREO:

Contaminación de ganado, arriba del río, cabras alrededor y también contaminación de detergentes.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 30 de Septiembre 1991.

LUGAR DE COLECCION: Pozo en Hacienda Cara Sucia

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO *

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M) 9

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 19

DESCRIPCION DEL LUGAR DE MUESTREO:

Esta hacienda está ubicada sobre la carretera que de Cara Sucia conduce a la Playa Garita Palmera. El pozo muestreado tiene una profundidad de 9 mts y el agua es extraída con bomba. La topografía del lugar es plana y se cultiva ajonjolí en las cercanías del pozo. Nivel de la superficie 9 mts.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 19 de Septiembre 1991.

LUGAR DE COLECCION: Pozo cerca del canal de descarga geotérmica

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO *

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M) 3.5

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 20

DESCRIPCION DEL LUGAR DE MUESTREO:

La topografía de la zona es plana y los cultivos predominantes en la zona son: caña de azúcar, ajonjolí, maíz, frijol, banano.
La muestra fue tomada en un pozo artesanal (familiar a la orilla del canal

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 9 de Octubre 1991

LUGAR DE COLECCION: Pozo en Guayapa Abajo

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO *

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M) 9

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 21

DESCRIPCION DEL LUGAR DE MUESTREO:

La muestra se tomó en el Caserío Guayapa Abajo; el pozo está ubicado a la orilla de un paredón sobre la carretera, el color del agua era turbio.
Nivel de la superficie: 9 mts.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 19 de Septiembre 1991.

LUGAR DE COLECCION: Pozo en Hacienda La Danta

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO *

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M) 5

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 22

DESCRIPCION DEL LUGAR DE MUESTREO:

La topografía de la zona es plana y los cultivos predominantes son: maíz, frijol, banano, caña de azúcar, etc. y además hay ganado lechero en la zona donde se tomó la muestra.
El pozo es artesanal y el agua se sacó con bomba, y esta es utilizada para el ganado.
* Nivel de la superficie 5 mts.
* El pozo sólo se usa para el ganado debido al sabor salobre del agua.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 30 de Septiembre 1991.

LUGAR DE COLECCION: Pozo en Población Cara Sucia

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO *

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M) 5 mts *

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 23

DESCRIPCION DEL LUGAR DE MUESTREO:

* El nivel de la superficie del agua 5mts.
El pozo muestreado es de tipo artesanal y el agua se usa para consumo familiar.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 11 de Septiembre 1991

LUGAR DE COLECCION: San José El Naranjo

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO *

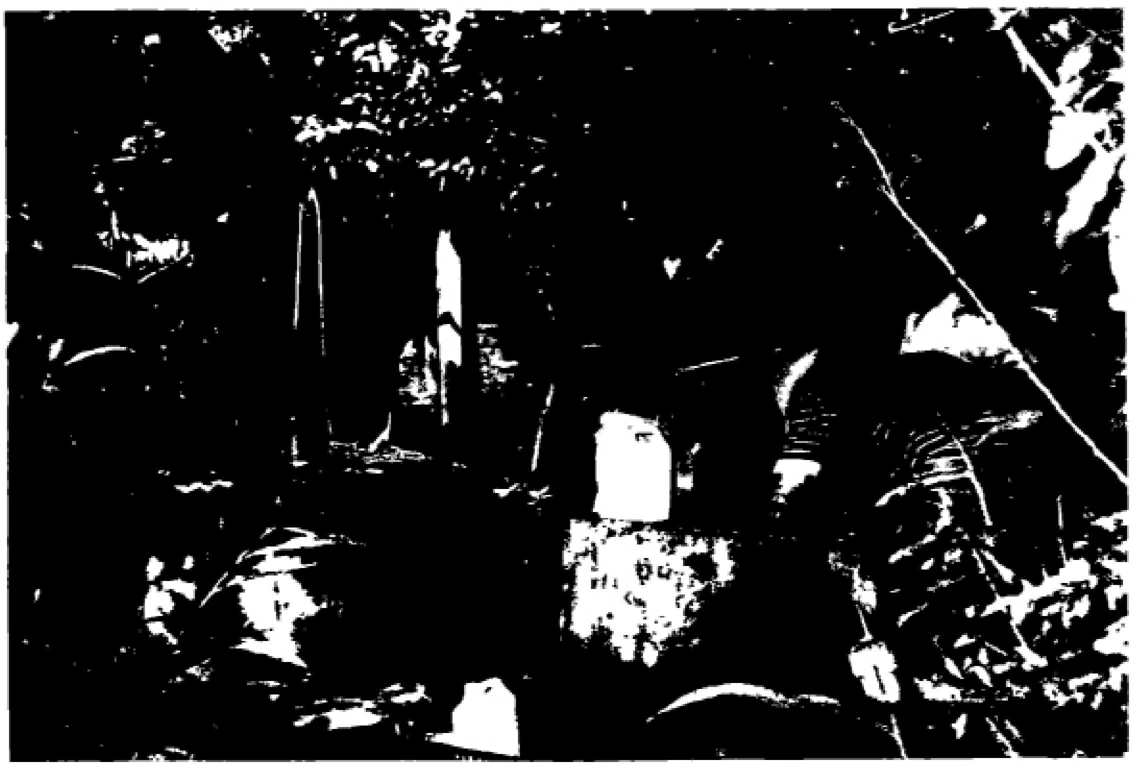
PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M) 10

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 24

DESCRIPCION DEL LUGAR DE MUESTREO:

La muestra de agua se tomó en un pozo ubicado dentro de la comunidad El Naranjo. La topografía de la zona es bastante irregular pero el monto freático es superficial según se pudo visualizar.



PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 17 de Septiembre 1991

LUGAR DE COLECCION: Hacienda Santa Rita

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO *

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M) 5

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 25

DESCRIPCION DEL LUGAR DE MUESTREO:

Cultivos cercanos de cereales, como a 50 mts alrededor, crianza de ganado porcino, medio de sacar el agua: por bomba.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 17 de Septiembre 1991

LUGAR DE COLECCION: San Antonio (Achiotal)

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO *

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M) 2.60

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 26

DESCRIPCION DEL LUGAR DE MUESTREO:

* Nivel de la superficie 2.60 mts.
Crianza de ganado alrededor del pozo y cultivos aledaños de cereales. Potreros. Uso de bomba para sacar el agua.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sediméntos
Septiembre 1991

FECHA DE MUESTREO: 7 de Octubre 1991.

LUGAR DE COLECCION: Pozo en Hacienda El Camalote

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO *

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M) 12

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 27

DESCRIPCION DEL LUGAR DE MUESTREO:

El pozo está ubicado en la Hacienda El Camalote, en medio de varias galeras destinadas a la crianza de gallinas ponedoras; además en los alrededores de esta hacienda hay establos para ganado y porquerizas.
Los cultivos predominantes en la zona son caña de azúcar y cereales. Nivel de la superficie: 12 mts.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 7 de Octubre 1991.

LUGAR DE COLECCION: Río Izcanal

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO * POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG) 0.45
- ANCHURA (M) 6
- PROFUNDIDAD (M) 0.60

SUELO _____ SEDIMENTO _____

NUMERO DE IDENTIFICACION DE LA MUESTRA: 28

DESCRIPCION DEL LUGAR DE MUESTREO:

La muestra original del mapa indica el muestreo de un pozo ubicado en Hacienda Izcanal, el cual se nos dijo está soterrado por las fuertes lluvias de los últimos días, motivo por el cual se muestreó el Río Izcanal.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sediméntos
Septiembre 1991

FECHA DE MUESTREO: 19 de Septiembre 1991.

LUGAR DE COLECCION: Pozo en El Porvenir

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO *

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M) 3.5

SUELO _____ SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: 29

DESCRIPCION DEL LUGAR DE MUESTREO:

La muestra se tomó en un pozo artesanal en el caserío El Porvenir este caserío es de tipo disperso y las letrinas existentes son de fosa. Los cultivos predominantes son maíz, frijol, ajonjolí, etc. La topografía de la zona es plana.
Nivel de la superficie 3.5 mts.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 9 de Octubre 1991

LUGAR DE COLECCION: Pozo en Embarcadero de Guayapa

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO *

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M) 4

SUELO _____ SEDIMENTO _____

NUMERO DE IDENTIFICACION DE LA MUESTRA: 30

DESCRIPCION DEL LUGAR DE MUESTREO:

La muestra se tomó en un pozo artesanal; la vegetación existente eran manglares y a pocos metros está el cementerio en medio de un caserío.
Nivel de la superficie: 4 mts.

CONTROL PARA MUESTRAS

DE SUELO

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 11 de Septiembre de 1991

LUGAR DE COLECCION: Camino Río El Rosario

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M)

SUELO * **SEDIMENTO** ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: S-1

DESCRIPCION DEL LUGAR DE MUESTREO:

Cultivo predominante maíz y caña, animales de crianza: aves, cerdos. Topografía regular. Suelo franco arenoso.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 11 de Septiembre de 1991

LUGAR DE COLECCION: Camino San José El Naranjo

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M)

SUELO * SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: S-2

DESCRIPCION DEL LUGAR DE MUESTREO:

Cultivos de cereales alrededor y potreros. Topografía irregular, suelo arenoso. Tierras agrícolas con uso de fertilizantes.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sediméntos
Septiembre 1991

FECHA DE MUESTREO: 11 de Septiembre de 1991

LUGAR DE COLECCION: Camino Río Cuilapa

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M)

SUELO * SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: S-3

DESCRIPCION DEL LUGAR DE MUESTREO:

Cultivo de platano, suelo. Topografía plana y caserío alrededor con crianza de animales, suelo con mucha materia orgánica. Suelo arcilloso-limoso.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 13 de Septiembre de 1991

LUGAR DE COLECCION: Camino Lomas de Guayapa

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M)

SUELO * SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: S-4

DESCRIPCION DEL LUGAR DE MUESTREO:

Actividades agrícolas, cultivos que utilizan pesticidas y fertilizantes. Topografía irregular. Suelo arcilloso-arenoso.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 13 de Septiembre de 1991

LUGAR DE COLECCION: Camino Río de Faya

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M)

SUELO * **SEDIMENTO** ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: S-5

DESCRIPCION DEL LUGAR DE MUESTREO:

Cultivos agrícolas como caña de azúcar y ajonjolí. topografía plana. Suelo arcilloso-arenoso muy orgánico.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 13 de Septiembre de 1991

LUGAR DE COLECCION: Hacienda El Camalote

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M)

SUELO * SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: S-6

DESCRIPCION DEL LUGAR DE MUESTREO:

Potreros, topografía poco irregular, donde pastorea el ganado. Suelo arcilloso.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 13 de Septiembre de 1991

LUGAR DE COLECCION: Zanjón El Chino

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M)

SUELO * SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: S-7

DESCRIPCION DEL LUGAR DE MUESTREO:

Tierras agrícolas cultivables con caña de azúcar. Terrenos muy humedos, suelo arcilloso orgánico, con topografía regular. Fuente de contaminación plaguicidas.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 13 de Septiembre de 1991

LUGAR DE COLECCION: Tubería La Cabaña

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M)

SUELO * SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: S-8

DESCRIPCION DEL LUGAR DE MUESTREO:

Tierras con presencia de inundación, topografía irregular, con zonas pantanosas alrededor. Suelo arcilloso, con presencia de ganado.

PROYECTO WASH-AID
265 Tas
Hoja de control para Muestras de Agua, Suelo y Sedimentos
Septiembre 1991

FECHA DE MUESTREO: 13 de Septiembre de 1991

LUGAR DE COLECCION: Santa Teresa

NOMBRE DEL COLECTOR: José Mario Vásquez

TIPO DE AGUA: RIO POZO

PARA RIOS:
- VELOCIDAD DE CORRIENTE (M/SEG)
- ANCHURA (M)
- PROFUNDIDAD (M)

SUELO * SEDIMENTO ______

NUMERO DE IDENTIFICACION DE LA MUESTRA: S-9

DESCRIPCION DEL LUGAR DE MUESTREO:

Tierras agrícolas, cultivos de maíz, maicillo y ajonjolí. Topografía plana, suelo arcilloso orgánico.

Appendix I

SAMPLING SITES DESCRIPTION FOR SEDIMENTS AND AQUATIC ORGANISMS

CONSIDERACIONES GENERALES SOBRE ALGUNOS ASPECTOS ECOLOGICOS DE LOS SITIOS DONDE SE COLECTARON LAS MUESTRAS.

En los sitios 1, 2 y 5 no se presenta mayor información, debido a que sus características son similares a las de los sitios 2 y 3.

SAN LUIS LA HERRADURA.

Se encuentra ubicada en el Estero de Jaltepeque, entre los ríos Jiboa y Lempa. El Estero cuenta con una longitud de 15 Km. Su anchura oscila entre 300 y 100 m. Las profundidades son de 1.5-5 m. bajo el nivel medio del mar. En el canal principal del Estero hay 7 islas grandes. De los canales laterales se distinguen 3 mas grandes cuyas anchuras oscilan entre 30 y 100 m. Todos los canales se orlan de manglares densamente cerrados, manifestándose perceptiblemente la influencia tidal. Existen además varios canales angostos que se internan en tierra firme hasta pequeños riachuelos del litoral llano.

La vigilancia del manglar de las zonas del paisaje del Estero de Jaltepeque, está caracterizada sobre todo por las especies Rhizophora mangle (mangle colorado), laguncularia racemosa (cincahuite) y Avecennia nitida (istatén), que se encuentran en substratos fangosos, arenosos fangoso y raras veces sobre los arenosos.

La distribución media de la salinidad oscila con el cambio de las estaciones del año, y por medio del suministro de agua dulce, habiéndose encontrado valores de 2 o/oo en el rincón íntimo del estero y de 33 °/oo en la bocana. La temperatura del agua oscila entre 25°C y 32°C.

PUERTO EL TRIUNFO

Municipio del distrito y Departamento de Usulután, ubicado en el Estero de Jiquilisco entre los ríos Lempa y Grande de San Miguel. El Estero cuenta con una longitud de 55 Km. de largo. Su anchura 1 Km. y más de 10 m. de profundidad.

El canal principal, como los laterales están orlados de paisaje de manglar, limitados hacia la planicie costera aluvial, suevemente ascendente.

Las condiciònes de vegetación del Estero de Jiquilisco, son las mismas del Estero de Jaltepeque.

Antes de la década de los años 80, las tierras adyacentes al estero eran asignadas al Cultivo del Algodón, en dicha actividad agrícola durante los meses de agosto a octubre practicaban la irrigación de insecticidas lo que ocasionaba mortalidad de organismos hidrobiológicos, pero en la década de los 80, esta actividad disminuyó, y el efecto mencionado se observa que ha disminuído

PUERTO PARADA

Caserío del Cantón Las Salinas, municipio y departamento de Usulután.

Las características psicológicas de este lugar son similares a las que posee Puerto El Triunfo, por encontrars en la misma Bahía.

BARRA DE SANTIAGO

Pertenece al Cantón y Cacerío del mismo nombre, jurisdicción del Municipio de Jujutla, Departamento de Sonsonate. Se caracteriza por ser una planicie de aluvión con una costa llana de playa ancha de arena, donde a lo largo desembocan tres pequeños ríos, terminando cerca de Acajutla.

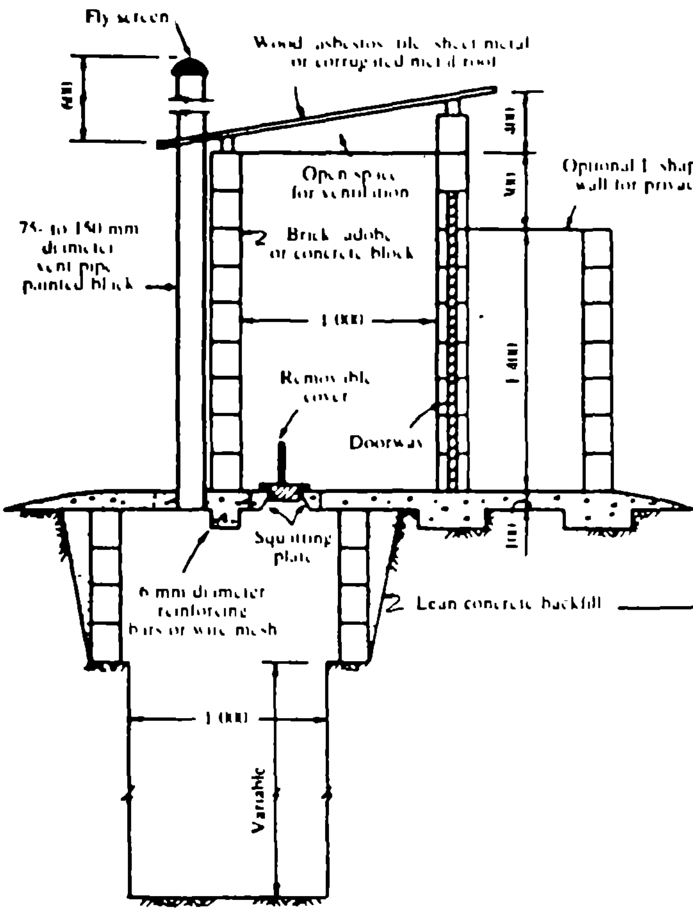
BARRA SALADA

Se encuentra ubicada en el Cantón Salinas de Ayacachapa, jurisdicción del Municipio y Departamento de Sonsonate. Barra Salada es considerada la única salina de El Salvador, que se ubica inmediatamente al mar.

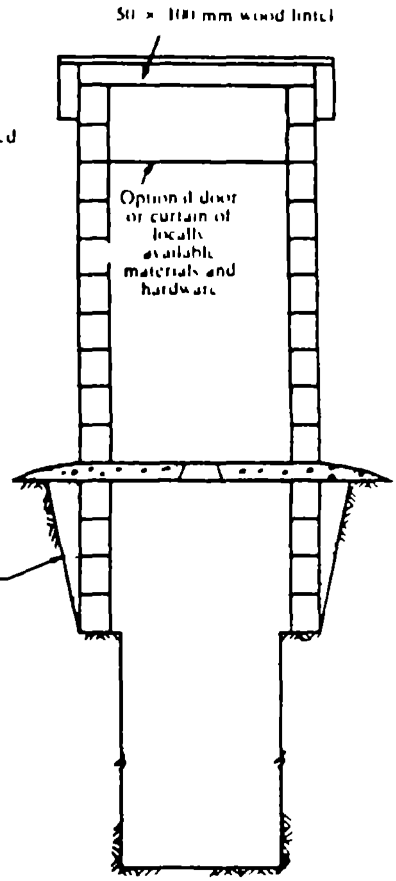
Appendix J

LATRINE DESIGNS

. *VIP Latrine*
(millimeters)

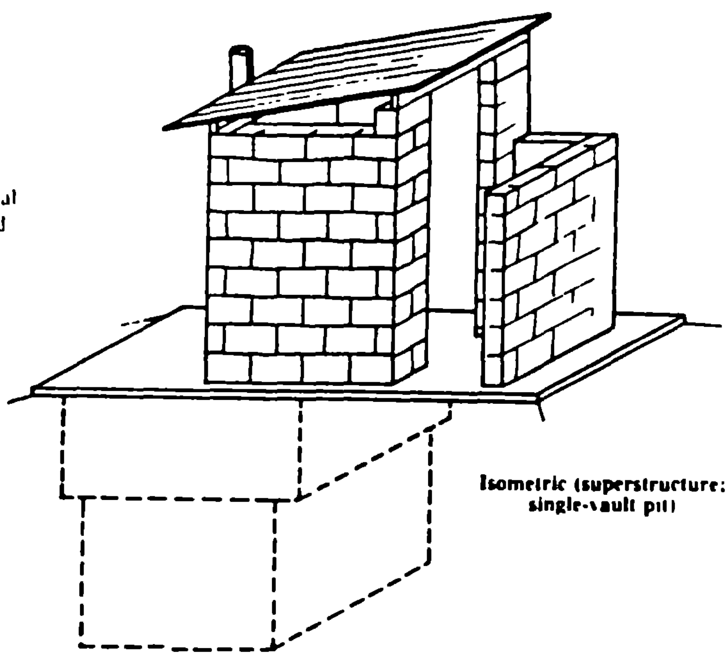


Side view (section)



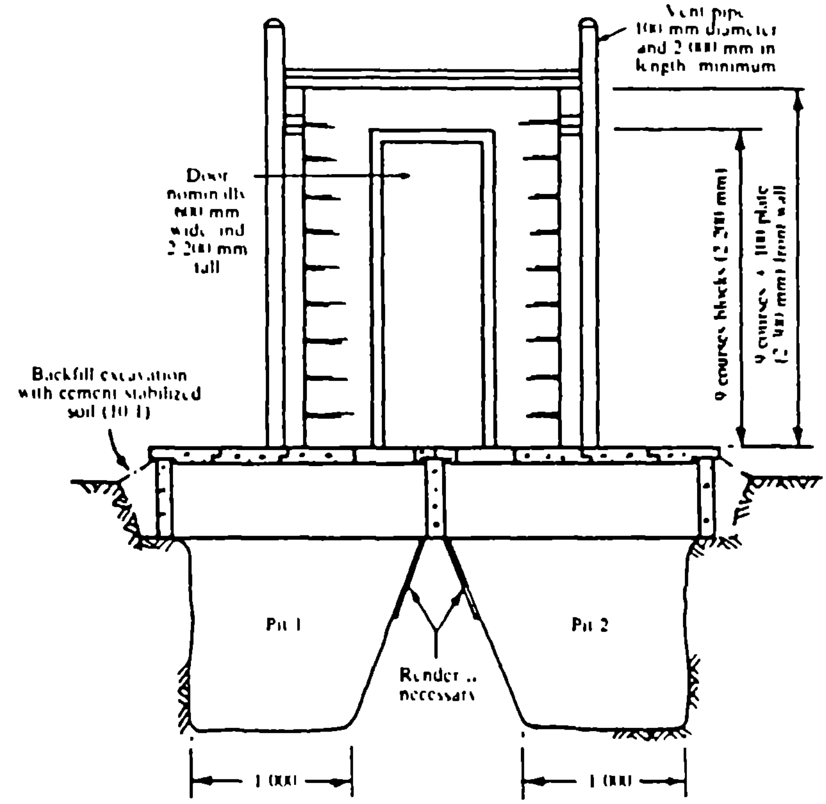
Front view (superstructure: L-shaped wall and vent not shown)

Note In the side view, a pedestal seat or bench may be substituted for the squatting plate. An opening for desludging may be provided next to the vent. Dimensions of the bricks or concrete blocks may vary according to local practice. Wooden beams, flooring, and siding may be substituted for concrete block walls and substructure.

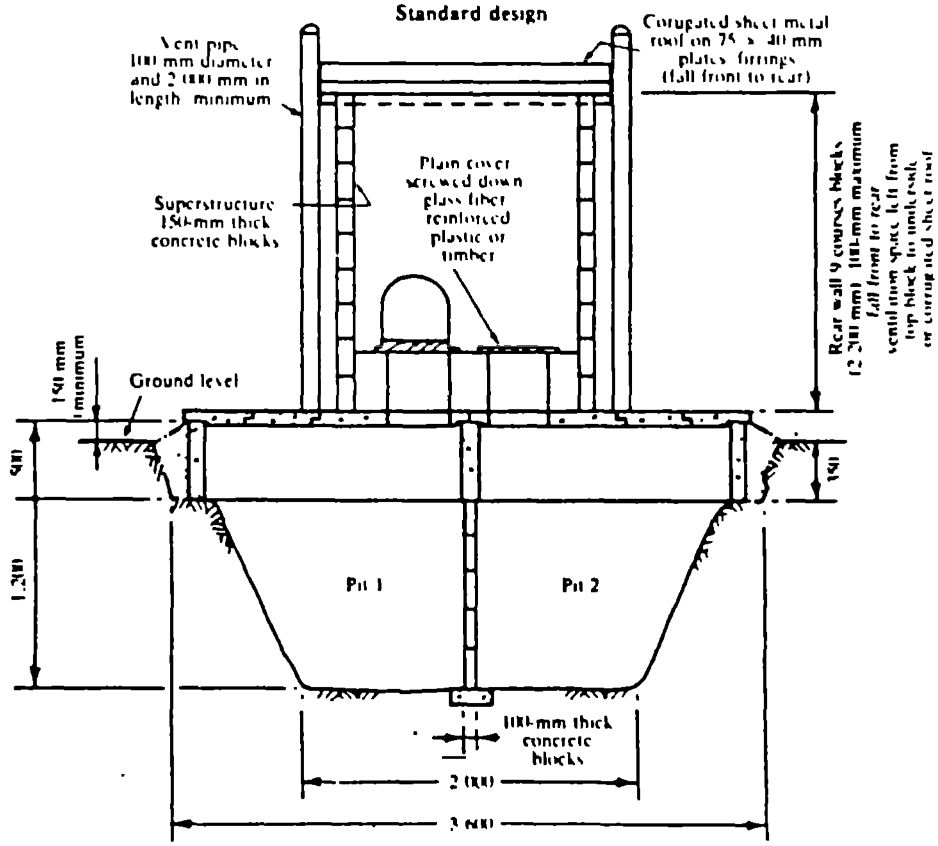


Isometric (superstructure: single-vault pit)

VIPD Latrine



Standard design

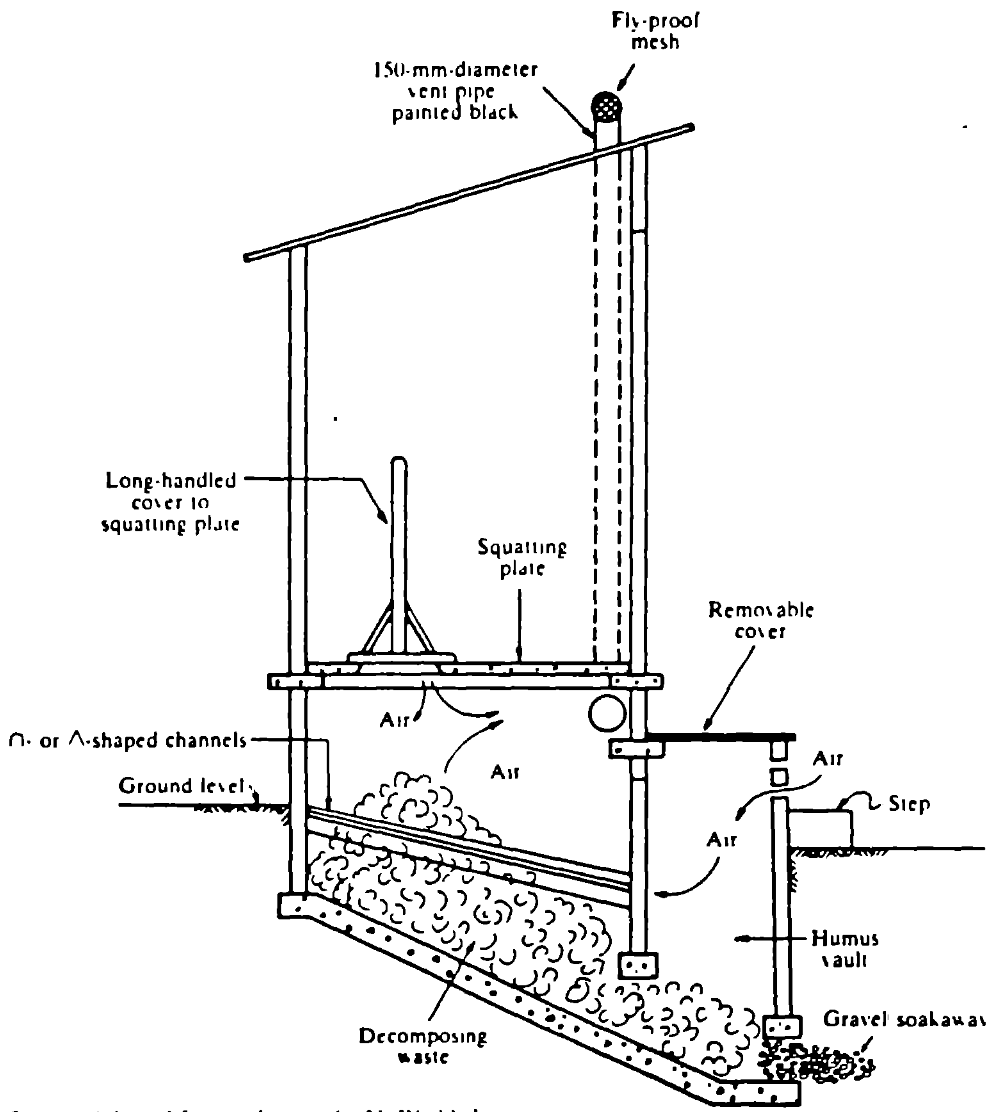


Optional design

Source Adapted from a drawing by R Carroll

"Multrum" Continuous-composting Toilet

(millimeters)



Source Adapted from a drawing by U Winblad

The Environmental Health Project (EHP) provides technical assistance to USAID missions and bureaus and other development organizations in nine areas: tropical diseases, water and sanitation, wastewater, solid waste, air pollution, hazardous waste, food hygiene, occupational health, and injury. It is part of the Office of Health and Nutrition's response to requests from USAID missions and bureaus for an integrated approach to addressing environment-related health problems. In addition to EHP, this effort includes an Environmental Health Requirements Contract and a PASA (Participating Agency Support Agreement) with the U.S. Centers for Disease Control and Prevention. A wide range of expertise is made available by EHP through a consortium of specialized organizations (see list below). In addition to reports on its technical assistance, EHP publishes guidelines, concept papers, lessons learned documents, and capsule reports on topics of vital interest to the environmental health sector. For information on the reports available, contact EHP headquarters.

ENVIRONMENTAL HEALTH PROJECT