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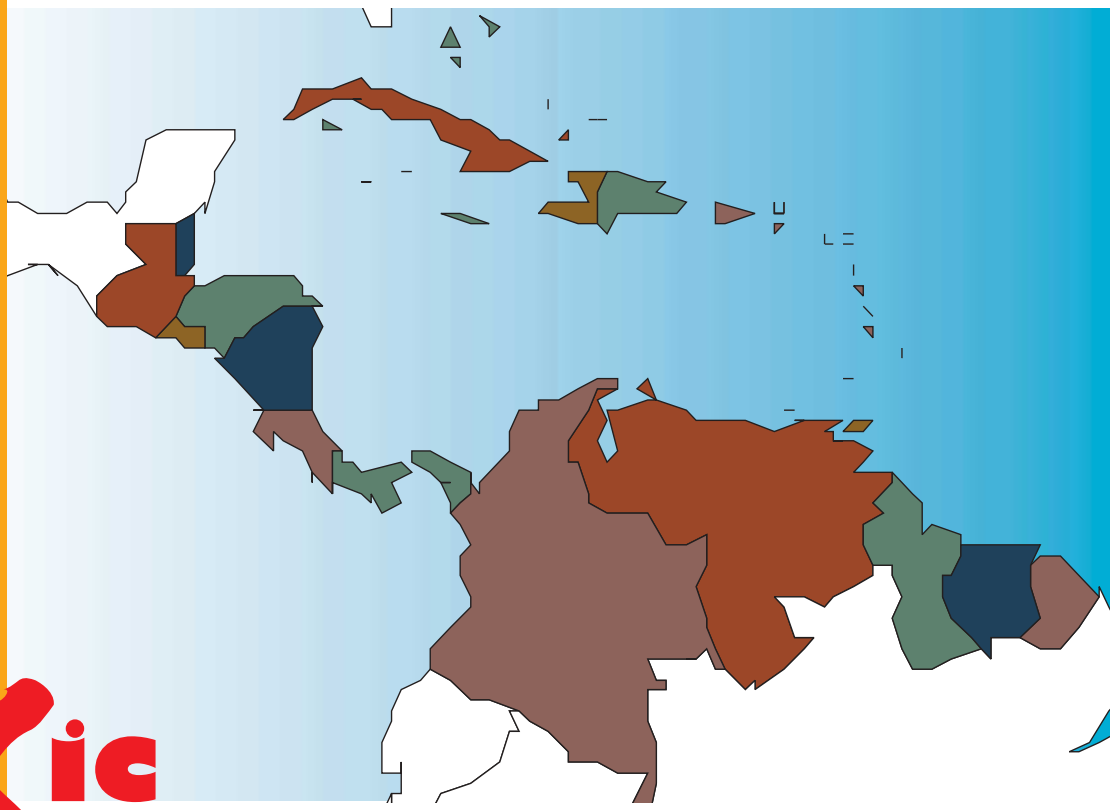

Regionally Based Assessment of Persistent Toxic Substances

December 2002

Global Environment Facility

UNITED NATIONS
ENVIRONMENT PROGRAMME

CHEMICALS

UNEP

Regionally Based Assessment of Persistent Toxic Substances

Antigua and Barbuda, Bahamas, Barbados, Belize, Bermuda, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Panama, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Venezuela

CENTRAL AMERICA AND THE CARIBBEAN REGIONAL REPORT

DECEMBER 2002

GLOBAL ENVIRONMENT FACILITY

This report was financed by the Global Environment Facility (GEF) through a global project with co-financing from the Governments of Australia, France, Sweden, Switzerland and the United States of America.

This publication is produced within the framework of the Inter-Organization Programme for the Sound Management of Chemicals (IOMC).

The Inter-Organization Programme for the Sound Management of Chemicals (IOMC), was established in 1995 by UNEP, ILO, FAO, WHO, UNIDO and OECD (Participating Organizations), following recommendations made by the 1992 UN Conference on Environment and Development to strengthen cooperation and increase coordination in the field of chemical safety. In January 1998, UNITAR formally joined the IOMC as a Participating Organization. The purpose of the IOMC is to promote coordination of the policies and activities pursued by the Participating Organizations, jointly or separately, to achieve the sound management of chemicals in relation to human health and the environment.

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PREFACE

In 2000, The United Nations Environmental Program asked IRET/CSUCA to participate in a global assessment of PTS, in particular to produce a report on PTS in the Central American and Caribbean Region. This document is intended to meet that request. The report is one of twelve, which make up the global assessment.

The report for the Central American and Caribbean Region (Region X) component of the UNEP Global Environmental Facility project entitled *Regionally Based Assessment of Persistent Toxic Substances (PTSs)* includes 23 countries (Antigua and Barbuda, Bahamas, Barbados, Belize, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Panama, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago and Venezuela), and 136 million inhabitants.

The preparation of this report has relied on data gathering of published material, preparation of country reports by regional experts, presentation and discussion of these reports at Technical Workshops and a final review and discussion at a three-day Regional Priority Setting Meeting held in Heredia, Costa Rica from October 30 to November 1, 2002.

The regional coordinator for this study was Prof. Dr. Luisa Eugenia Castillo (IRET/CSUCA, Heredia Costa Rica). The production of this report was possible through the co-operation of the regional team and regional experts who produced country reports. The overview of the project included in Chapter 1 was prepared by Mr. Paul Whylie. Chapter 2 was prepared by Luisa E. Castillo, Roosebelt Gonzalez and Joth Singh. Chapter 3 was prepared by Luisa Eugenia Castillo, Oscar Nieto and Clemens Ruepert. Chapter 4 was prepared by Gonzalo Dierksmeier, Jaime Espinoza and Luisa Eugenia Castillo; Chapter 5 by the members of the Regional Team. Chapter 6 was produced by the regional team and participants at the priority setting workshop. The authors are grateful to Region IV for providing the standard set of definitions of the chemicals. In addition, the drafts of UNEP Region II and III provided a useful guide. Mr. Timo Partanen is acknowledged for his significant contribution to the edition of this report.

EXECUTIVE SUMMARY

This is the report for the Central American and the Caribbean Region (Region X) component of the UNEP Global Environmental Facility project entitled *Regionally Based Assessment of Persistent Toxic Substances (PTSs)*. Region X incorporates 23 countries and 136 million inhabitants in the Greater Antilles, the eastern and southern islands of the Lesser Antilles, the Bahamas, Belize, Colombia, Costa Rica, El Salvador, Guatemala, Guyana, Honduras, Nicaragua, Panama, Suriname, and Venezuela. Within the often severe constraints of available data, the project identified major regional sources of PTSs; summarized the evidence on their impact on environment and on human health; assessed their transboundary transport; explored the sources of PTS-related problems; evaluated the regional capacity for the containment and abatement of PTSs; identified regional priorities for PTS-related environmental and health issues; and contributed to the identification of global priorities related to PTSs. The regional component addressed the 12 persistent organic pollutants (POPs) defined by the Stockholm Convention on Persistent Organic Pollutants 2001: aldrin, endrin, dieldrin, chlordane, DDT, toxaphene, mirex, heptachlor, hexachlorobenzene (HCB), polychlorinated biphenyls (PCBs), polychlorinated dibenzodioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs). Atrazine, endosulfan, lindane, organic lead compounds, organic mercury compounds, octyl phenols, and nonyl phenols, organic tin compounds, pentachlorophenol, phthalates, polybrominated diphenyl ethers, polychlorinated phenols, polycyclic aromatic hydrocarbons (PAHs), short chain paraffins, were included as additional, regionally important compounds.

Data gaps in the Region for PTSs are considerable and necessitate reliable inventories of sources, monitoring of emission, transmission and deposition data; and surveillance of environmental and health effects. Sectoral distribution of production determines the use profile of PTSs in the Region, but part of the contaminant burden is likely to be transported from elsewhere. The predominant regional sources of PTSs are agriculture, energy, industry, waste management, and the marine sector. All the pesticides selected for the project have been applied in the Region in agriculture or vector control. In one or several Central American countries, atrazine, DDT, endosulfan, heptachlor, lindane, mirex, and pentachlorophenol are currently registered; endrin, hexachlorobenzene and toxaphene may be still in use; and aldrin, dieldrin, and lindane are probably no more in use. Polycyclic aromatic hydrocarbon compounds (PAHs) are generated and emitted in power generation; extraction and refining of crude oil; and in combustion engines, including traffic emissions. Polychlorinated biphenyls (PCBs) have been used in the 1950s and 1960s in transformers and capacitors. Sources of organic lead have been gasoline and batteries. Organic tin compounds are emitted from marine vessels, industrial discharges and other sources. Chlorinated paraffins are not produced in the Region but are imported in unknown quantities. Unknown, probably small amounts of nonyl phenol and octyl phenol are imported. Inadequate incineration of domestic, industrial and agricultural waste and combustion for land clearing are a potential source of PCDDs, PCDFs, HCH, and PAHs. Waste oil adds to the burden of PAH contamination. Incinerators are widely used for hospital wastes. Worn tires are burned as an energy source. Disposal of obsolete stocks of banned pesticides and other PTSs poses a problem. Data from Barbados, Trinidad and Tobago, and Jamaica suggest that PTSs may be transported to the Region from elsewhere in the air mass of the Northeast Trade Winds.

Regional evidence of PTSs in air, marine, freshwater and terrestrial ecosystems, foods, and human biological samples is scattered across time periods, locations, and methods. An overall picture is difficult to make because of incomparability between surveys and lack of monitoring and surveillance programs. Chlorinated hydrocarbon pesticides and PCBs have been detected in atmospheric, marine freshwater, groundwater, sediment, soil, food and biota samples, including human blood and milk. The incidence of *acute pesticide poisonings* in humans is high in Central America. The causal agents vary according to use patterns and toxicity. Regional data suggest neurobehavioral deterioration following exposure to DDT and an association between breast cancer and DDE.

The Region lacks data on environmental concentrations of a number of pollutants. In particular, flow data are nonexistent. The Caribbean coast is a critical region. A dense tanker traffic and offshore oil exploration contribute to the hydrocarbon contamination. Rivers transport high quantities of pesticides to the seawater. Combustion of leaded gasoline, diesel and other fuels and wastes, and aerial spraying of pesticides release

contaminants directly to the atmosphere. No regional data are available on groundwater transport of PTSs. Cetaceans, migratory birds, fish and plankton are releasers and receptors of PTSs.

Monitoring capacity of PTSs across the Region varies between countries. In particular, there are no facilities in the Region for routine monitoring of dioxins and furans. Internationally recognized, accredited reference laboratories are few. A few Central American countries are equipped with national laboratory accreditation bodies.

Legislation and regulation of import, export, transport, use, production, emission, storage and disposal of PTSs are deficient and scattered between and within countries of the Region. Pesticide regulation is ahead of regulation of other PTSs. Ratification of relevant international conventions and harmonization of legislation within the Region has taken place to some extent.

The following conclusions were reached for the reduction of the PTS load in the Region:

(1) Development of human resources.

Training of scientists, technicians, governmental policy makers, policy experts, administrators and managers at universities, in the public and private sectors and NGOs is necessary in risk assessment, alternative technologies, pest management, toxicology, epidemiology, environmental and industrial hygiene, ecotoxicology, environmental management, PTS analysis, and waste management in the containment of PTSs. Strengthening of the bonds among universities, national science and technology organizations, and other research and education institutions is a major goal. Participation of major stakeholders needs to be encouraged.

(2) Risk assessment and risk communication

Risk assessment of PTSs incorporates systematic monitoring and establishment of inventories of sources, emissions, transmission and contamination, surveillance of biological and environmental effects of PTSs, and hot spot studies of episodes of contamination or poisonings. Comprehensive PTS monitoring covers atmospheric and aquatic environments, soil, food, waste, and organisms, supported by an integrated infrastructure for regional and national monitoring systems and databases as a long-term goal.

Risk communication is necessary at all levels in the form of training, dissemination of information, information transfer to public agencies and regulators, the research community, private sector, investors, trade unions, communities, NGOs and the general public. Risk communication needs to cover also contamination control and cleaner and less toxic technologies for agriculture, industry, and waste management.

(3) Enhancement of laboratory capacity

Laboratory capacity needs improvement by way of updating equipment and analytical techniques for PTSs; setting up reference laboratories in the region; ensuring budgetary provisions for the necessary infrastructure and analytical functions; and supporting the upgrading of existing laboratories on QA/QC and accreditation processes.

(4) Enhancement of clean technologies

Priorities for clean technologies include application, appropriate modification and development of clean technologies and effluent and emission treatment for agriculture, industry, and waste management; safe disposal of waste oil and obsolete stocks of PTSs and transformers containing PCBs; containment of emissions from internal combustion engines; and enhancement of technology transfer.

(5) Regulatory development, enforcement and compliance

This is another area with a need for major improvements, including creation and harmonization of effective legal regulation and its implementation concerning import, export, transport, use, production, emission, storage and disposal of PTSs; ratification of relevant international conventions; harmonization within the Region and with international treaties and conventions; strengthening the weak inspection and enforcement infrastructure; definition and enforcement of allowable concentrations of PTSs in the environment and workplaces; legal framework for PTS monitoring; coordination between official agencies involved in PTS

management within the countries and within the Region; empowerment of the primary health care sector in prevention, diagnosis and treatment of adverse health effects of PTSs. Regional and national intersectoral coordination of administrative regulation and implementation is necessary.

1. INTRODUCTION

1.1. OVERVIEW OF THE PROJECT

Following the recommendations of the Intergovernmental Forum on Chemical Safety, the UNEP Governing Council decided in February 1997 (Decision 19/13 C) that immediate international action should be initiated to protect human health and the environment through measures which will reduce and/or eliminate the emissions and discharges of an initial set of twelve persistent organic pollutants (POPs). Accordingly an Intergovernmental Negotiating Committee (INC) was established with a mandate to prepare an international legally binding instrument for implementing international action on certain persistent organic pollutants. These series of negotiations have resulted in the adoption of the Stockholm Convention in 2001. The initial 12 substances fitting these categories that have been selected under the Stockholm Convention include: aldrin, endrin, dieldrin, chlordane, DDT, toxaphene, mirex, heptachlor, hexachlorobenzene, PCBs, dioxins and furans. Beside these 12, there are many other substances that satisfy the criteria listed above for which their sources, environmental concentrations and effects are to be assessed.

Persistent toxic substances can be manufactured substances for use in various sectors of industry, pesticides, or by-products of industrial processes and combustion. To date, their scientific assessment has largely concentrated on specific local and/or regional environmental and health effects, in particular hot spots such as the Great Lakes region of North America or the Baltic Sea.

1.1.1. Objectives

There is a need for a scientifically based assessment of the nature and scale of the threats to the environment and its resources posed by persistent toxic substances that will provide guidance to the international community concerning the priorities for future remedial and preventive action. The assessment will lead to the identification of priorities for intervention, and through application of a root cause analysis will attempt to identify appropriate measures to control, reduce or eliminate releases of PTS, at national, regional or global levels.

The objective of the project is to deliver a measure of the nature and comparative severity of damage and threats posed at national, regional and ultimately at global levels by PTS. This will provide the GEF with a science-based rationale for assigning priorities for action among and between chemical related environmental issues, and to determine the extent to which differences in priority exist among regions.

1.1.2. Results

The project relies upon the collection and interpretation of existing data and information as the basis for the assessment. No research will be undertaken to generate primary data, but projections will be made to fill data/information gaps, and to predict threats to the environment. The proposed activities are designed to obtain the following expected

- Identification of major sources of PTS at the regional level
- Impact of PTS on the environment and human health
- Assessment of transboundary transport of PTS
- Assessment of the root causes and regional capacity to manage PTS problems
- Identification of regional priorities for PTS related environmental issues
- Identification of PTS related priority issues at the global level.

The outcome of the project will be an evidence-based assessment of the threats posed by persistent toxic substances to the environment and human health. The activities to be undertaken in this project comprise an evaluation of the sources of persistent toxic substances, their levels in the environment and consequent impact on biota and humans, their modes of transport over a range of distances, the existing alternatives to their use and remedial options, as well as the barriers that prevent their good management.

1.2. METHODS

1.2.1. World Regional Dvisions

For the purposes of this project, the world was divided into 12 Regions: Arctic; North America; Europe; Mediterranean; Sub-Saharan Africa; Indian Ocean; Central and Northeast Asia (Western North Pacific); Southeast Asia and South Pacific; Pacific Islands; Central America and the Caribbean; Eastern and Western South America; and Antarctica.

1.2.2. Project Management

The project is directed by the Project Manager situated at UNEP Chemicals in Geneva, Switzerland. A Steering Group comprising of representatives of other relevant intergovernmental organizations along with participation from the industry and the nongovernmental community monitors the progress of the project and provides direction for the project manager. Each region is controlled by a Regional Coordinator assisted by a Regional Team of 4 persons on the average. The Regional Coordinator and the Regional Team are responsible for the implementation the project, national data collection, and organizing a series of technical and priority setting workshops for the analysis of regional PTS data. In addition to the 12 POPs of the Stockholm Convention, the Regional Team selected further substances to be assessed for its region, the selection being open for review during the various workshops undertaken throughout the assessment process. Each Regional Team writes a Regional Report.

1.2.3. Data

Data on sources, environmental concentrations, and human and ecological effects were collected from all available sources. Presentations of regional experts at the technical workshops were used in the preparation of regional reports. Priority workshops with representatives from each country established regional priorities for PTS based on threats and damages in each Region. Information and conclusions derived from the 12 regional reports will then be used to develop a global report on the state of PTSs in the environment.

The project is not intended to generate new data but to rely on existing data for the setting of priorities. A broad network all sectors of society was established for data collection and subsequent evaluation. Close cooperation with other intergovernmental organizations such as UNECE, WHO, FAO, UNPD, World Bank was obtained. Most have representatives on the Steering Group Committee that monitors the progress of the project and critically reviews its implementation. Contributions were garnered from UNEP focal points, UNEP POPs focal points, national focal points selected by the Regional Teams, industry, government agencies, research scientists and NGOs.

1.2.4. Funding

The project costs amount approximately to US$ 4.2 million, funded mainly by the Global Environment Facility (GEF) with sponsorship from countries including Australia, France, Germany, Sweden, Switzerland and USA. The project was implemented between September 2000 and April 2003 with the intention that the reports are presented to the first meeting of the Conference of the Parties of the Stockholm Convention projected for 2003/4.

1.3. SCOPE OF THE REGIONAL ASSESSMENT

1.3.1. Introduction

For the purposes of the project, the Central American and Caribbean Region, denoted Region X, was defined as consisting of the Greater Antilles, the eastern and southern islands of the Lesser Antilles, the Bahamas, Belize, Colombia, Costa Rica, El Salvador, Guatemala, Guyana, Honduras, Nicaragua, Panama, Suriname, and Venezuela. Puerto Rico and Grenada were not included within this region.

The Region is made up of the long, tapering isthmus that forms a bridge between North and South America and includes the countries of Guatemala, Belize, El Salvador, Honduras, Nicaragua, Costa Rica and Panama; the Greater and Lesser Antilles, that extend in an arc from near southern Florida to the coast of Venezuela and forms a breakwater of 3200 km long against the Atlantic Ocean, separating it from the Caribbean Sea;

and four of the northern most countries in South America, all of which have a Caribbean influence (Colombia, Venezuela, Guyana and Suriname). The Region incorporates 23 countries, with an area of 3 190 000 sq. km and a population of 136 297 000 (Microsoft® Encarta® Online Encyclopedia 2001).

1.3.2. Scope of Central American Assessment

This is the first comprehensive Central American and Caribbean assessment on persistent toxic substances. The preparation of this report has relied on data gathering of published material, preparation of country reports by regional experts, presentation and discussion of these reports at Technical Workshops and a final review and discussion at a three-day Regional Priority Setting Meeting held in Heredia, Costa Rica from October 30 to November 1, 2002.

1.3.3. Interregional Links and Collaboration

The authors are grateful to Region IV for providing the standard set of definitions of the chemicals. In addition, the drafts of UNEP Region II and III provided a useful guide.

1.4. CLIMATE

In general, the climate in Region X is tropical. All countries, with the exception of the northern part of the Bahamas, lay between the Tropic of Cancer and the Equator. There is practically no real change in temperature during the year, although in the higher areas (above 900 m or 3000 ft) the climate is considered temperate. In the low areas (sea level to under 900 m or 3000 ft), the temperatures range from 22°C to 29°C in January and from 23 °C to 34°C in July. Highland temperatures drop to an average of 14°C – 23°C and below 0°C in the highest peaks (over 3000 m or 10000 ft) in Los Andes mountain range in Colombia and Venezuela. In the highlands of Guatemala, the temperature may drop to -10°C.

Rainy and dry seasons follow each other. Depending on the position of the country in relation with trade winds and on the location and topography, two patterns emerge: one with two rainy seasons and two dry seasons, each three months on average; and one with a long rainy season and a relatively short dry season. Precipitation varies by location and topography. In Central America, the Atlantic zone is considerably more humid than the Pacific region, the annual rainfall volume reaching in some areas 6500 mm (250 in). With the exception of Trinidad, the southern islands of the Lesser Antilles are shielded from the moist Atlantic air by the eastern islands of the Lesser Antilles and have hot, dry climates. Solar heat is moderated by the cool temperatures of the Atlantic Ocean and by the trade winds, which blow from the northeast throughout the year. These winds are strongest between January and April, bringing cooler temperatures and showers from far Atlantic. The weather is drier close to the ocean in the north of the South America, except in Suriname, where the southern part receives more precipitation. The Pacific side of Colombia is more humid than the Atlantic because of the barrier formed by the Andes mountain range.

1.5. POPULATION

The “mestizo” population (people of mixed heritage, usually Spanish and Native American) is the vast majority in this Region, though the ethnic composition of the national populations varies greatly. The current populations are a result of emigrants having arrived from Europe (Spanish, Dutch, English, French), slaves brought in from Africa, indentured workers from Asia (China, India, Indonesia), mestizos, “mulattoes” (mixture of Spanish and African) and in a small percentage, Native Americans that survived the Colonial period. The Central and South American countries have a mestizo majority, while the islands of the Caribbean are mostly of African descent. There are exceptional cases, such as Belize, where more than half of the population is of black African heritage, and Guyana and Suriname, where the most important ethnic group is of Indian descent.

1.6. ECONOMY

Agriculture was the basis of the economy of all the countries in the Region during a long time period. In Venezuela, Guyana and Suriname, mining gained considerable importance. Tourism has been the main economic activity since the 1970’s in a number of Caribbean islands. Nonetheless, most of the countries still

depend heavily on agriculture. After the second half of the 20th century, various governments made efforts to diversify production in order not to have to depend on only one or few products. Manufacturing industries have flourished in the Region during the last few decades.

Agriculture. Since the first years of colonization, the Region became gradually transformed from forest into farmland. Most of the export products that are cultivated today in large plantations such as sugarcane, coffee, bananas and citrus fruits are not indigenous. Indigenous crops such as sweet potatoes, cassava or manioc, beans, corn or maize and others, are for local consumption, planted by families in small plots all around the countryside and on hillsides where the slaves were offered land after the abolition.

Neither forestry nor fishing represents a major activity in the Region, except in Venezuela, Jamaica, Guyana and Suriname, where shrimp is an important product. In several countries firewood is still a significant source of energy for the rural population.

Mining. Jamaica and Guyana are major bauxite producers. Nickel, emeralds, platinum, gold, copper and diamonds are extracted. Colombia extracts one third of the world emeralds and has the largest platinum deposits. Central American countries are not known for their mineral production. Mining has stimulated mineral processing industries in a number of countries.

Manufacturing. Manufacturing industries the Region are diverse, including companies that refine agricultural products or extracted minerals, companies that are componens of a transnational assembly line, those that manufacture electronic devices, etc. Products manufactured in the Region either for local consumption or for export include foods, furniture, cement, glass, textiles, soap, paint, tires, paper and cardboard, fertilizers, insecticides, tobacco, iron and steel, aluminum and aluminum products, petroleum derivatives, and wood products.

Foreign Trade. United States is the principal trading partner of the Region. Other important partners are Canada, Mexico, and Western European and South American countries. Free Trade treaties between countries within and outside the region are common.

Organizations such as the Central American Common Market (CACM) and the Association of Caribbean States (ACS), both free-trade organizations, strive toward increasing economic integration and international trade. CACM was founded 1960 and included all Central American countries except Belize and Panama. A number of circumstances kept it from achieving its goal of trade liberalization and the establishment of a free-trade area. Today, Central American countries are facing new tariff barriers as the result of the Caribbean Basin Initiative (1984) and the North American Free Trade Agreement (NAFTA) (1994), these barriers preventing them from increasing global trading patterns.

The Caribbean Community (CARICOM) has also established the Caribbean Single Market and Economy (CSME) which enables the CARICOM Member States to coordinate trade and economic policy and positions. Formulation and coordination of trade and economic policy is the primary responsibility of the Council for Trade and Economic Development (COTED). Caribbean Free Trade Access (CARIFTA), provides trade leads and listings for businesses in the region. CARIFTA provides trade brokerage service to assist buyers and seller of products and services from the Caribbean.

1.7. GENERAL DEFINITIONS OF CHEMICALS

1.7.1. Introduction

The twelve Persistent Organic Pollutants (POPs) defined by the Stockholm Convention (2001) are included in this assessment. These are: aldrin, endrin, dieldrin, chlordane, DDT, heptachlor, mirex, toxaphene, hexachlorobenzene, PCBs, dioxins and furans. The UNEP assessment allows for adjustments to the list of chemicals to be reported in the regional reports, based on regional priorities and available data. In addition to the twelve substances selected under the Stockholm Convention, the following substances have been included in this assessment: atrazine, endosulfan, pentachlorophenol, polybrominated diphenyl ethers, lindane, organic mercury, organic lead, organic tin, polychlorinated phenols, polyaromatic hydrocarbons, short chain chlorinated paraffins, phthalates, and octyl and nonyl phenols.

1.7.2. Pesticides

1.7.2.1. Aldrin

Chemical Name: 1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-endo,exo-5,8-dimethanonaphthalene ($C_{12}H_8Cl_6$).

CAS Number: 309-00-2

Properties: Solubility in water: 27 µg/L at 25°C; vapor pressure: 2.3 x 10^{-5} mm Hg at 20°C; log K_{OW}: 5.17-7.4.

Discovery/Uses: Aldrin has been manufactured commercially since 1950 and used worldwide up to the early 1970s to control soil pests such as corn rootworm, wireworms, rice water weevil, and grasshoppers. It has also been used to protect wooden structures from termites.

Persistence/Fate: Readily metabolized to dieldrin by plants and animals. Biodegradation is slow. Aldrin binds strongly to soil particles and is resistant to leaching into groundwater. It was classified as moderately persistent with half-life in soil and surface waters ranging from 20 days to 1.6 years.

Toxicity: Aldrin is toxic to humans; the lethal dose for an adult has been estimated at about 80 mg/kg body weight. The acute oral LD_{50} in laboratory animals is in the range of 33 mg/kg body weight for guinea pigs to 320 mg/kg body weight for hamsters. The toxicity of aldrin to aquatic organisms is variable, with aquatic insects being the most sensitive group of invertebrates. The 96-h LC_{50} values range from 1-200 µg/L for insects, and from 2.2-53 µg/L for fish. The maximum residue limits in food recommended by FAO/WHO varies from 0.006 mg/kg milk fat to 0.2 mg/kg meat fat. Water quality criteria between 0.1 to 180 µg/L have been published. Aldrin is not classifiable as to its carcinogenicity to humans because of inadequate or limited data (IARC Group 3).

1.7.2.2. Dieldrin

Chemical Name: 1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydroexo-1,4-endo-5,8-dimethanonaphthalene ($C_{12}H_8Cl_6O$).

CAS Number: 60-57-1

Properties: Solubility in water: 140 µg/L at 20°C; vapor pressure: 1.78 x 10^{-7} mm Hg at 20°C; log K_{OW}: 3.69-6.2.**Discovery/Uses**: Dieldrin appeared in the market in 1948 and was used mainly for the control of soil insects such as corn rootworms, wireworms and catworms.

Persistence/Fate: Dieldrin is highly persistent in soils, with a half-life of 3-4 years in temperate climates. It bioconcentrates in organisms. The persistence in air has been estimated in 4-40 hrs.

Toxicity: The acute toxicity for fish is high (LC_{50} between 1.1 and 41 mg/L) and moderate for mammals (LD_{50} in mouse and rat ranging from 40 to 70 mg/kg body weight). However, a daily administration of 0.6 mg/kg to rabbits adversely affected the survival rate. Aldrin and dieldrin mainly affect the central nervous system but there is no direct evidence that they cause cancer in humans. The maximum residue limits in food

recommended by FAO/WHO varies from 0.006 mg/kg milk fat and 0.2 mg/kg poultry fat. Water quality criteria between 0.1 to 18 µg/L have been published. Dieldrin is not classifiable as to its carcinogenicity to humans because of inadequate or limited data (IARC Group 3).

1.7.2.3. Endrin

Chemical Name: 3,4,5,6,9,9-Hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-2,7:3,6-dimethanonaphth[2,3-b]oxirene ($C_{12}H_8Cl_6O$).

CAS Number: 72-20-8

Properties: Solubility in water: 220-260 µg/L at 25 °C; vapor pressure: 2.7 x 10^{-7} mm Hg at 25°C; log K_{OW}: 3.21-5.34**Discovery/Uses:** Endrin has been used since 1950s against a wide range of agricultural pests, mostly on cotton but also on rice, sugar cane, maize and other crops, and also as a rodenticide.

Persistence/Fate: Endrin is highly persistent in soil (half-lives of up to 12 years have been reported). Bioconcentration factors of 14 to 18,000 have been recorded in fish after continuous exposure.

Toxicity: Endrin is highly toxic to fish, aquatic invertebrates and phytoplankton; the LC_{50} values are mostly less than 1 µg/L. Acute toxicity is high in laboratory animals, with LD_{50} values of 3-43 mg/kg, and a dermal LD_{50} of 5-20 mg/kg in rats. Long-term toxicity in the rat has been studied over two years; a NOEL of 0.05 mg/kg bw/day was determined. Endrin is not classifiable as to its carcinogenicity to humans because of inadequate or limited data (IARC Group 3).

1.7.2.4. Chlordane

Chemical Name: 1,2,4,5,6,7,8,8-Octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methanoindene ($C_{10}H_6Cl_8$).

CAS Number: 57-74-9

Properties: Solubility in water: 56 µg/L at 25°C; vapor pressure: 0.98 x 10^{-5} mm Hg at 25 °C; log K_{OW}: 4.58-5.57.

Discovery/Uses: Chlordane appeared in the market in 1945 and was used primarily as an insecticide for control of cockroaches, ants, termites, and other household pests. Technical chlordane is a mixture of at least 120 compounds. Of these, 60-75% are chlordane isomers, the remainder being related to endo compounds including heptachlor, nonachlor, diels-alder adduct of cyclopentadiene and penta/hexa/octachlorocyclopentadienes.

Persistence/Fate: Chlordane is highly persistent in soils with a half-life of about 4 years. Its persistence and high partition coefficient promotes binding to aquatic sediments and bioconcentration in organisms.

Toxicity: LC_{50} from 0.4 mg/L (pink shrimp) to 90 mg/L (rainbow trout) have been reported for aquatic organisms. The acute toxicity for mammals is moderate with an LD_{50} in rat of 200-590 mg/kg body weight (19.1 mg/kg body weight for oxychlordane). The FAO/WHO maximum residue limits for chlordane in food range between 0.002 mg/kg milk fat and 0.5 mg/kg poultry fat. Water quality criteria of 1.5 to 6 µg/L have been published. Chlordane has been classified as a substance with evidence of endocrine disruption in an intact organism. Chlordane is possibly carcinogenic to humans (IARC Group 2B).

1.7.2.5. Heptachlor

Chemical Name: 1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene ($C_{10}H_5Cl_7$).

CAS Number: 76-44-8

Properties: Solubility in water: 180 µg/L at 25°C; vapor pressure: 0.3 x 10^{-5}mm Hg at 20°C; log K_{OW}: 4.4-5.5.

Production/Uses: Heptachlor is used primarily against soil insects and termites, but also against cotton insects, grasshoppers, and malaria mosquitoes. Heptachlor epoxide is a more stable breakdown product of heptachlor.

Persistence/Fate: Heptachlor is metabolized in soils, plants and animals to heptachlor epoxide, which is more stable in biological systems and is carcinogenic. The half-life of heptachlor in soil is in temperate regions 0.75 – 2 years. Its high partition coefficient provides the necessary conditions for bioconcentrating in organisms.

Toxicity: The acute toxicity of heptachlor to mammals is moderate (LD_{50} values between 40 and 119 mg/kg have been published). Toxicity to aquatic organisms is higher; LC_{50} values down to 0.11 µg/L have been found for pink shrimp. Limited information is available on the effects in humans. Heptachlor is possibly carcinogenic to humans (IARC Group 2B). The maximum residue levels recommended by FAO/WHO are between 0.006 mg/kg milk fat and 0.2 mg/kg meat or poultry fat.

1.7.2.6. Dichlorodiphenyltrichloroethane (DDT)

Chemical Name: 1,1,1-Trichloro-2,2-bis-(4-chlorophenyl)-ethane ($C_{14}H_9Cl_5$).

CAS Number: 50-29-3.

Properties: Solubility in water: 1.2-5.5 µg/L at 25°C; vapor pressure: 0.2 x 10^{-6} mm Hg at 20°C; log K_{OW}: 6.19 for *p,p'*-DDT, 5.5 for *p,p'*-DDD and 5.7 for *p,p'*-DDE.

Discovery/Use: DDT was first used during World War II to control insects that spread diseases such as malaria, dengue fever and typhus. It was subsequently widely used on a variety of agricultural crops. The technical product is a mixture of about 85% *p,p'*-DDT and 15% *o,p'*-DDT isomers.

Persistence/Fate: DDT is highly persistent in soils with a half-life of up to 15 years and of 7 days in air. It also exhibits high bioconcentration factors (in the order of 50000 for fish and 500000 for bivalves). In the environment, the product is metabolized mainly to DDD and DDE.

Toxicity: The lowest dietary concentration of DDT reported to cause egg shell thinning is 0.6 mg/kg for the black duck. LC_{50} of 1.5 mg/L for largemouth bass and 56 mg/L for guppy have been reported. The acute toxicity of DDT for mammals is moderate, with an LD_{50} in rat of 113-118 mg/kg body weight. DDT has an estrogen-like activity and is possibly carcinogenic to humans (IARC Group 2B). The maximum residue level in food recommended by WHO/FAO range from 0.02 mg/kg milk fat to 5 mg/kg meat fat. Maximum permissible DDT residue levels in drinking water (WHO) is 1.0 µg/L.

1.7.2.7. Toxaphene

Chemical Name: Polychlorinated bornanes and camphenes ($C_{10}H_{10}Cl_8$).

CAS Number: 8001-35-2

Properties: Solubility in water: 550 µg/L at 20°C; vapor pressure: 3.3 x 10^{-5} mm Hg at 25°C; log K_{OW} : 3.23-5.50.

Discovery/Uses: Toxaphene has been in use since 1949 as nonsystemic insecticide with some acaricidal activity, primarily on cotton, cereal grains fruits, nuts and vegetables. It was also used to control livestock ectoparasites such as lice, flies, ticks, mange, and scab mites. The technical product is a complex mixture of over 300 congeners, containing 67-69% chlorine by weight.

Persistence/Fate: Toxaphene has a half life in soil from 100 days up to 12 years. It has been shown to bioconcentrate in aquatic organisms (BCF of 4247 in mosquito fish and 76000 in brook trout).

Toxicity: Toxaphene is highly toxic in fish, with 96-hour LC_{50} values in the range of 1.8 µg/L in rainbow trout to 22 µg/L in bluegill. Long-term exposure to 0.5 µg/L reduced egg viability to zero. The acute oral toxicity is in the range of 49 mg/kg body weight in dogs to 365 mg/kg in guinea pigs. In long term studies, NOEL in rats is 0.35 mg/kg bw/day, LD_{50} ranging from 60 to 293 mg/kg bw. There is a strong evidence of the potential for endocrine disruption. Toxaphene is carcinogenic in mice and rats, with a cancer potency factor of 1.1 mg/kg/day for oral exposure. Toxaphene is possibly carcinogenic to humans (IARC Group 2B).

1.7.2.8. Mirex

Chemical Name: 1,1a,2,2,3,3a,4,5,5,5a,6-Dodecachlorooctahydro-1,3,4-metheno-1h-cyclobuta[cd]pentalene ($C_{10}Cl_{12}$).

CAS Number: 2385-85-5

Properties: Solubility in water: 0.07 µg/L at 25°C; vapor pressure: 3 x 10^{-7} mm Hg at 25°C; log K_{OW}: 5.28.

Discovery/Uses: The use in pesticide formulations started in the mid 1950s, largely focusing on the control of ants. It is also a fire retardant for plastics, rubber, paint, paper and electrical goods. Technical grade preparations of contain 95.19% mirex and 2.58% chlordecone, the rest being unspecified. Mirex is also used to refer to bait comprising corncob grits, soybean oil, and mirex.

Persistence/Fate: Mirex is considered to be one of the most stable and persistent pesticides, with a half-life is soils of up to 10 years. Bioconcentration factors of 2600 and 51400 have been observed in pink shrimp and fathead minnows, respectively. Mirex is capable of undergoing long-range transport due to its volatility (VPL = 4.76 Pa; H = 52 Pa m^3/mol).

Toxicity: The acute toxicity of Mirex for mammals is moderate with an LD_{50} in rat of 235 mg/kg and dermal toxicity in rabbits of 80 mg/kg. Mirex is also toxic to fish and can affect their behavior (LC_{50} [96 h] from 0.2 to 30 mg/L for rainbow trout and bluegill, respectively). Delayed mortality of crustaceans occurred at 1 µg/L exposure levels. There is evidence of potential for endocrine disruption and possible carcinogenic risk (IARC Group 2B).

1.7.2.9. Hexachlorobenzene (HCB)

Chemical Name: Hexachlorobenzene (C_6Cl_6)

CAS Number: 118-74-1

Properties: Solubility in water: 50 µg/L at 20°C; vapor pressure: 1.09 x 10^{-5} mm Hg at 20°C; log K_{OW}: 3.93-6.42.

Discovery/Uses: HCB was first introduced in 1945 as fungicide for seed treatments of grain crops. It was used for fireworks, ammunition and synthetic rubber. Today it is mainly a byproduct in the production of a large number of chlorinated compounds, particularly lower chlorinated benzenes, solvents and several pesticides. HCB is emitted to the atmosphere in flue gases generated by waste incineration facilities and metallurgical industries.

Persistence/Fate: HCB has an estimated half-life in soils of 2.7-5.7 years and of 0.5-4.2 years in air. HCB has a relatively high bioaccumulation potential and long half-life in biota.

Toxicity: LC_{50} for fish varies between 50 and 200 µg/L. The acute toxicity of HCB is low with LD_{50} values of 3.5 mg/g for rats. Mild effects of the rat liver have been observed at a daily dose of 0.25 mg HCB/kg bw. HCB is known to cause liver disease in humans (porphyria cutanea tarda) and has been classified as a possible carcinogen to humans by IARC (Group 2B).

1.7.3. Industrial compounds

1.7.3.1. Polychlorinated biphenyls (PCBs)

Chemical Name: Polychlorinated biphenyls ($C_{12}H_{(10-n)}Cl_n$, where n is within the range of 1-10).

CAS **Number**: Various (e.g. for Aroclor 1242, CAS No.: 53469-21-9; for Aroclor 1254, CAS No.: 11097-69-1);

Properties: Water solubility decreases with increasing chlorination: 0.01 to 0.0001 µg/L at 25°C; vapor pressure: 1.6-0.003 x 10^{-6} mm Hg at 20°C; log K_{OW}: 4.3-8.26.

Discovery/Uses: PCBs were introduced in 1929 and were manufactured in different countries under various trade names (e.g., Aroclor, Clophen, Phenoclor). They are chemically stable and heat resistant, and were used worldwide as transformer and capacitor oils, hydraulic and heat exchange fluids, and lubricating and cutting oils. Theoretically, a total of 209 possible chlorinated biphenyl congeners exist. About 130 are likely to occur in commercial products.

Persistence/Fate: Most PCB congeners, particularly those lacking adjacent unsubstituted positions on the biphenyl rings (e.g., 2,4,5-, 2,3,5- or 2,3,6-substituted on both rings) are extremely persistent in the environment. They are estimated to have half-lives ranging from three weeks to two years in air and, with the exception of mono- and dichlorobiphenyls, more than six years in aerobic soils and sediments. PCBs also have extremely long half-lives in adult fish, for example, an eight-year study of eels found that the half-life of CB153 was more than ten years.

Toxicity: LC_{50} for the larval stages of rainbow trout is 0.32 µg/L with a NOEL of 0.01 µg/L. The acute toxicity of PCB in mammals is generally low and LD_{50} values in rat of 1 g/kg bw. PCBs have been classified as substances for which there is evidence of endocrine disruption in an intact organism. PCBs are carcinogenic to laboratory animals and probably carcinogenic to humans (IARC Group 2A).

1.7.4. Unintended By-products

1.5.4.1. Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)

Chemical Name: PCDDs ($C_{12}H_{(8-n)}Cl_nO_2$) and PCDFs ($C_{12}H_{(8-n)}Cl_nO$) may contain between 1 and 8 chlorine atoms. Dioxins and furans have 75 and 135 possible positional isomers, respectively.

CAS Number: Various (2,3,7,8-TetraCDD: 1746-01-6; 2,3,7,8-TetraCDF: 51207-31-9).

Properties: Solubility in water: in the range 0.43 – 0.0002 ng/L at 25°C; vapor pressure: $2 – 0.007 \times 10^{-6}$ mm Hg at 20°C; log K_{OW}: in the range 6.60 – 8.20 for tetra- to octa-substituted congeners.

Discovery/Uses: PCDDS and PCDFs are byproducts in the production of other chemicals and may be formed in low-temperature combustion and incineration processes. They have no known use.

Persistence/Fate: PCDDs and PCDFs are characterized by their lipophilicity, semi-volatility, and resistance to degradation (half life of TCDD in soil of 10-12 years) and to long-range transport. They are also known for their ability to bio-concentrate and biomagnify under typical environmental conditions.

Toxicity: The toxicological effects reported refers to the 2,3,7,8-substituted compounds (17 congeners) that are agonist for the AhR. All the 2,3,7,8-substituted PCDDs and PCDFs plus coplanar PCBs (with no chlorine substitution at the ortho positions) show the same type of biological and toxic response. Possible effects include dermal toxicity, immunotoxicity, reproductive effects and teratogenicity and endocrine disruption. PCDDs and PCDFs are not classifiable as to carcinogenicity to humans because of inadequate or limited data (IARC Group 3). The only known persistent effect associated with dioxin exposure in humans is chloracne. The most sensitive groups are fetus and neonatal infants. Effects on the immune systems in the mouse have been found at doses of 10 ng/kg bw/day, while reproductive effects were seen in rhesus monkeys at 1-2 ng/kg bw/day. Biochemical effects have been seen in rats down to 0.1 ng/kg bw/day. In a re-evaluation of the TDI for dioxins, furans (and planar PCB), the WHO decided to recommend a range of 1-4 TEQ pg/kg bw, although more recently the acceptable intake value has been set monthly at 1-70 TEQ pg/kg bw.

1.7.5. Region-Specific Compounds

1.7.5.1. Atrazine

Chemical Name: 2-Chloro-4-(ethlamino)-6-(isopropylamino)-s-triazine (C10H6Cl8).

CAS Number: 19-12-24-9

Properties: Solubility in water: 28 mg/L at 20°C; vapour pressure: 3.0 x 10-7 mm Hg at 20°C; log Kow: 2.34.

Discovery/Uses: Atrazine is a selective triazine herbicide used to control broadleaf and grassy weeds in corn, sorghum, sugarcane, pineapple, christmas trees, and other crops, and in conifer reforestation plantings. It was discovered and introduced in the late 50's. Atrazine is still widely used today because it is economical and effectively reduces crop losses due to weed interference.

Persistence/Fate: The chemical does not adsorb strongly to soil particles and has a lengthy half-life (60 to >100 days). Atrazine has a high potential for groundwater contamination despite its moderate solubility in water.

Toxicity: The oral LD50 for atrazine is 3090 mg/kg in rats, 1750 mg/kg in mice, 750 mg/kg in rabbits, and 1000 mg/kg in hamsters. The dermal LD50 in rabbits is 7500 mg/kg and greater than 3000 mg/kg in rats. Atrazine is practically nontoxic to birds. The LD50 is greater than 2000 mg/kg in mallard ducks. Atrazine is slightly toxic to fish and other aquatic life. Atrazine has a low level of bioaccumulation in fish. Available data regarding atrazine's carcinogenic potential are inconclusive.

1.7.5.2. Hexachlorocyclohexanes (HCH)

Chemical Name: 1,2,3,4,5,6-Hexachlorocyclohexane (mixed isomers) ($C_6H_6Cl_6$).

CAS Number: 608-73-1 (γ-HCH, lindane: 58-89-9).

Properties: γ-HCH: solubility in water: 7 mg/L at 20°C; vapor pressure: 3.3 x 10^{-5} mm Hg at 20°C; log K_{OW}: 3.8.

Discovery/Uses: There are two principle formulations: "technical HCH", which is a mixture of various isomers, including α-HCH (55-80%), β-HCH (5-14%) and γ-HCH (8-15%), and "lindane", which is essentially pure γ-HCH. Historically, lindane was one of the most widely used insecticides in the world. Its insecticidal properties were discovered in the early 1940s. It controls a wide range of sucking and chewing insects and has been used for seed treatment and soil application, in household biocidal products, and as textile and wood preservatives.

Persistence/Fate: Lindane and other HCH isomers are relatively persistent in soil and water, with half-lives generally greater than 1 and 2 years, respectively. HCHs are much less bioaccumulative than other organochlorine compounds because of their relatively low liphophilicity. Their relatively high vapor pressures, particularly of the α-HCH isomer, determine their long-range transport in the atmosphere.

Toxicity: Lindane is moderately toxic for invertebrates and fish, with LC_{50} values of 20-90 µg/L. The acute toxicity for mice and rats is moderate, with LD_{50} values in the range of 60-250 mg/kg. Lindane is not known for mutagenic potential in a number of studies, but has endocrine disrupting activity. Hexachlorocyclohexanes are possibly carcinogenic to humans (IARC Group 2B).

1.7.5.3. Chlorinated Paraffins (CPs)

Chemical Name: Polychlorinated alkanes ($C_xH_{(2x-y+2)}Cl_y$), manufactured by chlorination of liquid n-alkanes or paraffin wax, and containing 30-70% chlorine. The products are often divided in three groups depending on chain length: short chain ($C_{10} - C_{13}$), medium ($C_{14} - C_{17}$) and long ($C_{18} - C_{30}$) chain lengths.

CAS Number: 108171-26-2

Properties: Properties depend on the chlorine content. Solubility in water: 1.7 to 236 µg/L at 25°C; vapor pressure: 6.78 x 10^{-2} to 8.47 x 10^{-9} mm Hg at 20°C; log K_{OW}: in the range from 5.06 to 8.12.

Discovery/Uses: The widest application is as a plasticizer, generally in conjunction with primary plasticizers such as certain phthalates in flexible PVCs. Chlorinated paraffins impart a number of technical benefits, of which the most significant are enhancement of flame retardant properties and extreme pressure lubrication.

Persistence/Fate: CPs may be released into the environment from improperly disposed metal-working fluids or polymers containing CPs. Loss of CPs by leaching from paints and coatings may also contribute to environmental contamination. Short chain CPs with less than 50 % chlorine content appear to be degraded under aerobic conditions. Medium and long chain products are degraded more slowly. CPs bioaccumulate. Both uptake and elimination are faster for the substances with low chlorine content.

Toxicity: The acute toxicity of CPs in mammals is low, with reported oral LD_{50} values ranging from 4 - 50 g/kg bw, although in repeated dose experiments, effects on the liver have been seen at doses of 10 – 100 mg/kg bw/day. Short-chain and mid-chain grades have shown in laboratory tests toxic effects in fish and other forms of aquatic life after long-term exposure. The NOEL appears to be in the range of 2–5 µg/L for the most sensitive aquatic species tested. Chlorinated paraffins are possibly carcinogenic to humans (IARC Group 2B).

1.7.5.4. Endosulfan

Chemical Name: 6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin-3-oxide ($C_9H_6Cl_6O_3S$).

CAS Number: 115-29-7.

Properties: Solubility in water: 320 µg/L at 25°C; vapor pressure: 0.17 x 10^{-4} mm Hg at 25°C; log K_{OW}: 2.23-3.62.

Discovery/Uses: Endosulfan was first introduced in 1954. It is used as a contact and stomach insecticide and acaricide in a great number of food and nonfood crops (e.g. tea, vegetables, fruits, tobacco, cotton), and it controls over 100 different insect pests. Endosulfan formulations are used in commercial agriculture and home gardening and for wood preservation. The technical product contains at least 94% of two pure isomers, α- and β-endosulfan.

Persistence/Fate: It is moderately persistent in the soil, with a reported average field half-life of 50 days. The two isomers have different degradation times in soil (half-lives of 35 and 150 days for α- and β-isomers, respectively, in neutral conditions). Endosulfan has a moderate capacity to adsorb to soils. It is not likely to leach to groundwater. In plants, endosulfan is rapidly broken down to the corresponding sulfate on most fruits and vegetables. Fifty % of the parent residue is lost within 3 to 7 days.

Toxicity: Endosulfan is highly to moderately toxic in bird species (Mallards: oral LD_{50} 31 - 243 mg/kg) and it is very toxic to aquatic organisms (96-hour LC_{50} rainbow trout 1.5 µg/L). It has also shown high toxicity in the rat (oral LD_{50}: 18 - 160 mg/kg, and dermal: 78 - 359 mg/kg). Female rats appear to be 4–5 times more sensitive to the lethal effects of technical-grade endosulfan than male rats. The α-isomer is considered to be more toxic than the β-isomer. There is a strong evidence of its potential for endocrine disruption.

1.7.5.5. Pentachlorophenol (PCP)

Chemical Name: Pentachlorophenol (C_6Cl_5OH).

CAS Number: 87-86-5.

Properties: Solubility in water: 14 mg/L at 20°C; vapor pressure: 16 x 10^{-5} mm Hg at 20°C; log K_{OW}: 3.32 – 5.86.

Discovery/Uses: It is used as insecticide (termiticide), fungicide, non-selective contact herbicide (defoliant) and, particularly as wood preservative. It is also used in anti-fouling paints and other materials (e.g. textiles, inks, paints, disinfectants and cleaners) as inhibitor of fermentation. Technical PCP contains trace amounts of PCDDs and PCDFs

Persistence/Fate: The rate of photodecomposition increases with pH ($t_{1/2}$ 100 hr at pH 3.3 and 3.5 hr at pH 7.3). Complete decomposition in soil suspensions takes >72 days. Half-lifes in soils of 23-178 days have been reported. Although enriched through the food chain, PCP is rapidly eliminated after discontinuation of exposure ($t_{1/2}$ = 10-24 h for fish).

Toxicity: PCP is acutely toxic to aquatic organisms and have certain effects on human health, at the time it exhibits off-flavor effects at very low concentrations. The 24-h LC_{50} values for trout were reported as 0.2 mg/L. Chronic toxicity has been observed at concentrations down to 3.2 µg/L. Mammalian acute toxicity of PCP is moderate to high. Oral LD_{50} in the rat ranges from 50 to 210 mg/kg bw. LC_{50} ranges from 0.093 mg/L in rainbow trout (48 h) to 0.77-0.97 mg/L for guppy (96 h) and 0.47 mg/L for fathead minnow (48 h). PCP is possibly carcinogenic to humans (IARC Group 2B).

1.7.5.6. Hexabromobiphenyl

Chemical Name: Hexabromobiphenyl ($C_{12}H_4Br_6$).

CAS Number: 59536-65-1

Properties: Solubility in water: 0.6 µg/L at 25°C; vapor pressure: 10^{-7} mm Hg at 20°C; log K_{OW}: 6.39.

Discovery/Uses: The production of polybrominated biphenyls (PBBs) began in 1970. Hexabromobiphenyl was used as a fire retardant mainly in thermoplastics for constructing business machines and housing, industrial, and electrical products. Smaller amounts were used as a fire retardant in coatings and lacquers and in polyurethane foam for auto upholstery.

Persistence/Fate: Hexabromobiphenyl is strongly adsorbed to soil and sediments and usually persist in the environment. Hexabromobiphenyl resists both chemical and biological degradation. Hexabromobiphenyl has been found in several sediment samples from the estuaries of large rivers and has been identified in edible fish.

Toxicity: Few toxicity data are available from short-term tests on aquatic organisms. The LD_{50} values of commercial mixtures show a relatively low order of acute toxicity (LD_{50} range from > 1 to 21.5 g/kg body weight in laboratory rodents). Oral exposure of laboratory animals to PBBs caused weight loss, skin disorders, nervous system effects, and birth defects in the offspring. Humans exposed through contaminated food developed skin disorders, such as acne and hair loss. PBBs exhibit endocrine disrupting activity and are possibly carcinogenic to humans (IARC Group 2B).

1.7.5.7. Polybrominated diphenyl ethers (PBDEs)

Chemical Name: Polybrominated diphenyl ethers ($C_{12}H_{(10-n)}Br_nO$, where n = 1-10). The total number of congeners is 209, with a predominance in commercial mixtures of the tetra-, penta- and octa-substituted isomers.

CAS Number: Various (PeBDE: 32534-81-9; OBDE: 32536-52-0; DeBDE: 1163-19-5)

Properties: Solubility in water: 0.9 ng/L at 25°C (PeBDE); vapor pressure: 3.85 x 10^{-3} to

<10^{-7} mmHg at 20-25 °C; log K_{OW}: 4.28 - 9.9.

Discovery/Uses: Since the 1960s, three commercial PBDE formulations are available. The pentabrominated product is used principally as flame retardant in polyurethane foams in furniture, carpet underlay and bedding. Commercial octa is a mixture of hexa- (10-12%), hepta- (44-46%), octa- (33-35%) and nonabromodiphenyl (10-11%) ethers. It is used to flame retard a wide variety of thermoplastics and is recommended for injection moulding applications such as high impact polystyrene (HIPS). The deca product (a single congener) is used predominantly for textiles and denser plastics such as housings for a variety of electrical products in particular TVs and computers.

Persistence/Fate: Data on environmental fate, although limited, suggest that biodegradation is not an important degradation pathway, but that photodegradation may play a significant role. PBDEs have been found in high concentrations in marine birds and mammals from remote areas. The half-lives of PBDE components in rat adipose tissue varies between 19 and 119 days, the higher values referring to the higher brominated congeners.

Toxicity: Available data suggest that the lower (tetra- to hexa-) PBDE congeners are likely to be carcinogens, endocrine disruptors, and/or neurodevelopmental toxicants. Studies in rats with commercial PeBDE indicate a low acute toxicity via oral and dermal routes of exposure, with LD_{50} values > 2000 mg/kg bw. In a 30-day study on the rat, effects on the liver were seen at a dose of 2 mg/kg bw/day, with a NOEL at 1mg/kg bw/day. The toxicity to *Daphnia magna* has also been investigated and LC_{50} was found to be 14 □g/L with a NOEC of 4.9 □g/L. Although data on toxicology is limited, PBDEs have potential endocrine disrupting properties, and there are concerns over the human health effects of exposure.

1.7.5.8. Polycyclic Aromatic Hydrocarbons (PAHs)

Chemical Name: PAHs is a group of compounds consisting of two or more fused aromatic rings.

CAS Number: Various

Properties: Solubility in water: 0.00014 -2.1 mg/L at 25ºC; vapor pressure: from 0.0015 x 10^{-9} to 0.0051 mmHg at 25°C; log K_{OW}: 4.79-8.20

Discovery/Use: Most PAHs are formed during incomplete combustion of organic material. The composition of a PAH mixture varies with the source(s) and selective weathering effects in the environment.

Persistence/Fate: Persistence of the PAHs varies with their molecular weight. The low molecular weight PAHs are most easily degraded. The reported half-lives of naphthalene, anthracene and benzo(e)pyrene in sediment are 9, 43 and 83 hours, respectively, while for higher molecular weight PAHs half-lives are up to several years in soils and sediments. The BCF in aquatic organisms frequently ranges between 100 and 2000 and increases with increasing molecular size. Due to their wide distribution, the environmental pollution by PAHs is a global concern.

Toxicity: The acute toxicity of low PAHs is moderate, with an LD_{50} of naphthalene and anthracene in rat of 490 and 18000 mg/kg body weight respectively, while the higher PAHs exhibit higher toxicity. Thus, LD_{50} of benzo(a)anthracene in mice is 10mg/kg body weight. In *Daphnia pulex*, LC_{50} for naphthalene is 1.0 mg/L, for phenanthrene 0.1 mg/L and for benzo(a)pyrene is 0.005 mg/L. The critical effect of many PAHs in mammals is their carcinogenic potential. The metabolic action of these substances produce intermediates that bind covalently with cellular DNA. IARC has classified benz[a]anthracene, benzo[a]pyrene, and dibenzo[a,h]anthracene as probable carcinogenic to humans (IARC Group 2A). Benzo[b]fluoranthene and indeno[1,2,3-c,d]pyrene were classified as possible carcinogens to humans (2B).

1.7.5.9. Phthalates

Chemical Name: Phthalates encompass a wide family of compounds. Dimethylphthalate (DMP), diethylphthalate (DEP), dibutylphthalate (DBP), benzylbutylphthalate (BBP), di(2-ethylhexyl)phthalate (DEHP)($C_{24}H_{38}O_4$) and dioctylphthalate (DOP) are some of the most common.

CAS Nos.: 84-74-2 (DBP), 85-68-7 (BBP), 117-81-7 (DEHP).

Properties: The physicochemical properties of phthalic acid esters vary greatly depending on the alcohol moieties. Solubility in water: 9.9 mg/L (DBP) and 0.3 mg/L (DEHP) at 25°C; vapor pressure: 3.5 x 10^{-5} (DBP) and 6.4 x 10^{-6} (DEHP) mm Hg at 25°C; log K_{OW}: 1.5 to 7.1.

Discovery/Uses: They are widely used as plasticizers, insect repellents, and solvents for cellulose acetate in the manufacture of varnishes and dopes. Vinyl plastic may contain up to 40% DEHP.

Persistence/fate: Phthalates are ubiquitous pollutants of marine, estuarine and freshwater sediments, sewage sludges, soils and food. Degradation ($t^{1/2}$) values generally range from 1-30 days in soils and freshwaters.

Toxicity: The acute toxicity of phthalates is usually low: the oral LD_{50} for DEHP is about 25-34 g/kg, depending on the species; for DBP reported LD_{50} values following oral administration to rats range from 8 to 20 g/kg body weight; in mice, values are approximately 5 to 16 g/kg body weight. In general, DEHP is not toxic for aquatic communities at the low levels usually present. In animals, high levels of DEHP damaged the liver and kidney and affected the ability to reproduce. Phthalates have been reported as endocrine disruptors. Phthalates are not classifiable as to carcinogenicity to humans because of inadequate or limited data (IARC Group 3). The EPA proposed a Maximum Admissible Concentration (MAC) of 6 □g/L of DEHP in drinking water.

1.7.5.10.Nonylphenol and octylphenol

Chemical Name: NP: $C_{15}H_{24}O$; OP: $C_{14}H_{22}O$.

CAS Number: 25154-52-3 (NP).

Properties: Solubility in water: 6.3 µg/L (NP) at 25°C; vapor pressure: 7.5 x 10^{-4} mm Hg at 20°C (NP); log K_{OW}: 4.5 (NP) and 5.92 (OP).

Discovery/Uses: NP and OP are the starting material in the synthesis of alkylphenol ethoxylates (APEs), first used in the 60s. These compounds are highly effective cleaning agents and surfactants that have been

widely used in a number of industrial applications including textiles, pulp and paper, paints, adhesives, resins and protective coatings. alkylphenol are used as plasticizers, stabilizers for rubbers, lube oil additives. Alkylphenol phosphite derivatives are used as UV stabilizers in plastics.

Persistence/Fate: NP and OP are the end degradation products of APEs under both aerobic and anaerobic conditions. Therefore, the major part is released to water and concentrated in sewage sludges. NPs and t-OP are persistent in the environment with half-lives of 30-60 years in marine sediments, 1-3 weeks in estuarine waters and 10-48 hours in the atmosphere. Due to their persistence they can bioaccumulate to a significant extent in aquatic species. However, excretion and metabolism is rapid.

Toxicity: NP and OP have acute toxicity values for fish, invertebrates and algae ranging from 17 to 3,000 µg/L. In chronic toxicity tests the lowest NOEC are 6 µg/L in fish and 3.7 µg/L in invertebrates. The threshold for vitellogenin induction in fish is 10 µg/L for NP and 3 µg/L for OP (similar to the lowest NOEC). Alkylphenols are endocrine disrupting chemicals also in mammals.

1.7.5.11.Organic Tin Compounds

Chemical Name: Organotin compounds comprise mono-, di-, tri- and tetrabutyl and triphenyl tin compounds. They conform to the following general formula $(n\text{-}C_4H_9)_nSn\text{-}X$ and $(C_6H_5)_3Sn\text{-}X$, where X is an anion or a group linked covalently through a hetero atom.

CAS Number: 56-35-9 (TBTO); 76-87-9 (TPTOH)

Properties: Solubility in water: 4 mg/L (TBTO) and 1 mg/L (TPTOH) at 25°C and pH 7; vapor pressure: 7.5×10^{-7} mm Hg at 20°C (TBTO) 3.5×10^{-8} mmHg at 50ºC (TPTOH); log K_{OW}: 3.19 - 3.84. In sea water and under normal conditions, TBT exists as three species in seawater (hydroxide, chloride, and carbonate).

Discovery/Uses: Organotin compounds are mainly used as antifouling paints (tributyl and triphenyl tin) for underwater structures and ships. Minor identified applications are as antiseptic or disinfecting agents in textiles and industrial water systems, such as cooling tower and refrigeration water systems, wood pulp and paper mill systems, and breweries. They are also used as stabilizers in plastics and as catalytic agents in soft foam production and to control schistosomiasis.

Persistence/Fate: Under aerobic conditions, TBT takes 1 to 3 months to degrade, but in anaerobic soils may persist for more than 2 years. Because of the low water solubility it binds strongly to suspended material and sediments. TBT is lipophilic and tends to accumulate in aquatic organisms. Oysters exposed to very low concentrations exhibit BCF values from 1000 to 6000.

Toxicity: TBT is moderately toxic and all breakdown products are even less toxic. Its impact on the environment was discovered in the early 1980s in France with harmful effects in aquatic organisms, such as shell malformations of oysters, imposex in marine snails and reduced resistance to infection (e.g. in flounder). Molluscs react adversely to very low levels of TBT (0.06-2.3 ug/L). Lobster larvae show a nearly complete cessation of growth at just 1.0 ug/L TBT. In laboratory tests, reproduction was inhibited when female snails exposed to 0.05-0.003 ug/L of TBT developed male characteristics. Large doses of TBT have been shown to damage the reproductive and central nervous systems, bone structure, and the liver bile duct of mammals.

1.7.5.12.Organic mercury compounds

Chemical Name: The major compound of concern is methyl mercury, $Hg(CH_3)_2$.

CAS Number: 22967-92-6

Properties: Solubility in water: 0.1 g/L at 21°C ($HgCH_3Cl$) and 1.0 g/L at 25ºC ($Hg(CH_3)_2$); vapor pressure: 8.5×10^{-3} mm Hg at 25°C ($HgCH_3Cl$); log K_{OW}: 1.6 ($HgCH_3Cl$) and 2.28 ($Hg(CH_3)_2$).

Production/Uses: There are many sources of mercury release to the environment, both natural (volcanoes, mercury deposits, and volatilization from the ocean) and anthropogenic (coal combustion, chlorine alkali processing, waste incineration, and metal processing). Mercury is also used in thermometers, batteries, lamps, industrial processes, refining, lubrication oils, and dental amalgams. Methyl mercury has no industrial uses; it is formed in the environment by methylation of the inorganic mercurial ion mainly by microorganisms in the water and soil.

Persistence/Fate: Mercury released into the environment may either stay close to its source for long periods, or be widely dispersed on a regional or even worldwide basis. Methylated mercury compounds are toxic and highly bioaccumulative. Mercury content rises in the aquatic food chain and results in relatively high levels of mercury in fish consumed by humans. Ingested elemental mercury is only 0.01% absorbed, but methyl mercury is nearly 100% absorbed from the gastrointestinal tract. The biological half-life of mercury is 60 days.

Toxicity: Long-term exposure to either inorganic or organic mercury can permanently damage the brain, kidneys, and developing fetus. The most sensitive target of low level exposure to metallic and organic mercury following short or long term exposures appears to be the nervous system. Methyl mercury compounds are possibly carcinogenic to humans (IARC Group 2B).

1.7.5.13. Organic lead compounds

Chemical Name: Alkyllead compounds may be confined to tetramethyllead (TML, $Pb(CH_3)_4$) and tetraethyllead (TEL, $Pb(C_2H_5)_4$).

CAS Number: 75-74-1 (TML) and 78-00-2 (TEL).

Properties: Solubility in water: 17.9 mg/L (TML) and 0.29 mg/L (TEL) at 25°C; vapor pressure: 22.5 and 0.15 mm Hg at 20°C for TML and TEL, respectively.

Discovery/Uses: Tetramethyllead and tetraethyllead were widely used as anti-knock additives in gasoline. The release of TML and TEL were drastically reduced with the introduction of unleaded gasoline in late 1970's in USA, followed by other parts of the world. However, leaded gasoline is still available, contributing to the emission of TEL and to a less extent TML to the environment. Recycling and production of lead batteries takes also place.

Persistence/Fate: In air or aqueous solutions, dealkylation occurs to produce the less alkylated forms and finally inorganic lead. However, there is limited evidence that under some circumstances natural methylation of lead salts may occur. Minimal bioaccumulation was observed for TEL in shrimps (650x), mussels (120x) and plaice (130x) and for TML in shrimps (20x) , mussels (170x), and plaice (60x).

Toxicity: Acute toxicity of TEL and TML are moderate in mammals and high for aquatic biota. LD50 (rat, oral) for TEL is 35 mg Pb/kg and 108 mg Pb/kg for TML. LC50 (fish, 96hrs) for TEL is 0.02 mg/kg and for TML is 0.11 mg/kg. Organic lead compounds are not classifiable as to carcinogenicity to humans because of inadequate or limited data (IARC Group 3).

1.8. SUMMARY

The UNEP Global Environmental Facility project for the assessment of environmental and health effects of persistent toxic substances (PTSs) was launched in 2000 in 12 regions. This is the report for the Central American and the Caribbean Region (Region X), which includes 23 countries and 136 million inhabitants in the Greater Antilles, the eastern and southern islands of the Lesser Antilles, the Bahamas, Belize, Colombia, Costa Rica, El Salvador, Guatemala, Guyana, Honduras, Nicaragua, Panama, Suriname, and Venezuela.

The project identified major regional sources of PTSs; determined their impact on environment and human health; assessed their transboundary transport; assessed the root causes of PTS-related problems; evaluated the regional capacity to solve these problems; identified regional priorities for PTS-related environmental and health issues; and contributed to the identification of global priorities related to PTSs.

The project structure involved a Project Manager at UNEP Chemicals in Geneva, a Steering Group, Regional Coordinators, and Regional Teams. The regional component addressed the 12 persistent organic pollutants (POPs) defined by the Stockholm Convention on Persistent Organic Pollutants 2001: aldrin, endrin, dieldrin, chlordane, DDT, toxaphene, mirex, heptachlor, hexachlorobenzene, polychlorinated biphenyls (PCBs), polychlorinated dibenzodioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and additional, regionally important compounds: atrazine, endosulfan, pentachlorophenol, polybrominated diphenyl ethers, lindane, organic lead, organic mercury, organic tin, polychlorinated phenols, polycyclic aromatic hydrocarbons (PAHs), short chain paraffins, phthalates, octylphenols, and nonyl phenols.

Preexisting data on sources, environmental concentrations, human and ecological effects were exploited. Regional priorities for compounds and actions were defined in workshops with representatives from the different countries. Most of the Region X countries depend heavily on agriculture, though mining, tourism and manufacturing are important sectors in a number of countries. Sectoral distribution of production determines the use profile of PTSs, but part of the contaminant burden is imported into the Region.

2. SOURCES OF PTS

2.1. BACKGROUND INFORMATION TO PTS SOURCES

PTSs may be introduced into the environment by various sources and activities. Point and diffuse sources include releases from agricultural, industrial and domestic sites, traffic, and waste disposal operations.

The major sources of PTSs in the Central American and Caribbean Region are the agricultural, energy, industrial, waste, and marine sectors. Limited data on PTSs are available on current and obsolete pesticides used in agriculture and vector control, PCBs in transformer oils, and PAHs from petroleum, petroleum products, engine emissions, and petroleum wastes. During the decades of 1950s until the 1970s DDT, aldrin, dieldrin, lindane, and toxaphene, among others, were profusely used in agriculture and DDT in public health treatments against vectors of human and animal diseases. However no reliable data can be found from that time concerning the import of those pesticides classified today as PTS and also no data in relation with their environmental levels or damage.

Sources of unintentional byproducts such as dioxins and furans remain undocumented. Combustion, especially of municipal waste, agricultural crops (such as sugar cane) and combustion for land clearing is common in the Region and constitutes a potential source of PCDDs, PCDFs, HCB, and PAHs. There is anecdotal evidence of organotin compounds in the marine environment, these compounds being used as anti-fouling agents in marine paints and are also imported as pesticides in some countries of the region. Leaded gasoline is still available in some countries of the Region and constitutes a source of organic lead compounds. Another source of lead is the lead car batteries. Industrial, commercial and domestic use of chlorinated solvents is an additional concern.

Source and emission inventories are necessary for the development and enforcement of appropriate risk control strategies for PTSs and other chemicals. No comprehensive national or regional inventories exist in the Region.

2.2. PESTICIDES

Large quantities of pesticides are imported for use in the agricultural sector and for vector control in the Region. Agriculture is important in the economies of all countries of the Region. The major crops, which vary within the Region, are sugar cane, coffee, banana, orange, pineapple, corn, cotton, vegetables, rice, cocoa, beans, root crops, etc. (Table 2.1.). Land available for agriculture is being reduced, and available lands are expected to become more productive. Great amounts of pesticides are used to achieve this goal as well as to meet the requirements of the products exported to international markets. Diversification of agriculture has taken place because of negative experiences of mono-cropping particularly in the Caribbean islands, and in an attempt to provide local food. This has led to the cultivation of crops such as tomatoes, vegetables, plantains, ginger, occasionally accompanied by new pesticides and increased doses.

Pesticides are used also on livestock and in household applications.

Table 2.1. Major crops in Central America and the Caribbean (hectares)

Country	Coffee	Sugarcane	Banana	Corn	Cocoa
Barbados	ND	9 000 (sugar & cotton)	ND	ND	ND
Belize	ND	57 322	4 663	35 019	ND
Colombia (1999)	2 049 244	447 568	123 756	150 184	ND
Costa Rica (2000)	106 000	46 000	48 080	10 395	3 550
Dominica	ND	ND	ND	ND	ND
Dominican Republic	ND	ND	11 564	23 212	ND
El Salvador	162 731	71 957	2 970	288 328	ND
Grenada	ND	530	3 560	ND	4 460
Guatemala (1996)	380 000	154 000	13 300	576 170	ND
Guyana (production, 2001)	ND	284 477 tons	ND	ND	ND
Honduras (production, 2000)	4 266 000 qq	81 305 000 qq	9 463 000 qq	11 285 000qq	ND
Jamaica (production)	13 408 tons	2 231 000 tons	43 052 tons	ND	2 325 tons
Nicaragua	134 388	79 816	2 451	373 479	ND
Panama	ND	ND	ND	ND	ND
St. Kitts & Nevis	ND	4 050	ND	ND	ND
St. Lucia	41	ND	5 346	ND	285
St. Vincent & Grenadines	ND	ND	486	ND	ND
Trinidad and Tobago (production)	343 tons	112 000 tons	ND	ND	ND
Venezuela (1997)	171 376	155 376	ND	651 697	51 573

Source : Country reports. ND: No documented information available

A number of PTS pesticides were introduced into the Region during the 1950's. Their use was intensified in Central America along with the economic integration of the Central America countries. In the Caribbean and Colombia this increase coincided with a similar economic acceleration process. Most OC pesticides were restricted in the early 1970s in the developed world. The majority of them is currently banned or restricted in Central America since 1980s (Table 2.2.). In cotton producing Guatemala, El Salvador, Nicaragua, and Honduras, 16 million Kg of organochlorine compounds were used from 1974 to 1975, equivalent to 56.5% of all insecticides in use (Murray, 1994).

Table 2.2. Legal status of persistent organic pesticides in Central America and the Caribbean

Pesticide	BAR	BEL	COL	CR	CUB	DCA	DOM	GUA	HON	JAM	NIC	PAN	SAL	VEN
Aldrin	B 1987	B 1985	B 1988	B 1988	B 1989	B	B 1991	B 1988	B 1991	B 1999	B 1977	B 1987	B 1980	R 1983
Atrazine		U 1997		U 1997				U 1997	U 1997		U 1997	U 1997	U 1997	
Chlordane	B 1986	U 1985	B 1988	B 1991	B 1989	B		B 1988	B 1999	B 1999		B 1987	B 1986	B 1983
DDT	B 1967	R 1990	B 1993	B 1988	B 1989	B	B 1991	B 1979	B 1991	B 1999	B 1980	B 1987	B 1980	R 1983
Dieldrin	B	B 1985	B 1988	B 1988	B 1989	B	B 1991	B 1988	B 1991	B 1999	B 1981	B 1987	B 1986	B 1983
Endosulfan		B 1985	B 2001	U 1997				U 1997	R 1991		U 1997	R 1992	U 1997	
Endrin	B	B 1985	B 1986	B 1990	B 1989			B 1988		B 1999	B 1981	B 1987	B 1986	B 1983
Heptachlor	B	B 1985	B 1988	B 1989	B 1989	B	B 1991	B 1988	B 1991	B 1999	R 1992	B 1997	B 1986	B 1983
Hexachloro-benzene			B 1993	Never registered				B		B 1999	Never registered	B 1987	B 2000	
Lindane	B 1989	R 1990		B 1989	B 1989		B 1991	B 1988	B 1991	B 1999	B 1977	B 1987	B 2000	
Mirex		R 1990	B 1993	R 1989	B 1989				B 1991	B 1999		R 1992	B 2000	B 1983
Pentachloro-phenol		R 1990		B 1990					R 1988	B 1999	B	B 1987	B 2000	
Toxaphene		B 1985	B 1988	B 1988	B 1989			B 1988	B 1991	B 1999	R,B	B 1987	B 1988	B

B: Banned; R: Restricted; U: Registered.

BAR: Barbados; BEL: Belize; COL: Colombia; CR: Costa Rica; CUB: Cuba; DCA: Dominica; DOM: Dominican Republic; GUA: Guatemala; HON: Honduras; JAM: Jamaica; NIC: Nicaragua; PAN: Panama; SAL: El Salvador; VEN: Venezuela

Notes: Trinidad and Tobago report having imported atrazine and endosulfan in 2001. All organochorine pesticides are banned in St. Lucia.

Sources: IRET, 1999; OPS, 2001; ICA, 2001; Min. de Salud y Desarrollo Social de la Rep. de Venezuela (personal communication).

2.2.1. Aldrin and Dieldrin

Aldrin has been manufactured commercially since 1950 and used worldwide. Both aldrin and dieldrin were used as broad-spectrum insecticides to protect crops such as cotton, corn, and citrus products, and for the extermination of termites. There was a small plant producing aldrin formulations for agricultural use during the 1970s and 1980s in Panama (Espinoza, 2002). Import data for Panama during the period 1970-1978

amounted to 198 tons of aldrin. Costa Rica imported 105 tons of aldrin and dieldrin during 1977-1980 (De la Cruz, 1994; Higalgo, 1986). No import data were found for the subsequent years, aldrin and dieldrin having been banned in Costa Rica in 1988. Aldrin and dieldrin are banned or canceled in all Central American countries and most Caribbean countries (Table 2.2.). Aldrin and dieldrin were used during 1950-1970 in Rio Cobre, Jamaica, for the control of fiddler beetle, annually in citrus and each two years on pineapple (Chin Sue, 2002).

2.2.2. Chlordane

Chlordane is a versatile, broad spectrum contact insecticide used mainly for nonagricultural purposes. Historical use data are scarce. Import data for Costa Rica indicate 28 metric tons of chlordane imported during 1977-1985. No subsequent import data were available. Most Central American countries canceled, banned or restricted its use between 1985 and 1991 (Table 2.2.). It was used in Jamaica for sugarcane, but no data on quantity and date are available on the last import.

2.2.3. DDT

DDT is not produced in the Region. Table 2.3. summarizes the use of DDT in Central America. The quantities of agricultural use of DDT were high during the years of cotton cultivation in Central America (1971-1980). DDT was mixed with toxaphene, methyl parathion and HCH, in some countries it was applied using the ultra low volume (ULV) system (González and Calderon, 2002).

DDT is still used in Guyana and Suriname in public health applications. Data on quantities are not available. Jamaica has been declared a malaria-controlled country since 1951, and no DDT is being used for vector control. DDT was used in agriculture and vector control in Cuba since the early 1950s.

Table 2.3. Public health application of DDT in Central America.

Country	Period	Households sprinkled	DDT 75%, kg	DDT 100%, kg	Comments
Belize	1997-1998	5 643			Households sprayed with DDT and K-otrine
Costa Rica	1957-1985	2 008 542	1 212 300	175 478	
El Salvador	1960-1973	5 161 260			Data from Ministry of Health
Guatemala	1958-1979	7 584 751	4 488 400	302 170	Data from Ministry of Health
Honduras	1950-1978		2 240 000	400 000	
Nicaragua	1959-1962	1 702 304			
	1959-1991		1 351 200	17 900	
Panama	1967-1971		79 410	109 230	Data from Ministry of Health

Source: UNEP/PAHO, 2000.

2.2.4. Endosulfan

The OC insecticide endosulfan is used in the control of a large number of pests on various crops. It is used in a number of countries in the Region. During 1998 and 1999 Guatemala, Colombia and Costa Rica were the highest importers in the region (See Table 2.9). It was banned in Belize in 1985, and in Colombia in 2001. The use of endosulfan in Jamaica has been restricted to coffee plantations and imports have been reduced to 6 000 L per year (Chin Sue, 2002).

2.2.5. Endrin

Endrin was used on cotton, rice, sugarcane, maize, and other crops. It is also a rodenticide. Its use has been banned in many countries and severely restricted in others. Endrin is still being manufactured in Mexico (IPCS, 1984).

Use data are not available for most countries of the Region. In Panama, 537 tons of endrin was imported during 1970-1978. In Costa Rica, over 150 thousand Kg of endrin was imported between 1977 and 1982 (De la Cruz, 1994, Hidalgo, 1986). No subsequent import data are found.

2.2.6. Heptachlor

Heptachlor is a contact insecticide against soil insects, termites, cotton insects, grasshoppers, and crop pests and to combat malaria. Heptachlor has been banned in most countries in the Region, and restricted in Nicaragua (Table 2). In Panama, 805 tons of heptachlor were imported during 1970-1978. This compound was used in Jamaica from 1948 to 1975 in coffee plantations (Mansingh et al., 2000). In Costa Rica, 198 tons were imported from 1977 to 1979 and 113 tons between 1980 and 1991 (De la Cruz, 1994; Hidalgo, 1986). Very little chlordane and heptachlor were found in recent air samples in Belize and Costa Rica (Wania et al. 2002).

2.2.7. Hexachlorobenzene

Hexachlorobenzene (HCB) is a fungicide and an impurity in a number of pesticide formulations, including pentachlorophenol (PCP) and dicloram formulations. HCB may still be found in the food chain; however, the principal source of release into the environment today is probably as a by-product of aluminum smelting. Manufacture of vinyl chloride monomer and volatile halocarbons produce HCB as a byproduct. Other potential sources of HCB include the usage of PCP, which may be contaminated with HCB during manufacture, and the electrolytic production of magnesium and aluminum. The use of HCB in such applications was discontinued in many countries in the 1970s owing to concerns about adverse effects on the environment and human health.

Currently, the principal sources of HCB in the environment are estimated to be the manufacture of chlorinated solvents, the manufacture and application of HCB contaminated pesticides, and inadequate incineration of chlorine-containing wastes (Bailey, 2001).

No source or emission data on HCB is available for the Region.

2.2.8. Mirex

The insecticidal use of mirex has been largely focused on the control of the ants. Mirex (dechlorane), was used also as a fire retardant in plastics, rubber, paint, paper, and electrical goods, and as a smoke-generating compound, combined with zinc oxide and powered aluminum. Use data are not available for most countries of the Region. In Costa Rica, 479 tons were imported from 1977 until 1992, when it was restricted (Table 2.2). In Guatemala and Cuba and possibly in other countries, the original mirex is not present. Another pesticide is registered with the same commercial name (Mirex), namely “sulfuramid”.

2.2.9. Toxaphene

Toxaphene (camphechlor) was used predominantly in pest control on cotton crops. It was also applied on other field crops and for the control of pests in livestock and poultry. All registered uses of toxaphene in the U.S. were canceled in 1990. However, U.S. chemical manufactures can legally produce toxaphene for export (ATSDR, 2002). It is still commonly used as an insecticide on bananas and pineapples in Puerto Rico and the Virgin Islands (U.S. EPA, 2002).

Toxaphene has been used extensively in cotton and to some extent in rice cultivation in the Region. Nicaragua produced toxaphene from 1974 to 1991 in a factory located on the shore of Lake Xolotlan. The factory discharged all its wastes into the Lake Xolotlan ecosystem. During 1974-1979, the annual toxaphene production averaged about 10 million Kg, and dropped 3.5 million Kg during 1980 to 1985 and to 0.6 million kg in 1988. Toxaphene produced in Nicaragua was exported to the rest of the Central American countries

until 1985; from 1985 on, toxaphene was exclusively produced for Nicaraguan consumption (Castillo et al, 1997; Calero et al., 1993).

In Panama, 131 tons of toxaphene was imported during 1970-1978. Costa Rica imported 89 tons of toxaphene during 1977-1980 and 151 tons of a mixture of toxaphene and DDT between 1977 and 1983. Guatemala imported 5,000 tons of toxaphene in 1978, the imports declined steeply to 61 tons in 1985 in relation with the reduction of the cotton growing area (de Campos, 2002). Toxaphene was banned in Guatemala in 1988.

2.3. INDUSTRIAL COMPOUNDS

2.3.1. Polychlorinated Biphenyls

Polychlorinated biphenyls (PCBs) are complex mixtures of chlorinated hydrocarbons that have been used extensively since the 1930s. They are products and byproducts formed in industrial processes.

The virtually universal distribution of PCBs throughout the world, including the arctic and other remote areas, suggests that PCBs are transported via the atmosphere and ocean currents (Ballschmiter and Wittlinger, 1991). On account of their low water solubility, it is expected that most of the discharged PCBs will be adsorbed by sediment at the bottom of rivers or lakes, and transport will be mainly via waterborne particles. PCBs in soil derive from particulate deposition (often concentrated in urban areas), wet deposition, the use of sewage sludge as a fertilizer, and leaching from landfill sites.

PCBs were introduced in Central America during the 1950s and 1960s in cooling systems, heat transfer fluids, capacitors and transformers. They may also have been used as lubricants and carrier substances in paints, plastics, paper and pesticides. Little source data exist (De la Cruz, 2002).

None of the countries in the Region has a comprehensive national inventory of PCB stocks and uses. This is attributed to lack of knowledge about PCBs and the implications associated with their use, lack of human and financial resources, and insufficient legislation. Incomplete inventories exist, however, for obsolete PCB stocks (see 2.7.).

Transformers used in Panama and Guyana today are non-PCB. However, large amounts of transformers imported decades ago are still in use. The oil contained in the transformers contains PCBs in concentrations ranging from 50 up to 1000 mg/L. The conventional criterion for classifying transformer oil as PCB type is 50 mg/L. Between 25 and 50% of the oil in transformers are PCB type. There is approximately 200 tons transformer oil containing PCBs in Panama (MINSA, 2001). PCBs may be present also in hydraulic and brake fluids of cars. PCB containing oil is used by a minority of the population as a popular remedy against arthritis and joint pains in Panama and the Dominican Republic (Espinosa, 2002; Porro, 2002). Costa Rica banned PCBs in 2001.

2.4. UNINTENTED BYPRODUCTS

2.4.1. Dioxins and Furans

Polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) constitute a complex group of PTSs. They are ubiquitous in the environment. Though produced at natural sources (volcanoes, forest fires), the majority of dioxins are anthropogenic. PCDDs and PCDFs are formed as unwanted byproducts when chlorinated materials are involved in combustion or other high-temperature processes. They are formed in trace amounts of undesired impurities in the manufacture of chemicals such as chlorinated phenols and PCBs. They are also unwanted by-products of a wide range of manufacturing processes including smelting, bleaching of paper pulp, and the manufacturing of some pesticides. Solid waste incinerators with inadequate clean-up technologies have been targeted as important contributors to total emissions to air, including dioxins. Other sources include Portland cement production, pulp mills using the kraft process, asphalt mixing plants, catalyst regeneration at petroleum refineries, cigarette smoking, and the pyrolysis of brominated flame retardants. In developing countries controlled and uncontrolled agricultural

and municipal waste burning is an additional source of dioxins, as well as burning of wood, tires, and other materials as an energy source.

Although many of these activities take place in the different countries of the Region, there are no specific inventories or studies on dioxin sources or emissions. However there is some information regarding activities known to generate dioxins and furans.

Municipal solid waste burning. Domestic and commercial wastes are typically disposed of in the Region at landfill sites. No intentional burning of municipal wastes should therefore take place, though it happens. While burning of wastes at landfill sites in most countries is illegal, burning does occur through spontaneous combustion. Household burning takes place in many countries and constitutes a further source of dioxins and furans.

Plastics represent 6 to 20% of local waste mass that is collected and disposed (Table 2.4). In Trinidad, municipal solid waste reaching the landfills in 1996 have been estimated at 280,000 tons, per capita equivalent being 0.7 kg/person/day. Spontaneous burning at the two major landfills in Trinidad has increased in frequency and duration as they approach their optimum capacity. Spontaneous burning of municipal waste has also been reported in Dominican Republic (Porro, 2002). In Jamaica, the total amount of solid waste has been estimated at 1 million tons of which 526 403 tons are from Kingston. Spontaneous combustions occurs from time to time causing fog over the city of Kingston. Also in Jamaica there was an estimated 264 million polyethylene terephthalate (PET) bottles in the markets (PIOJ, 2001). The PET bottle problem in Jamaica characterizes the entire Caribbean, where the bottles are a major nuisance in the absence of recycling facilities for plastics. In Guatemala, burning of municipal waste is not regulated and is common. In Haiti most of the solid waste is not collected and it is burned all over the country; most of it is organic waste but it includes also plastic materials. Table 2.4 summarizes the composition of municipal waste in five countries in the Region. Table 2.5 presents information on percentage of urban waste collected in selected countries in the region.

Table 2.4. Composition of municipal waste (% of total weight) in selected countries

Country	Carton, paper	Metal	Glass	Textiles	Plastics	Organics	Other
Costa Rica	19	-	2	-	11	58	10
El Salvador	18	1	1	4	6	43	27
Guatemala 1991	14	2	3	4	8	63	6
Guyana	30	2	2	5	11	40	3
Jamaica	17*	5	9	2	12	55	-
Trinidad and Tobago	20	10	10	7	20	27	6

* Incluyes 13% paper and 4% cardboard, wood and board

Source: RFI, 2002; Chin Sue, 2002; EPA Guyana, personal communication.

Table 2.5. Urban waste disposal in selected countries.

Country	Population (millions)		Collected	Landfills or other controlled method
	Total	Urban		
Cuba (1991)	10.9	8.3	95%	90%

Costa Rica (1996)	3.7	1.8	66%	68%
El Salvador	6.00	3.6	70%	1.5%
Trinidad (1993)	1.3	0.8	95%	70%
Honduras (1996)	5.7	2.5	20%	0%
Dominica (1995)	0.07	0.03	50%	-

Source: RFI, 2002.

Hazardous waste incineration. While the use of incinerators in Region X for disposing of municipal waste is the exception rather than the rule, incinerators are widely used for the disposal of hospital wastes. Hospital wastes, usually contained in plastic bags, are burned in small incinerators located at the hospitals. The majority of these incinerators operates with low temperatures and therefore produces dioxins and furans. In addition to hospital incinerators, cement kilns and crematoria are examples of point sources of dioxins and furans.

Guatemala has 37 hospitals, each of which has an incinerator for nonpathological material. Guatemala has established a Regulation for the Management of Hospital Solid Wastes. One private incinerator is authorized to burn hospital wastes based on an environmental impact assessment (Ecotermo of Guatemala, S.A.). Five incinerators are operated by the hospitals of the Guatemalan Institute for Social Security in the metropolitan area and in the Pacific coast, with an average capacity of 75 to 100 pounds/hour. There are 6 incinerators in the public hospitals with the capacity of 35 to 50 kg per hour. One pesticide company operates an incinerator with a capacity of 45 to 90 kg/hour. A cement kiln in Guatemala incinerates waste materials, including plastic pesticide containers. The kiln operates at temperatures between 1 800 and 2100 degrees Centigrade and is equipped with a filter (Cifuentes, 2002).

In Honduras there are 16 hospital incinerators, of which only three are currently functioning. Capacities of these incinerators are: Hospital Mario Catarino Rivas, in San Pedro Sula: 80-100 kg/day; Hospital in San Lorenzo, Valle: 20-25 kg/day; and Hospital Francis Asis, Olancho: 20-25 kg/day. Two of the inoperative incinerators were destroyed when the fuel tank of the incinerator exploded. In both instances the fuel was stored next to the incinerator. Incineration of hazardous wastes is not permitted in cement kilns in Honduras (Sabillón, 2002).

In the Caribbean countries, small incinerators operating at the majority of hospitals are expected to be principal point sources of dioxins and furans. In Belize each of the seven district hospitals has a medical waste incinerator with an average age of five years. The combined total annual output from these incinerators is approximately 1 200 pounds (RFI, 2002). In Bogotá, Colombia, 21 incinerators were reported with burdens between 8.3 kg/hour and 120 kg/hour of organic materials (Nieto, 2002). Seven hospitals in Jamaica have small incinerators for disposal of medical waste. The cement company is also used to dispose of small quantities of hazardous chemicals (Chin Sue, 2002).

In Costa Rica, cement companies use alternative materials as fuel, including paper, tires, plastics, and oils. It is recognized that if the combustion process using these materials is not adequately controlled, may produce dioxins and other PTSs. The cement companies have made efforts to avoid the use of unwanted substances by controlling the emissions from the plants. No analyses of emissions are undertaken.Tables 2.6. to 2.8. summarize data on incinerators in Costa Rica, Trinidad and Tobago, and Jamaica.

Table 2.6. Incinerators in Costa Rica

Incinerators	Location	Material	Volume
Agrochemical industry	Puntarenas	Agrochemical packing	45 kg/hour; 700 tons/year

Cement kiln 1	Cartago	Oils, paper, plastic, tires, etc (<2% Cl)	4000 tons/year Plans to expand to 30000 tons/year
Cement kiln 2	Puntarenas	Oils (no PCBs)	14000 L/month Plans to expand to 60000 L/week
Hospital A	San Jose	Hospital waste	11 tons/year
Hospital B	San Jose	Hospital waste	1 ton/year
Hospital C	San Jose	Not authorized by Ministry of Health	

Source: Ministry of Health, personal communication; Jihad Sasa, personal communication

Table 2.7. Incinerators and other PTS sources in Trinidad and Tobago

Source	Details
Medical waste incinerators (3)	Port of Spain; San Fernando; Eric Williams Medical Sciences Complex
Cement kilns (2)	Trinidad Cement Ltd.; Claxton Bay
Landfill sites (5)	Forres Park, Beetham; Guapo
Crematoria (3)	Mosquito Creek; Caroni; St. James
Waste oil refinery (1)	Point-a-Pierre

Source: RFI, 2002

Table 2.8. Incinerators in Jamaica

Incinerator	Location	Type of material	Volume
Carib cement Kiln 4 (dry)	Kingston	Coal	13,000 tons/hour
Carib cement Kiln 3 (wet)	Kingston		700 tons/day
Hospital 1	St. Ann's Bay	Medical waste	
Hospital 2	Savanna la mar	Medical waste	
Hospital 3	Mandeville	Medical waste	
Hospital 4	May Pen		
Hospital 5	Cornwall Regional	Medical waste	
Blood Bank	Slipe Pen Road	Medical waste	
National Public Health	Kingston	Medical waste	

Laboratory			

Source: Chin Sue, 2002

Worn tires are used as energy source in countries such as Colombia, Costa Rica and El Salvador. Data on quantities are scarce. In the city of Bogotá, almost 2 million tires per year (13,560 tons/year) are burned as an energy source (DAMA, 2000). Using the same assumptions, it can be estimated that approximately 28,500 tons of worn tires would have been burned in Colombia in 2001 (Nieto, 2002).

Crop burning and forest and scrub fires. Burning of crops to facilitate harvesting of sugarcane and to eliminate encounters with vermin, including snakes and rats, has been practiced in most countries and is still being occasionally practiced. Forest and scrub fires are common in many countries of the Region.

In El Salvador, the annual number of forest fires is estimated at 1 200, affecting an area of 3 500 ha. The area of sugar cane cultivation is approximately 71 957 ha., of which about 80% is burnt before harvesting (González and Calderón, 2002).

In Costa Rica, the proportion of burned sugar cane fields has dropped from 90% to 69% of the total production area over the past 10 years, a total of 32 200 ha having been burned in 2001-2002 (Liga de la Caña, personal communication). The estimated area of burned pastureland in 1996 was 6 120 ha in Costa Rica. Residues of crops such as coffee, sugar cane and rice are used as fuel (Com. Ozono, 2000).

The significance of forest fires in Cuba as a source of PAH and dioxins has been assessed (Dierksmeier, 2002). The importance of this source of PTSs to the environment is recognized but its contribution to environmental pollution in relation to fires is small. Cuba has approximately 221 fires on average per year with only 0.2% being forest fires (Dierksmeier, 2002). Furthermore, agricultural burning of sugarcane fields is no more practiced. This was achieved with the introduction of mechanical harvesting in most sugarcane fields where the topography allows its use, which amounts to over 70% of the cultivated area.

In Guatemala, 126 forest fires and 10 other fires took place during January-March 2001. The affected area was 1 646 ha of forests (Cifuentes, 2002). Intentional fires accounted for 30% of all fires; agricultural burning 25%; and waste burning 3%. In 21%, causes were not identified.

Production of greenhouse gases in 1995 in Honduras, estimated at 9,685 kg of CO_2, represented a volume equivalent to 63% of the emissions from burning of wood and sugarcane wastes, and 37% from fuel combustion (Sabillón, 2002).

In 1997 the World Wide Fund for Nature reported 7 000 forest fires that destroyed 17 000 hectares of national parks in Colombia (Anderson, 1997 *in* Nieto, 2002). A news release (ANCOL, 30/11/2000) reported that in one year there were 10 289 events related to fires in vegetal covertures, which affected about 175 670 hectares, mainly in the Andean Region, where 67% of Colombian population reside. The Department of Environment of Colombia registered 360 fires and 15 ha affected in 1999 and 470 fires and 47 ha in 2000 (DAMA, 2001).The Ministry of Environmental and Natural Resources of Venezuela reports 755 fires for 1998, 491 agricultural, 146 intentioned, 91 waste burning, 22 forest, and 5 urban area and undetermined. The number of forest fires reported is surprisingly low probably due to under registration of events. No information on area affected was available.

2.6. OTHER PTSs OF EMERGING CONCERN

2.4.2. Atrazine

Atrazine, a triazine herbicide, has been used over the past 40 years as an effective broad-leaf herbicide in corn, sorghum, sugarcane and other crops and for non-specific treatment of weeds along railways and highways. In many developed countries use of atrazine is restricted. Atrazine is one of the most used herbicide in the Region. Import statistics for this compound amount to

1 276 241 kg for 1998-1999 in 11 countries of the region (Table 2.9).

Table 2.9. Atrazine, endosulfan, and pentachlorophenol imported in Region X during 1998-1999 (in kg of active ingredient)

Country	Atrazine	Endosulfan	Penta-chlorophenol
Belize	16 768	-	-
Guatemala	326 131	231 121	
El Salvador	407 865	33 010	
Honduras	191 740	41 514	4 856
Nicaragua	35 046	23 560	700 (F)
Costa Rica	10 503	50 282	
Panama	113 048	4 096	
Dominican Republic (F)	5 040	42 108	
Jamaica (1999, F)	4 200	6 000	
Trinidad and Tobago (1999, F)	61 000	2 100	
Colombia (F)	104 900	173 500	

F: formulated compound

NA: data not available

Source: IRET/UNA database of pesticide importations for the Central American countries; Chin Sue, 2002; Nieto, 2002; Porro, 2002.

2.4.3. Brominated Flame Retardants

There are more than 60 brominated flame retardants (BFRs) of variable toxicity, including polybrominated diphenyl ethers (PDBEs). PDBEs represent important additive flame retardants with numerous uses within industrial and domestic electronic equipment and textiles. They are similar in behavior (hydrophobic, lipophilic, thermally stable) to PCBs. Growing evidence suggests that PBDEs are widespread global environmental pollutants and that they are capable of bioaccumulation in food chains. Together with polybrominated biphenyls (PBB), PBDEs are the compounds most likely to form dioxins and furans during incineration. When these PBDEs are burned, brominated materials are converted into polybrominated dibenzofurans (PBDFs) and polybrominated dibenzodioxins (PBDDs). Therefore, when plastics containing BFRs, in particular PBB and PBDE, are extruded during the recycling process or when they are incinerated for disposal, hazardous compounds may be released into the environment (Environment Canada, 2000).

Three commercial PBDE formulations are in production. The penta product is used principally to flame retard polyurethane foams in furniture, carpet underlay and bedding. Demand has decreased significantly in Europe, but global demand is continuing to climb with the vast majority 97% (8 290 tons) used in North America in 1999. The deca product consists predominantly of a single congener, BDE 209. Global demand was 54 800 tons in 1999 with the majority (44%) consumed in North America. Deca is used predominantly for textiles and denser plastics such as housings for a variety of electrical products in particular TVs and computers.

Commercial octa is a mixture of several PBDEs, used to flame retard a wide variety of thermoplastics and is recommended for injection molding applications such as high impact polystyrene (HIPS) (Holoubeck, 2002).

No data on sources or emissions of brominated flame retardants are available in the Region, although given the uses of these compounds, they are most probably present in imported goods such as computers, TVs, carpets, and prime materials for industry.

2.4.4. Endosulfan

Endosulfan is a mix of two forms of the same chemical (α- and β-endosulfan). In Central America and the Caribbean, it is used to control insect pests in coffee, ornamental plants and vegetables.

Endosulfan is the most imported OC insecticide in Central America today. With the exception of Belize, endosulfan was imported in all Central American countries (Table 2.9). The Central American countries import endosulfan from India, United States, Colombia, Israel, England, Italy and France (IRET/UNA database of pesticide importations for the Central American countries).

Endosulfan is also imported in Colombia, Dominican Republic, Jamaica, and Trinidad and Tobago. The importation of endosulfan in Trinidad in Tobago has decreased to 0.8 and 0.7 tons in 2000 and 2001, respectively. Stocks of endosulfan are still available in pesticide outlet stores in Barbados, but licenses for importation of this pesticide are no longer being issued. However, the sale of endosulfan has also been restricted because of deteriorating labels on the stocks that exist and is therefore not in compliance with the labeling laws operating in the country. Import statistics for this compound amount to 606 291 kg for 1998-1999 in 11 countries of the region (Table 2.9).

2.4.5. Lindane (γ-HCH)

Lindane is the gamma isomer of hexachlorocyclohexane (HCH). It has been used to control soil insects, vectors of human diseases, ectoparasites in animals, and for seed treatment. Volatilization constitutes an important route of dissipation to the atmosphere, particularly in high temperature conditions. Lindane is highly persistent in soils and accumulates in the surface layers.

The annual import of lindane to Costa Rica was of 1.8 tons during 1977-1985, 1.1 tons during 1985-1990 and was subsequently banned. Lindane was canceled or banned in most Central American countries between 1987 and 2000. In Panama lindane was used until 1999 under medical prescription for the control of mites on humans. Currently this use of lindane has been replaced by a treatment based on oils containing limonene as the active ingredient (Espinosa, 2002).

In Belize, lindane has been restricted since 1990, only formulations with less than 1% of the active ingredients being allowed. Belize imported 2 783 kg of active ingredient lindane in 1998-1999. No imports were registered in the rest of the Central American countries during 1998-1999. For the legal status of lindane in Central American countries, see Table 2.2. Lindane was used for screwworm control in Jamaica up to the 1990s. Some quantities are still available at shops. Lindane is still used in Haiti but no data is available on quantities. No information was available for the rest of the Caribbean countries.

2.4.6. OrganicMmercury

Mercury is a highly toxic element for living organisms, which occurs in various physical and chemical forms in the environment. Elemental (Hg^0) and mercuric ions (Hg^+, Hg^{2+}) are the predominant natural forms in the atmosphere and water, while cinnabar (HgS) is commonly found in mineralized soils and under anaerobic conditions (Mitra, 1986; Lindqvist, 1991). It enters into the aquatic environment as inorganic mercury through the river discharges and by air transport: as a result of volcanism, weathering of the rocks, as fungicide in agriculture and paint and paper industry or as a side product in different human activities. Once in the water column or in the sediments the microbial activity can transform it in monomethyl mercury (CH_3Hg^+) a form that is more toxic and retained longer in the organisms (Ramamoorthy *et al*., 1982).

Many of the Central American and Caribbean countries have important natural sources of mercury. Many of them posses high volcanic activity and have been formed through volcanic activity. Some of the countries in the region are located in the East Pacific's high mercury sediment content belt. Most countries have banned

the use of mercury as a fungicide or insecticide since the 1960s. Mercury might also be a side product of human activities such as gold mining, non metal extraction; dental laboratories and hospitals; fish canning; municipal waste; mercury lamps, batteries and electrical components (de la Cruz, 2002). Organic mercury compounds such as mercury phenylacetate (5 500 kg/year) and mercury succinate (600 kg/year) are imported by paint companies in Haiti (Carré, 2002). Within the Region, no data has been reported for emissions to air, water and soil.

The Government of the Dominican Republic established an interinstitutional Working Group on heavy metals, with supporting studies ongoing.

2.4.7. Organic Lead

Lead may be used in the form of metal, either pure or alloyed with other metals, or as chemical compounds. The commercial importance of lead is based on its ease of casting, high density, low melting point, low strength, ease of fabrication, acid resistance, electrochemical reactivity with sulfuric acid, and chemical stability in air, water, and soil. At least half of all lead consumed worldwide is used for lead-acid batteries used in automotive and various industrial applications. Certain dispersible or readily bio-available uses, such as lead in gasoline, as a solder in piping for drinking water and food cans, and household paints, have been or are being phased out due to environmental and health concerns (ATSDR 2002).

Leaded gasoline, which has been used throughout the Region X as the primary fuel for automobiles is gradually being phased out. Leaded gasoline is still being used in Trinidad. The number of registered vehicle on the roads in Trinidad has been increasing at an annual rate of 20 000 and is now estimated at 300 000, or 23 cars per 100 persons (personal communication 2002, Ministry of Works and Transport). This source of tetraethyl lead has significant potential for impact on biota, including humans.

In Panama, tetraethyl lead was added to the gasoline (premium and regular) until august 2001. In 1999 an amount of 416 kg of the antiknock agent was imported. In 2000, the quantity introduced into the country was 7 954 kg. The annual consumption in the year 2000 of leaded gasoline was a volume of 74 447 970 gallons. The amount of tetraethyl lead added into the gasoline was 3.25 ml/gallon. The vehicles operated with leaded gasoline have been the major source of lead in Panama (Espinosa, 2002).

In the Dominican Republic, lead was eliminated from gasoline as of January 1999 (Porro, 2002) and in Guyana leaded gasoline was phased out in December, 2000 (EPA Guyana, personal communication). The Dominican Republic Government established an interinstitutional Working Group on heavy metals, with supporting studies ongoing. Leaded gasoline is also banned in Jamaica and Costa Rica. It is probably phased out in other countries too but we have no documented information. Lead contaminated sites have been identified in St. Catherine and St.Andrew, Jamaica, recycling of batteries was the source of this release (Chin Sue, 2002). Lead-acid batteries used in automotive and various industrial applications are a source of lead in all countries of the region. As in Trinidad the number of registered vehicles is increasing every year. Costa Rica reports an annual increase in vehicles of about 8% for an estimated 900 000 vehicles in 2002. A recent study (Ortiz, 2002) reports Costa Rica exports 154-198 tons of lead-acid batteries to El Salvador for recycling.

2.4.8. Organic Tin

Organic tin compounds comprise mono-, di-, tri- and tetrabutyl and triphenyl tin compounds. Their impact on the environment is well known. Tributyl tin compounds are the most hazardous tin compounds. Studies in world oceans have demonstrated shell malformations of oysters, imposes in marine snails, reduced resistance to infection in flatfish, and effects on the human immune system. Organotin is used in the production of plastics, food packages, plastic pipes, pesticides, paints, and pest repellents (ATSDR, 2002). Inorganic tin compounds are used in the glass industry to give added strength to glass. Inorganic tin compounds also serve as the base for the formulation of colors, as catalysts, and in perfumes and soaps (ATSDR, 2002).

The major primary source of tributyl tin is leaching from ocean ship hulls. Related activities that cause emissions of tributyl tin compounds are sea ship traffic, docking activities and dumping of dredged material. In addition sources include industrial discharges from production and formulation of all organic tin compounds and atmospheric deposition of organic tin compounds. Tributyl tin compounds are used for wood

conservation: application, leaching, dumping of conserved wood as waste. Further sources are antiseptic or disinfecting use of tributyl tin compounds and disposal of harbor sediments contaminated with organic tin compounds (OSPAR 2000).

In Region X, no data are available for emissions to air and soil. Yachting and boating are popular pastimes in the Caribbean. The region is also exposed to heavy ship traffic. Small-scale fishing is prevalent. Organotin compounds, particularly tributyl tin, used in marine paints as an antifouling agent, are expected to be found concentrated in coastal waters and sediments around boatyards and marinas in the Caribbean. These compounds are normally released from the paint used on boat bottoms into surrounding waters. In boatyards where scraping of boats for repainting is done, high levels are usually found in sediments in surrounding areas. However, few studies on organotin levels in the environment have been conducted in the Caribbean region. Studies conducted in Trinidad for levels of tributyl tin in sediments and in the United States Virgin Islands revealed levels of tributyl tin in and around boatyards significantly higher than the limits known to be safe to invertebrate organisms (Singh, 2002).

All countries of the Region are exposed to ship traffic. Panama is exposed to the heaviest traffic, with some 15 000 ships crossing the Panama Canal each year.

Panama also reports the use of triphenyl tin as a fungicide in agriculture (Espinosa, 2002). Some 300 farmers in 3-4 areas of approximately 500 hectares use triphenyl tin. Two other organotin pesticides are registered for use in some Central American countries: fentin hydroxide and fentin acetate (IRET, 1999). Organotin pesticides are still used in Cuba for potato growing, however, the use of these compounds is declining (Dierksmeier, 2002).

In Guatemala, the organotin compound fenbutatin oxide (commercial name Torque 50 WP) is registered as an insecticide and acaricide. Even if not legally banned, it is not used currently. The last importation of 723 kg occurred in 2000 (de Campos, 2002). In 1999 Panama imported 648 kg and Costa Rica 779 kg of fentin hydroxide (IRET/UNA database of pesticide importation for the Central American countries).

Organotins are also used as accelerators of the vulcanization reaction in tire production.

2.4.9. Pentachlorophenol

Because of their broad pesticidal efficiency spectrum and low cost, PCP and its salts have been widely used as algicides, bactericides, fungicides, herbicides, insecticides, and molluscicides with a variety of applications in the industrial, agricultural, and domestic fields. Its salt, sodium pentachlorophenate, is used for similar purposes and readily degrades to PCP. World production of PCP is estimated to be of the order of 30 000 tons per year. The relatively high volatility of PCP and the water solubility of its ionized form and release into the environment from a number of diffuse sources have led to widespread contamination of the environment with this compound.

The only documented reports of importation of PCP in the Region concerns 4 856 kg of active ingredient in Honduras where it is of restricted use since 1988 and 700 kg of formulated product in Nicaragua for the period 1998–1999. PCP is not registered in Guatemala, but it is widely distributed in hardware stores for wood preservation (Campos, 2002).

2.4.10. Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a group of compounds consisting of molecules containing 3 or more fused benzene rings, although bicyclic compounds are often included. PAH compounds are toxic and bioconcentrate in invertebrates in the aquatic environment. Vertebrates are able to metabolize PAHs, the resultant metabolites being reactive compounds, some of them carcinogenic.

Combustion sources are thought to account for over 90% of the environmental burden of PAHs. Stationary point sources account for around 90% of these inputs (Howsam and Jones 1998). Inputs to the atmosphere are dominated by emissions associated with residential heating (coal, wood, oil and gas burning) and industrial processes such as coke manufacture. Non-combustion processes such as the production and use of creosote and coal tar and the remediation of sites contaminated with these substances, though poorly quantified, are significant primary and secondary sources.

There are no inventories of PAH sources or estimates of emissions for the Central American and Caribbean region. An overview of PAH sources is shown in Table 2.10.

A major source of PAHs in the Region is import and national production of crude oil in. In most countries, this fossil fuel is used mainly for transport and power generation. Crude oil extraction through terrestrial and offshore drilling operations in countries such as Trinidad & Tobago, Venezuela and Barbados produce a commodity rich in polycyclic aromatic hydrocarbons. In Barbados, which is the smallest producer of crude oil and natural gas, approximately 37.9 million cubic meters of natural gas were sold and 559 675 barrels of crude oil produced in 2000. Local crude oil production meets roughly half of the domestic requirements. The crude oil produced is exported to Trinidad for processing. Within Region X there are three major centers where crude oil is processed through refinery operations. These refineries are located in Venezuela, Trinidad, and Jamaica. Refinery operations in Barbados were halted approximately five years ago.

Jamaica imports 7 202 million barrels of crude oil annually. The Jamaica Petroleum Cooperation refines it locally. Other major industries within Jamaica include bauxite processing into aluminum and cement manufacture (Chin Sue, 2002). Eighty five percent of the chemicals imported into St. Lucia are petroleum products and related materials (Magloire, 2002). In the Dominican Republic, refined petroleum is produced at a daily rate of 16 000 barrels in Falconbridge (Monseñor Nouel); the Dominican Refinery of Petroleum REFIDOMSA (Haina) produces 33 250 barrels per day. REFIDOMSA imports petroleum for refining, most of it from Mexico.

In Nicaragua, the ESSO refinery, located beside lake Xolotlan, in Managua City, is a major source of contamination by petroleum hydrocarbons. Costa Rica has an annual consumption of 14.4 million barrels of petroleum hydrocarbons, processing 25 000 barrels per day in a refinery in Limon next to the Caribbean coast. Energy consumption in Colombia was estimated for 1999 as follows: oil 49.2%, natural gas 14% and coal 7.8%.

Motor vehicles with internal combustion engines using fossil fuels are another source of PAHs. Colombia reported 2 821 457 motor vehicles in 2001, 43% of which were more than 15 years old. Venezuela had 2 039 000 motor vehicles in 1995. Costa Rica reports 900 000 vehicles for 2002 and Panama 300 000. The number of motor vehicles in Honduras was of 460 808 units in 2000 (Sabillon, 2002). The number of registered vehicles in Trinidad & Tobago has been increasing at a rate of 20 000 per year and is now estimated at around 300 000, or 23 cars per 100 persons (personal communication 2002, Ministry of Works and Transport). Barbados estimated 68 580 vehicles, or 25 cars per 100 persons, and St. Lucia 22 275 vehicles (15 vehicles per 100 persons).

Waste oil is a source of PAHs of considerable concern in every country in the Region. A major source of used oil results from the growing number of vehicles. Thus, in Nicaragua, waste lubricating oil discarded from motor vehicles is a significant problem. Attempts are being made to contain waste oil by legal means (Cruz and Flunky, 2002)

Oil-lubricated engines, including generators for electricity, contribute significantly to the generation of used oil. Oily waste from ships and boats sailing the Caribbean Sea are either discharged illegally into the coastal waters or offloaded at Caribbean ports. An inventory conducted by the Caribbean Environmental Health Institute (Singh & Glasgow-Chung, 2001) revealed used oil to be the hazardous waste of major concern in the six countries surveyed in the inventory.

An important source of PTS in the environment in Colombia is the spillage of oil and oil derivatives as a consequence of dynamiting oil pipelines by armed groups. Statistics from the oil company ECOPETROL show that during 1986-2000 there were 752 bombings of the pipeline, with a spillage of 2 400 000 barrels. More than 6 000 ha with agricultural and cattle-raining potential, 2 500 km of rivers and other running surface waters, and 1 600 ha of lakes and marshes have been affected (Nieto, 2002). Some of the spillages have affected Venezuela and Ecuador.

In October 2001, one of the many incidents involving the dynamiting of the Caño Limon pipeline in Colombia caused 43 000 barrels of crude oil to spill into Catatumbo and Tarra rivers that flow into Venezuela. In the past, there have been 34 similar incidents that affected Venezuela. Though the oil spills

have been contained, the areas remain contaminated. The environmental damage from the oil spills has affected local fishing and farming.

One of the major environmental oil-spill related accidents took place in the middle of the night of February 28, 1997, when a Greek tanker fractured its hull in the navigation channel of Lake Maracaibo, the largest lake in South America, extending over 13,280 square kilometers. In a matter of an hour, 25,000 barrels of heavy oil spilled into the waters. Between February 1996 and February 1997, an average of one accident took place in this navigation channel every 40 days. Spills also occur regularly from the many oil wells in the area. In 1997, simultaneous spills from two wells leaked oil Lake Maracaibo for two weeks undetected, seriously damaging neighboring mangroves and local wildlife (Centeno,).

Table 2.10. Occurrence of potential sources and sub-sources of PAHs in Region X

Source	Occurrence
Agriculture	
Field burning of stubble/straw	XX
Transport and infrastructure	
Road transport	XX
Inland waterways	X
Maritime activities	X
Air traffic	X
Building materials	
Construction and demolition (use of creosote treated timber)	XX
Households	
Other equipments (domestic combustion of wood, oil, coal and peat)	X
Industrial activities	
Combustion processes (Power generation)	X
Manufacture of pulp, paper and paper products; publishing and printing (combustion of wood)	X
Manufacture of chemicals, chemical products and man-made fibbers	
Manufacture of basic metals and metal products	X
Wood preservation (creosote and carbolineum treated timber)	X

Coke oven furnaces (door leakage and extinction)	X
Smelters of iron and steel	X
Source	**Occurrence**
Ferro alloy industry	X
Shipbuilding and repair	X
Anode production	X
Extraction and distribution of fossil fuels and geothermal energy	X
Waste disposal	
Waste water treatment	X
Waste incineration and pyrolysis	X
Open burning of agricultural wastes	XX
Cremation	
Solid waste disposal on land	XX
Contaminated land/sediments	
Sediments in lakes and rivers	
Contaminated sites and soils	XX

XXX: major; XX medium: X: minor

2.4.11. Short chain Chlorinated Paraffins

Chlorinated paraffins are complex mixtures of straight chain chlorinated hydrocarbon molecules with a range of chain lengths (short C_{10-13}, intermediate C_{14-17} and long C_{18-30}) and degrees of chlorination (between 40 - 70 % weight basis). It is believed that 50% of the chlorinated paraffins produced in the world have carbon chain lengths of between 14 and 17 and a chlorine content of between 45 and 52%.

Over 200 commercial formulations with a range of physical and chemical properties exist which make them useful in a wide range of applications, such as secondary plasticizers in PVC and other plastics (C_{10-13} and C_{14-17}), extreme pressure additives in lubricants (C_{14-17}), flame retardants (C_{10-13}), sealants (C_{10-13} and C_{14-17}), and paints. In 1985, the estimated world production of chlorinated paraffins was about 300 000 tons (WHO, 1996).

Chlorinated paraffins may be released into the environment from improperly disposed metalworking fluids containing chlorinated paraffins and from polymers containing chlorinated paraffins. Loss of chlorinated paraffins by leaching from paints and coatings may contribute to environmental contamination. The potential for loss during production and transport is expected to be less than that during product use and disposal.

Chlorinated paraffins are not produced in the Region but are imported in goods or as raw material for the regional industries. For example, limited amounts are expected in Jamaica where thinners and other solvents are frequently used. Jamaica does not regulate these products. No data on quantities are available for the region.

2.4.12. Phthalates

Phthalates are used as plasticizers in gloves, flooring and flexible sheets, adhesives, coatings, cosmetics (perfume solvent and fixative), suspension agents for solids in aerosols, lubricants for aerosol valves, antifoamers, and skin emollients.

Phthalates are imported for use in different industrial activities, such as paint and plastics manufacture and tanneries. Import data are scarce. El Salvador (Gonzalez & Calderon, 2002) reported annual volumes of 193 kg of phthalate anhydride and 964 kg of di-octylortho phthalate.

2.4.13. Nonyl and Octyl Phenols

These are high-volume chemicals that have been used for more than 40 years as detergents, emulsifiers, wetting agents and dispersing agents. Nonyl phenol polyethoxylate-containing products are used in textile processing, pulp and paper processing, paints, resins and protective coatings, oil and gas recovery, steel manufacturing, pest control products and power generation (CEPA, 1999).

A variety of cleaning products, degreasers and detergents containing these products are available for institutional and domestic use. They have numerous applications, including controlling deposits on machinery, cleaning equipment, scouring fibers, as wetting and de-wetting agents, in dyeing, in machine felt cleaning and conditioning and in product finishing. They are also used in a wide range of consumer products, including cosmetics, cleaners and paints (CEPA, 1999).

Octyl and nonyl phenols are imported for use in different industrial activities, such as textiles, tanneries, paints, plastics, pesticide formulating and other chemical industries. Quantitative information is scarce. Import statistics from El Salvador (Gonzalez & Calderon, 2002) indicate average annual values of only 93 kg of octyl and nonyl phenols.

2.5. OBSOLETE STOCKS

Obsolete PTSs are old, outdated PTSs, unused and stockpiled as waste or awaiting disposal. They include large quantities of banned organochlorine compounds that are highly persistent in the environment, such as DDT, dieldrin, endrin, HCH, and PCBs. Dealing with obsolete stocks is a global problem. The world total is estimated at over 500 000 tons (Poznan, 2001).

Obsolete pesticides are stockpiled in underground wells called tombs or simple holes, in old warehouses, military bunkers, unsecured ground pits, open sheds in the field, in farms, etc. Many such stocks have seriously deteriorated and are currently a source of severe pollution, a threat to human health and the environment, especially groundwater.

To combat the problem of obsolete PTSs, further accumulation of expired or obsolete stocks has to be prevented. Inventories of obsolete stocks have to be carried out, followed by a safe and environmentally sound disposal of bulk quantities of obsolete PTSs.

Unsafe storage of obsolete stocks is common in the Region. Data on the locations, contents and volumes are grossly insufficient. Technical and financial resources for the safe disposal are lacking.

2.5.1. Export of Hazardous Chemicals

Some of the countries in the Region have been exporting their stocks of obsolete PTSs to countries where they can be safely disposed of. Nicaragua sent, in 1999, 437 000 kg of the most dangerous waste of pesticides to incinerate in Finland. Of the total approximately 25% were financed by the PROMAP/MARENA, 75% by the Government of Finland (Cruz and Flunky, 2002).

During 1998 to 2000, the Government of Barbados exported several shipments of hazardous waste for disposal to Canada. The export of the hazardous waste from Barbados and the import of the said waste into Canada were done under the requirements of the Basel Convention for the Control of Transboundary Movement of Hazardous Waste and their Disposal. The compounds exported included 1840 L of a mixture of aromatic and aliphatic solvents, 400 L of methylene chloride, 200 L of toluene, 200 L of petroleum oil and 32

L of chloroform. It is noteworthy that while the classification system used for waste intended for export by industries in Barbados indicated solid and liquid toxic pesticides, the substances exported out of Barbados and eventually identified through analysis did not indicate corresponding levels of pesticides. Officials at the Environmental Engineering Division of the Ministry of Physical Development and Environment explained this incongruence as being due to a classification scheme developed and applied by the importing firm in the receiving country. This company did not have information on the chemical composition of the waste to be imported and erred apparently on the side of caution.

Jamaica conducted an island-wide exercise to dispose of obsolete pesticides, including some PTSs. Between 1996 and 1998, approximately 8 000 kg were exported to the United States. Included were obsolete stocks of DDT. Between 1993 and 2000, approximately 1 200 tons of PCBs were exported to France for incineration. The procedure was carried out as stipulated under the Basel Convention, with the Natural Resource Conservation Authority (NRCA) acting as the competent authority in Jamaica. Since then, other pesticides and PTS containers have been located and await disposal. The new stock includes heptachlor, dieldrin, and empty containers of endosulfan.

Colombian exports of hazardous and other wastes in 2000 included 16.9 metric tons of PCB-containing capacitors and transformers PCBs to France. Trinidad and Tobago exported 1 200 tons of PCB waste to Canada, the year was not specified (RFI, 2002). On December 1999 after Hurricane Mitch, Honduras exported, with the assistance from the World Bank, 103 000 kg of obsolete pesticides (Sabillon, 2002). Costa Rica has exported 56.5 tons of PCBs during 4 years (Min. of Health, personal communication). Presumably all of these exportations were carried out under the requirements of the Basel Convention.

2.5.2. Identification of Stocks and Reservoirs of PTS

An inventory of stocks and reservoirs of PTSs in the Caribbean was undertaken through the Food and Agriculture Organization, focusing on capturing data on obsolete pesticides but also of unknown substances with some probability of being pesticides. Inventories were compiled in Trinidad and Tobago and St. Vincent, with the last update for the year 2000. The information captured in these inventories remained indicative, since the inventories were not comprehensive. The most detailed inventory was compiled for Trinidad and Tobago, which showed 210 entries. PTSs identified included: atrazine (108 kg), DDT (24 tons), endosulfan (0.75 L) and mirex (26 kg) (FAO, 2000). The St. Vincent inventory listed only 11 entries. The only PTS of concern was 28 kg of aldrin.

In Colombia, according to a public invitation by the Ministry of Health to quote repackaging, baling and organizing of DDT stocks, there are approximately 123.5 tons of DDT stored in two warehouses located in Honda and Bogotá (www.minsalud.gov.co/newsite/msecontent/news detail). However, preliminary data from the FAO/COL/TCP/0065 Project Technical Assistance for the Elimination of Obsolete Pesticides (FAO –Ministry of Environment), presented at a seminar in 2001, reported some 178 tons of DDT being stored under the responsibility of provincial and national health services. A private organization of cotton growers reported 20 tons of toxaphene and 250 kg of calcium arsenate in stock (Nieto, 2002). There are possible burials of obsolete pesticides in zones of intensive use of pesticides in the departments of Antioquia, Atlantico, Bolivar, Cesar and Cundinamarca. Just one of these sites has been evaluated for organophosphate and organochlorine compounds. An inventory in Venezuela identified 140 tons of obsolete PTS pesticides around the country (Min of Environment, personal communication).

The National Center for Control of Tropical Diseases of the Dominican Republic has a stock of 40 tons of DDT. A small amount of heptachlor has been stocked in St. Lucia. Guatemala has poorly stored stocks of 10 obsolete pesticides, including DDT and dieldrin (Table 2.11). Costa Rica reported only obsolete stocks of DDT but the recent finding of an old PCB containing transformer in a residential area and a buried drum of toxaphene in an abandoned banana plantation area near a drinking water well, illustrates the fact of unknown quantities and location of obsolete PTS and the need for inventories (Castillo, 2002). Table 2.11. presents data on select obsolete pesticides in some countries of the Region.

Table 2.11. Obsolete pesticides known in the Central America and Caribbean Region (kg)

Country	Aldrin-Dieldrin	Chlordane	DDT	Endrin	Heptachlor	Mirex	Toxaphene	HCH
Belize	1	19	13 000		-	28	6	1
El Salvador	1 814	-	4 672		1 040	-	27 900	7 802
Nicaragua			6 300				250 000	
Guatemala	100		14 585					
Honduras		19 900	18 900					12 560
Panama			5 000					
Costa Rica			8 300					
Colombia			178 000				20 000	
Dominican Republic			40 000					
Jamaica					55			
St. Lucia		23			23			
Trinidad and Tobago			24 000			26		
Venezuela	17 146	11 607	113	96 693			15 359	

Source: Country reports for RBA PTS - Region X

Obsolete DDT and toxaphene stocks for the 13 countries which presented information amounted to a total of 312 870 kg and 313 265 respectively. Additionally Belize reported 7.5 liters of endosulfan and Trinidad and Tobago 108 kg of atrazine. Endosulfan and atrazine are still used in all countries except for Colombia and Belize, where endosulfan is banned. The danger of obsolete stocks is illustrated by the fact that 658 Kg of DDT stocked at a facility of the Ministry of Health in Matagalpa, Nicaragua, was lost during Hurrican Mitch in October of 1998 and carried away by the waters of the River Grande de Matagalpa which drains into the Caribbean (ISAT, 2000).

None of the countries in the region have full national inventories of PCBs stocks and uses. This is attributed to the lack of human and financial resources, and legislative frameworks. Colombia, Costa Rica, Cuba, El Salvador, Nicaragua, Panama and Venezuela have compiled preliminary inventories for PCBs. The Costa Rica inventory concerns stocks, not uses. The country reported having exported 56 472 kg in transformers between 1998 and 2001. Nicaragua´s preliminary estimates of PCB in transformers in use for electrical distribution nationally during 1980–2000 were 820 684 gallons, and in privately owned transformers 4 430 gallons.

In El Salvador, the preliminary inventory of PCBs was carried out by the Ministry of Environmental and Natural Resources. It showed that approximately 165 000 kg of PCBs are stored and will be exported to France according to the Basel Convention.. The shipment will be destroyed by incineration in soil and will take place in 2002-2003 (González and Calderón, 2002). The PCBs are contained in 17 transformers and 153 capacitors.

Honduras does not have an inventory of PCBs. The National Electric Company is the principal source of PCBs. Transformers with labels that identify PCB levels in the range of 50-500 ppm have been sold to

private companies. New transformers are labeled “non-PCBs” and are reported to contain less than 1 ppm of PCBs (Sabillon, 2002).

Panama has undertaken a preliminary survey of PCBs and reports approximately 95 tons of PCBs being stored in both solid and liquid forms at Rio Hato by one firm, Edemet Edichi S.A. In addition, gallons of electrical fluid are warehoused in Bahia Las Minas by the hospital of the Caja de Seguro Social; and 30 000 kg in an Egeminsa transformer. Another 200 000 kg of PCB fluid form Egeminsa is being shipped to Belgium for controlled incineration (Espinosa, 2002).

A project for the Central American region to train official authorities and interested organizations in the management of PCBs, including an inventory for each country and action plan, will take place in 2002-2003.

At the beginning of 1998, a preliminary inventory of PCBs was undertaken in Colombia by the Ministry of Mines and Energy by sending a questionnaire to companies of the electrical (generators, carriers and distributors) and oil sectors. Only 22% of companies answered. The total quantity of PCBs was estimated at 2 000 tons, which was recognized as an underestimate (Proyecto CERI-ACDI-COLOMBIA, 1999). Companies in the electrical sector are carrying out plans to discontinue PCB-containing transformers and other equipment. Some have designed and put contingency plans into action (Nieto, 2002).

Sites have been identified in Santo Domingo containing unused transformers without any care and protection. The oil of the old transformers is sold at about 6 to 17 US$ per 55 gallons. There are more than 18 facilities for fixing transformers (Porro, 2002).

In Jamaica, use of PCBs in transformers is prohibited. Transformers containing PCBs are awaiting disposal. Since there are no areas for storage of stocks for disposal, the Authority has been hesitant to make a national appeal to report obsolete pesticides. However, the authorities are occasionally notified of small quantities (Chin Sue, 2002).

PCB oils and other PCB containing materials are still imported to St. Lucia. St. Lucia has a waste transformer farm containing 150 discarded transformers that are said to contain PCB (Magloire, 2002).

In Trinidad, the Power Generation Company of Trinidad and Tobago targeted the full replacement of PCB based oils by 2000. All the oils have been replaced and are in secure storage awaiting off-island disposal at a licensed facility in Canada. The Trinidad and Tobago Electricity Commission, which is responsible for the distribution of electricity on a countrywide basis, reported that they no longer use PCB-based oils. An inspection was performed of one of their main distribution facilities in east Trinidad where used oils are stored in drums on the premises. The consultant who visited the site observed that the oils are insecurely stored and therefore pose a significant risk of entering the environment. Trinidad and Tobago exported $1.2x10^{-5}$ kg of PCB waste to Canada for destruction, the year was not specified (RFI, 2002).

In the Dominican Republic, an inventory of sources of PCB is being designed. The country does not have a mechanism for the elimination of PCBs. A Venezuelan inventory identified 270 tons of PCB oil in 14 locations, the amount of PCBs in Venezuela in 1993 was estimated at 3 374.5 tons, located in all the states (Min. of Environment, personal communication). Registered oil and electricity companies owned most.

National inventories are needed to determine uses and quantities in materials (transformers, capacitors, ballast, motors, magnetos, heat-exchange fluids, hydraulic fluids, electrical interrupters, weapons, voltage regulators, electrical cable fluids, plastics, adhesives, carbon copy papers, tints, lubricants, insulating material, sealants, paint in ships, etc.), spread uses, PCBs in storage, and in contaminated sites.

2.5.3. PAHs and Waste Oils

For the Caribbean region, the CEHI conducted a study entitled “Regional Inventory of Hazardous Waste focusing on Discarded and Outdated Chemicals in Caribbean Countries” (Singh & Glasgow-Chung, 2001). This study provides data on stocks of these chemicals in Antigua and Barbuda, Barbados, Jamaica, St. Lucia, St. Kitts and Nevis, and Trinidad and Tobago (Table 2.12.). The information generated in this study is indicative rather than quantitative, since there was a limitation on the completeness of the study brought about by financial constraints.

The CEHI study revealed that in all six countries the main hazardous substances of concern being stockpiled were oily wastes and a variety of solvents, including chlorinated compounds. The types of wastes being stockpiled within these islands can be illustrated by the Barbados example (Singh, 2002). In Barbados, none of the particular chemicals identified for focus of this project is identified. However, through queries made to the Pesticide Control Board, it was revealed that some unidentified obsolete stocks of some pesticides could be stored within the Ministry of Agriculture.

Table 2.12. Information gathered by the CEHI/BASEL study in Antigua and Barbuda, Barbados, Bahamas, Jamaica, St. Lucia, St. Kitts and Nevis, and Trinidad and Tobago

Company	Type of waste	Volume/mass
Advocate Company Ltd.	Developer/finisher: alkylated naphthalene sulfonate; sodium salt; benzyl alcohol; tetrapotassium pyrophosphate; ethoxylated methyl glucoside dioleate; polyethylene glycol; sodium metabisulfite; water	1.5 gal /week
Arawak Cement Plan	Waste oil	1 1000 gal (stored) 550 gal generated per month
B S & T Motors	Engine/gear oil	800 L (stored) 400 L generated per month
Barbados Community College	Organic waste (mixture of carbon tetrachionde, chloroform, acetone, benzene, benzaldehyde, 1,1,3-trichloroethane, propan-1-ol, propan-2-ol.	42 L
Barbados Reference Laboratory	Xylene	10 gal (stored) 5 gal generated per 18 months
Barbados Reference Laboratory	Xylene	4 gals (stored) 2 gals/year
Barbados National Oil Company Ltd.	Cementing defoamer (unknown) Cementing extender (trade secret) Cementing fluid (trade secret) Fiocheck (trade Secret) Retarder (trade secret) Hill Plug walnut (trade secret) Ethylene glycol Triethylene glycol Parid dispersant (unknown) Hunting D6350 demulsifier (unknown) Hyrolic oil	125 gal 770 gal 1 320 gal 275 gal 250 gal 450 gal 600 gal 385 gal 330 gal 330 gal 110 gal
C.F. Caribbean Flavours Ltd.	Chloroform	4.5 L (stored) 1L/month generated
Coles Printery Ltd	VARN A. 230 (unknown)	550 gal
Courtesy Garage Ltd.	Engine Oil	400 gal (stored) 300 gal/month generated

Harrison college	Mixture of organic solvents and lead compounds Xylene Chloroform	500 ml (stored) 1L 750 ml
McEnearney Sevice Centre	Waste oil Thinners	500 gal/month generated 45 gal/month
Steve´s Dry Cleaning	Tetrachloroethylene	2035 gal (stored) 150 gal/year
Tropical laundries	Tetrachloroethylene	55 gal (stored)

Source: Singh & Glasgow-Chung, 2001

The principal uncertainty in terms of these obsolete stocks is their characterization in terms of PTS content. Little is known of the composition of the waste material and it is recognized that within the mixes of chemicals, PTS substances will be present in unknown amounts.

2.6. DATA GAPS

The bulk of the data presented in this section is qualitative and incomplete. There are therefore significant data gaps. Comprehensive inventories on sources and emissions of persistent toxic substances imported are not available in the Region. Caribbean data on the importation of pesticides have not been compiled for the individual pesticides of concern. It is therefore difficult to create a clear picture of the extent of the problem through importation data. However, several countries are improving data collection and reporting.

An inventory of non-pesticidal chemical substances imported as raw material and in goods is necessary to identify and develop appropriate hazard control strategies for PTSs and other chemicals. The countries in the Central American and Caribbean Region have little control over the use of PTSs in commercial goods such as plastics, foams, tires, paints, detergents, etc.

Source data for dioxins and furans have been compiled on the basis of processes that generate them. Reference to the production of dioxins and furans through burning of plastics, land-filling operations, burning of fuels and incineration has been more or less haphazard. Quantities of PTSs emitted through the burning of organic materials during forest and scrub fires and crops have not been estimated.

Likewise, data on PAHs and PCBs in used oil, motor vehicle emissions and industrial estate processes are deficient. Industrial establishments are suspected sources of PTS releases to air, water, soil and waste. Supporting data are scarce.

Available data indicate a need for continued and more extensive data collection to identify hot spots in terms of sources and to measure or calculate emissions.

2.7. SUMMARY

The major anthropogenic sources of PTSs in the Region are agriculture, energy, industry, waste management, and the marine sector. The broad categories of PTSs are *pesticides, unintended byproducts, industrial compounds and PTSs of emerging concern,*. Quantitative source data for PTSs are scarce in the Region, with some documentation for pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), petroleum products, organolead, organotin, and chlorinated solvents, but none for dioxins and furans.

All pesticides selected for the project have been applied in the Region in agriculture or vector control. In one or several countries, atrazine, DDT, endosulfan, heptachlor, lindane, mirex, and pentachlorophenol are currently registered. Endrin, hexachlorobenzene and toxaphene may be still in use. Aldrin and dieldrin are

probably no more in use. Pentachlorophenol has probably been used in several countries and more recently in Honduras and Nicaragua.

PAHs are formed and emitted in power generation, extraction and refining of crude oil, and in combustion engines, including traffic emissions. The petroleum industry, including extraction and refining of crude oil, is a major source of PAHs in the Region. These operations have led to contamination of water, soil and air. PCBs have been used in a number of functions in the 1950s and 1960s in the Region. Transformer oil containing PCBs is encountered. No source or emission data are available for brominated flame retardants or organic mercury compounds. Organic tin compounds are emitted from boats and ships, industrial discharges and other sources. No emission data are available. The historic use of leaded gasoline took place in all countries of the Region. Its continued use in some countries, e.g., Trinidad and Tobago, has contributed to the contamination of air, soil, and water. Chlorinated paraffins are not produced in the Region but are imported in unknown quantities. Unknown, probably small amounts of nonyl and octyl phenols are being imported.

For unintended by-products, occasional inventories of sources or estimates of emissions of PAHs are encountered. Inadequate incineration of domestic, industrial and agricultural waste and combustion for land clearing are potential sources of polychlorinated dibenzodioxins (PCDDs) and dibenzofurans (PCDFs), hexachlorobenzene (HCB), and PAHs. Spontaneous ignition at landfill sites, and in some cases deliberate burning of municipal garbage were regarded as further significant sources of dioxins and furans. Waste oil adds to the burden of PAHs contamination. Large quantities of oily waste have been discharged into the environment leading to contamination of waterways, coastal areas and soil. Some used oil has been stockpiled. Internal combustion engines, especially diesel engines, are a potentially major source of PAHs to the environment. Burning of wastes in landfill sites in most countries is illegal, though spontaneous burning of municipal waste has been reported. Incinerators are widely used for hospital wastes. Worn tires are burned as an energy source in Colombia, Costa Rica and El Salvador and probably other countries. PCDDs and PDCFs may be produced as by-products in a number of industrial processes and also by volcanic activity and forest fires. The deficiency or absence of recycling regulations and facilities for plastic waste adds to the waste burden. Disposal of obsolete stocks of banned pesticides poses a problem. At least 312 000 kg of DDT is stocked in the Region, especially in Colombia; and some 313 000 kg of toxaphene, most of it in Nicaragua. Further stocks contain aldrin-dieldrin, chlordane, endrin, and heptachlor. Some of the stocks, such as PCBs and obsolete pesticides including PTSs, have been exported outside the Region for incineration. The use of PCBs in electrical transformers represents the single largest source of PCBs in the region. Stocks of PCBs in all the countries are awaiting full inventory and disposal.

The most important PTSs of emerging concern are atrazine, brominated flame retardants, endosulfan, lindane, organic mercury, organolead compounds, organo tin, pentachlorophenol, PAHs, short chain chlorinated paraffins, phthalates, nonyl phenols and octyl phenols.

Data gaps in the Region for PTSs are considerable, emphasizing the need for reliable inventories and emission data.

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3. ENVIRONMENTAL LEVELS

3.1. LEVELS AND TRENDS IN THE ENVIRONMENT

3.1.1. Introduction

This chapter summarizes the regional evidence of the presence of PTSs in the different environmental compartments, with emphasis on environmental levels and trends. The compartments are defined as air, marine and fresh water, and terrestrial ecosystems.

There are very little systematic data on the environmental occurrence of PTSs in the Region. No regional monitoring and surveillance programs exist for several PTSs. On the country level, some data are available. The PTSs with some data are OC pesticides (mainly DDTs, HCH and toxaphene) and in some cases PCBs, but there are very few data about PAHs, phthalates, and no data on PCDDs or PCDFs. Guatemala reports that even if no quantification has been attempted on phthalates, their ubiquitous nature shows up as interference when environmental samples are analyzed for OCs.

Occasional studies of environmental levels of PTSs have been conducted during the past 3 decades in almost all countries of the Region, starting in Guatemala in 1971. University research groups or governmental institutes conducted most studies. Many were conducted in collaboration with and/or supported by universities, institutions from the US, Canada or Europe, or by international agencies. International agencies such as IAEA and PAHO/WHO, usually supported regional studies.

Most of the available data are summarized in tables 3.1 – 3.22. Unfortunately, comparisons between the different studies are difficult because of various factors: limited number of studies, different types of substrates analyzed, different analytical methodologies (packed versus capillary column separation, lower versus higher precision and accuracy, different quatification limits), and results not presented in a standardized form. For example, OC residues in biota are presented as fresh weight, dry weight or lipid weight. Crucial information, such as time, location and conditions of sampling, was sometimes insufficiently described or missing. Most of the studies have been carried out at different times, by different researchers, and for different purposes. The data tended to remain unique and samples were seldom analyzed in duplicate.

Some of these studies have been published in international or national peer reviewed journals Book chapters, doctoral or master theses and technical reports were reviewed. In addition to OC pesticides, some of these studies dealt with organophosphate insecticides, phenoxy acid herbicides, and particular pesticides used on particular crops. The majority of studies included more than one environmental substrate.

3.1.2. Air

Air constitutes an important medium for transport of PTSs. Certain extensively used PTSs such as DDT may migrate through air from the tropical areas to the colder areas (Jones & De Voogt, 1999). No regional monitoring data are available. The only data available are for OC pesticides from two ambient air sampling campaigns in Belize and Costa Rica (Alegria et al, 2000; Wania, 2002). This type of studies should be carried out on a more regular basis. The levels and its relation with an inventory of sources would greatly enlighten the knowledge on transboundary movement.

3.1.2.1. DDTs

The two only studies in the region indicate that DDTs are present in Belize in levels indicating recent usage (Table 3.1). The levels found for DDTs in Belize air were elevated and were higher than the levels measured at Great Lakes monitoring stations. DDT residues were higher in the rural environment in Belize and the levels tended to be higher during the winter sampling period (Dec-Jan) (Alegria et al., 2000). The most recent data (Wania et al., 2002) derive from a large scale mapping of long-term average atmospheric POP concentrations in a network of more than 40 passive sampling stations in North America and elsewhere. Two of these stations were located in the Region, one in the mountain region in Costa Rica and one in the lowlands in Belize over a period of one year (Table 3.1). DDT concentrations were almost ten times lower in samples taken in the cloud forest in Costa Rica than in the samples taken in the Belize lowlands.

3.1.2.2. Dieldrin

Concentrations of dieldrin were determined in 1995-1996 (Table 3.1) during two periods in samples collected from two locations in Belize with active sampling technique (Alegria et al 2000). Dieldrin residues were 20 times higher in the inland rural than in the coastal urban environment. Levels tended to be higher during the winter sampling period (Dec-Jan).

The results are summarized in Table 3.1. The authors concluded that the levels found for aldrin/dieldrin were elevated and were comparable to levels at the Great Lakes monitoring stations which is rather surprising since Belize banned pesticide use of aldrin and dieldrin in 1985, most of the countries in the region banned this substances in the 80´s or early 90´s with the exception of Jamaica where it was banned in 1999.

3.1.2.3. Other OCs

Toxaphene, heptachlor and chlordane levels were comparable or lower than recently measured levels in the USA. Endosulfan levels analyzed with the passive sampling technique were low in Belize but the results from Costa Rica were non conclusive since the duplicate samples showed different results (Wania, 2002). Endosulfan is one of the PTS pesticides regularly used in the region (Table 2.9).

Table 3.1. Atmospheric levels of PTS in air

Country /period	Sampling site(s)	Results	Observations	Reference
Belize 1995-96	Belmopan (Inland: citrus, banana, vegetable growing area); Belize City (coastal area). 2 sampling stations; 2 sampling periods (Dec/Jan and July/Aug); sampling time 18-67 h; sampling volume 500 – 1400 m^3	Geometric means Belize / Belmopan (pg/m^3): ΣDDT 216 / 992 Dieldrin 34 / 728 Toxaphene 28 / 33 γ-HCH 26 / 33 Heptachlor 0.3 / 0.9	Aldrin, dieldrin and DDTs tended to be higher in Dec/ Jan period. Higher levels found in inland sampling point. DDT higher in Belize than North American stations.	Alegria et al., 2000
Belize 2001-02	Belmopan Passive air sampling (over 1 year); 1 sampling station; sample in duplicate	Values of duplicates in ng/sample γ-HCH 1.1, 1.3 α-HCH 0.3, 0.5 cis chlordane 1.3, 1.4 trans chlordane 1.3 : 1.8 α-endosulfan 0.9 heptachlor 0.3, 0.2 p,p'-DDE 38.2, 38.0 p,p'-DDT 44.2, 48.7	Central America has the lowest continental α-HCH concentrations. High DDT levels in Belize indicate a recent usage.	Wania et al., 2002
Costa Rica 2001-02	Monteverde (cloud forest, mountain); Passive air sampling (over 1 year); 1 sampling station; sample in duplicate	Values of duplicates (ng/sample) γ-HCH 4.5 : 5.7 α-HCH 0.5 : 1.4 cis chlordane 0.4 : 0.7 trans chlordane 0.3 : 0.5 α-endosulfan 0.0 : 21.8 heptachlor 0.0 : 0.0 p,p'-DDE 0.5 : 0.4 p,p'-DDT 1.8 : 2.8		

3.1.3. Aquatic ecosystems

3.1.3.1. Marine environment

PTS levels in the coastal and marine environment depend on direct release, such as via rivers by industrial discharges, agricultural runoff and urban runoff and by atmospheric deposition.

Lipophilic PTSs accumulate in biota and in the organic fraction of the sediments. They may affect living organisms and become a public health problem through contamination of seafood. Uptake for the smaller marine organisms takes place from the surrounding water by respiratory surfaces. For the higher trophic levels in the marine food chain, such as marine birds and mammals, the major route is by food intake, with the associated biomagnification. It is generally accepted that elimination for lipophilic contaminants decrease with increasing body size.

Evidence suggests that several PTSs may persist in the marine environment for a number of years. The coastline of the countries of the mainland on both sides, the Pacific and the Caribbean, is characterized by mangrove swamps, marshy wetlands, coastal lagoon systems (semi-enclosed water bodies), bays and coral reefs. In Central America most of the rivers are relatively short and several pass through more than one country. In Colombia and Venezuela long rivers end up in estuaries frequently characterized by large mangrove ecosystems with high biodiversity, like the Ramsar Site Cienaga Grande de Santa Maria in northern Colombia, along the Caribbean Coast. Jamaica has 120 rivers, like most Caribbean countries, the island can be considered a watershed. Mangrove swamps can be found along the coastline.

Tropical rainfall causes huge amounts of water draining into the coastal systems and deposits a lot of sediments in these systems.

3.1.3.2. Coastal Water And Estuaries

Few data are available on OC pesticides and PCBs in water samples taken in the marine environment (Table 3.2). The sampling was done in potentially contaminated areas such as estuaries, coastal areas and harbors. No data are available for the open ocean.

Most of the sampled compounds have low water solubility and are often adsorbed to suspended organic material. For example, concentrations of PCBs in filtered ocean water are usually reported in the pg/L range. Lindane has higher water solubility and is found at higher levels. Most of the studies did not report whether the water was filtered before extraction.

3.1.3.2.1.DDTs

Limited data on levels of DDTs in coastal water samples exists for the region, but some data exists for Colombia, Honduras, Jamaica and St. Lucia. Levels of DDT and in some cases DDE and DDD have been established in Colombia (1996) within the Ciénaga de la Virgen, Cartagena, former rice fields; in Honduras (1995-97) within the Golfo de Fonseca; in Jamaica (1982-96) within Hunts Bay, Hellshire and Kingston Harbour; in Jamaica (1990-91) within Portland and north east coastal waters; and in St. Lucia within coastal sites (Table 3.2).

3.1.3.2.2.PCBs

The only data available for PCBs in coastal waters was captured for Colombia which was collected within the coastal ecosystems Ciénaga de la Virgen, Cartagena, former rice fields. Levels ranging from 0.1 to 173 ng/g were found.

3.1.3.2.3.Endosulfan

Limited data sets on endosulfan levels in coastal waters are available. Countries where information have been gathered include Honduras (1995-97) where levels of 0.03 mg/L were found. In Jamaica (1982-96) mean levels of 2.2 µg/L for α-endosulfan and of 7.86 µg/L for β-endosulfan were recorded in a coffee production area. The concentrations of α-endosulfan ranged from 0.42-7.12 µg/L in samples collected in 1990-91 in Portland coastal waters in a coffee production area; no β-endosulfan was detected (Robinson & Mansingh, 1999).

3.1.3.2.4.Other organochlorines

Small data sets on levels of heptachlor epoxide, lindane, endrin in Honduras, (1995-97); dieldrin, aldrin, endrin and lindane in Jamaica (1982-96); and lindane and dieldrin in St. Lucia (1986-89) were compiled. These levels are recorded in Table 3.2.

Table 3.2. Levels of organochlorine pesticides and PCBs in water samples from marine environment.

Country/ year of study	Area	Results	Observations	Reference
Colombia 1996	Coastal ecosystems Ciénaga de la Virgen, Cartagena former rice fields	DDT 2.5 – 53.4 ng/g DDE <0.001- 0.5 ng/g DDD <0.001- 3.6 ng/g PCBs 0.1-173 ng/g		Castro, 1997
Honduras 1995-97	Pacific Ocean, Golfo de Fonseca 3 estuaries	Maximum concentrations: β-endosulfan 0.03 mg/L Lindane 0.02 mg/L p,p'-DDT 0.012 mg/L Heptachlor epoxide 0.01 mg/L Endrin 0.011 mg/L	Results indicate a widespread contamination of coastal waters. Most concentrations were low.	Meyer, 1999
Jamaica	Kingston Harbour	Mean levels: α-endosulfan 2.2 µg/L β-endosulfan 7.86 µg/L Endosulfan sulphate 0.003 µg/L p,p'-DDT 7.02 µg/L Dieldrin 1.88 µg/L Endrin 0.26 µg/L Lindane nd	Pesticides were also detected in sediments samples from the harbour. Contamination caused by discharge from the Rio Cobre, among others by the use of endosulfan 2-3 times/ year in coffee plantations.	Mansingh & Wilson, 1995, *in:* Mansingh et al., 2000
Jamaica 1990-91	Portland, north east coastal waters	Mean levels α-endosulfan 0.42-7.12 µg/L β-endosulfan nd p,p'-DDE 0.8 µg/L	Coffee production area. Pesticides detected also in sediment and biota.	Robinson & Mansingh, 1999
St Lucia 1986-89	Coastal sites	Maximum concentrations found Lindane 5-40 ng/L Dieldrin 4 ng/L DDT 4-20 ng/L		Singh & Ward, 1992 *in:* Magloire, 2002.

3.1.4. Marine Sediments

Most of the scarce data in the marine environment of the Region derive from sediment and biota samples from coastal lagoons, summarized in Tables 3.3 and 3.4.

The first known study (Keiser et al., 1973) reported OC residues in estuarine and marine fish and invertebrates in Guatemalan coastal area in 1970, influenced by cotton plantations. The area was divided into five subregions according to cotton growing activity. DDT levels of most organisms were higher in subregions bordered by cotton fields, with 53% of the samples containing toxaphene. Maximum concentration of 15.8 mg/kg fresh weight of total DDTs was reported in mussels from the Guatemalan Pacific Coast.

Data on organochlorines and PCBs in marine sediments though limited were more substantive that those available for coastal waters. Most of this data has been derived from sediment samples from coastal lagoons. This data is presented in Table 3.3.

3.1.4.1. DDTs

DDT levels in marine sediment have been gathered from Colombia, Costa Rica, Cuba, Guatemala, Honduras, Jamaica and Nicaragua. The upper levels recorded were 9 mg/kg found on the Pacific ocean coast in Honduras. Other levels found included 7 mg/kg dw on the Guatemalan Pacific Southern coast; 0.08 ng/g in a wetland on the Caribbean coast of Colombia, and 0.8 ng/g within a coastal ecosystems in Cartagena located in a former rice field; 6.1 ng/g of DDE and 0.35 ng/g of p,p DDT in sediments of Portland and Kingston Harbour in Jamaica; and between 0.71 and 270 ng/g dw found in Pacific coastal lagoons of Nicaragua. The study in Nicaragua showed the highest concentrations of DDTs close to the mouth of a river that crossed an old cotton growing area (Carvalho et al., 1999), other areas showed significantly lower levels. Results from 1992 to 2001 of an ongoing monitoring study on the south-west coast of Cuba showed results from 4-6- 61.4 μg/kg dw, where the lower levels were measured in 2001 (Dierksmeier, 2002). This data is presented in Table 3.3.

3.1.4.2. PCBs

As for coastal waters, limited data was available on PCB levels in marine sediments. The only data which was compiled were for Colombia (1996) ranging from 1.3 to 6.9 ng/g, and for Nicaragua (1995) within the Pacific coastal lagoons at a maximum of 45 μg/g dw (Carvalho, et al., 1999).

3.1.4.3. Endosulfan

Endosulfan data was only compiled for Jamaica, β-endosulfan was found at mean levels of 5.1 ng/g in sediments from Portland and 0.35 ng/g in Kingston Harbour; α-endosulfan mean levels of 0.52 in Kingston Harbour (See table 3.3). Waters from from citrus, coffee and vegetable growing areas discharge into Kingston Harbour.

3.1.4.4. Toxaphene

A screening for persistent chlorinated hydrocarbons was carried out in December 1995 in the main coastal lagoons on the Pacific Nicaragua (Carvalho et. al., 1999), where most of the country's agriculture and pesticide use has been taking place for decades. Results for a wide range of OC pesticides in lagoon sediments in Estero Real, Estero Padre Ramos, and estuary of San Juan del Sur showed levels that were generally very low. However, sediments of the Esteros Naranjo-Paso Caballos system showed much higher levels, with maximum values of 1,420 ng/g for toxaphene. The very high concentrations of toxaphene and DDTs (Table 3.3) are a result of the intensive use of these pesticides in cotton growing in the district of Chinandega. Due to the long environmental half-lives of these compounds ($t_{½} > 10$ years in temperate soils), their concentrations in lagoon sediments are likely to remain high for years to come. Based on the results, the development of the new shrimp farming activities in the Pacific coastal lagoons should be restricted to selected areas.

3.1.4.5. Other organochlorines

Low levels of other organochlorine compounds including lindane, heptachlor, aldrin, dieldrin, chlordane were collected and presented in Table 3.3.

Table 3.3. OC pesticides and PCBs levels in sediment samples in marine environment

Country/year	Environment	Results	Observations	Reference
Colombia 1986	Caribbean Coast Ciénaga Grande de Santa Maria	Lindane 0.4 – 44.2 ng/g Heptachlor 2 – 28.2 ng/g Aldrin 0.2 – 1.1 ng/g Dieldrin 0.2 – 1.9 ng/g p,p'-DDT 0.0-0.1 ng/g	Levels lower than in other coastal areas. Data provide a baseline for future studies.	Ramirez, 1988
Colombia 1996	Coastal ecosystems Cartagena former rice fields	DDT <0.001 – 0.8 ng/g DDE 0.02 – 1.0 ng/g DDD 0.09 – 0.1 ng/g PCBs 1.3 - 6.9 ng/g	Sediment concentrations comparable to Colombian Pacific coast data published in 1995.	Castro, 1997
Costa Rica 1995-1996	Golfo Dulce, Pacific Coast	OC pesticides detected	No detailed data	Spongberg & Davis, 1998
Cuba 1992-2001	SW Coast, agricultural area	ΣDDT 4.6 – 61.4 μμg/kg dw	No PCBs detected; DDT levels 2001 lower.	Dierksmeier, 2002
Guatemala 2001	Escuintla (Pacific coast), Izabal (Atlantic coast)	ΣDDT Escuintla (8/8) mean 1.6 mg/kg dw; range 0.25-7 mg/kg Izabal (0/6)		Campos, 2002
Honduras 1995-1997	Pacific Ocean, Golfo de Fonseca 3 estuaries	Maximum conc (mg/kg) Lindane 0.08 p,p'-DDT 9.0 p,p'-DDE 0.21 Heptachlor epoxide 0.01 Heptachlor 0.09 Chlordane 0.074 Aldrin 0.029	In several sediment samples the concentrations of DDTs were high, exceeding 2 mg/kg in 4 of the samples	Meyer, 1999

Country/year	Environment	Results	Observations	Reference
Jamaica 1990-1991	Portland, NE coastal waters	Mean ± SD (ng/g) β-endosulfan 5.1 ± 0.3 Dieldrin 0.1 ± 0.005 DDE 6.1 ± 0.4	see Table 3.2.	Robinson & Mansingh, 1999
Jamaica	Kingston Harbour (Citrus, coffee, & vegetable area)	p,p'- DDT 0.35 ng/g Aldrin 9.18 ng/g Lindane 0.56 ng/g α-endosulfan 0.52 ng/g β-endosulfan 0.35 ng/g		Mansingh & Wilson, 1995 *in:* Mansingh et al., 2000
Nicaragua 1995	Pacific coastal lagoons	Cotton area (µg/kg dw): ΣDDT 0.71-270 Toxaphene 13-1,420 Σendosulfan (8/13) max 1.23 PCBs max 45 Other areas (µg/kg dw): ΣDDT 4.5 ± 3.4	Sampling during dry season. Highest concentrations of toxaphene and DDTs close to the mouth of the river that crosses an old cotton growing area. DDT and toxaphene in sediments high compared with coastal North America.	Carvalho et al, 1999

3.1.5. Marine Biota

Biota samples for which some PTS data exist includes fish, mussels, shrimp, starfish, oyster, and crab (Table 3.4).

3.1.5.1. DDTs

DDT levels in fish have been compiled for Colombia, El Salvador, Guatemala, Honduras, Jamaica and St. Lucia. For Central America the highest level of total DDTs found in fish in 1970 significantly differ from those found in 1985 to 1991 (Castillo et al., 1997). The maximum concentration found in 1970 by Keiser et al. (1973) was 45.2 mg/kg fw, whereas the highest level found in more recent years in fish in Central America was 114 µg/kg fw in lake Xolotlan in Nicaragua (Calero et al., 1993).

In the study carried out in the lagoon systems of Nicaragua by Carvalho et al. (1999) the authors indicate that the high proportion of fish samples (90%) containing DDT suggested that bioaccumulation had taken place.

In Colombia, DDT levels established for fish were 0.7 to 0.78 ng/g in 1996, whereas Honduras reported levels of 0.2 to 2.6 mg/kg lipid weight in 1988. No specific data were provided for St. Lucia and El Salvador.

The monitoring phase of International Mussel Watch Project on both coastal zones of the Region took place in 1991-1992 (Farrington & Tripp, 1994). PCBs and OC pesticides were determined in bivalve samples from in coastal areas that were not connected with obvious sources of contamination. The sampling sites are indicated in Figure 3.1. The study included 17 stations on the Atlantic and Pacific Coasts of Central America, with a total of 24 samples. The levels were low, in many instances below detection limits, and were comparable to those reported for the Gulf of Mexico and other little contaminated Latin American coasts. The maximum concentration of total DDTs (including o,p'-DDE and p,p'-DDT) was 199.5 µg/kg dry weight in a sample from Nicaragua. DDTs were the most prevalent OC compounds in the biota.

Figure 3.1. Sampling stations International Mussel Watch Project, 1991-1992 (Farrington & Tripp, 1994)

Pollution levels of OC pesticides were determined in 1988-1991 in the bivalve *Anadara tuberculosa* inhabiting the mangrove ecosystems of the Nicoya Gulf, Pacific Coast of Costa Rica (de la Cruz, 1994). The objectives were to assess the state of the marine resources of the upper Nicoya Gulf of Costa Rica, to evaluate the use of *Anadara tuberculosa* as a sentinel organism for water and sediment quality of mangrove areas, and to understand the distribution and fate of the compounds under study. The maximum concentration of total DDTs found was 134 µg/kg dry weight from a total of 137 mussels. The study included also PCBs and metals.

Another study (de la Cruz et al,, 1998) was conducted in 1995-1997 for the occurrence, behavior and biological impact of pesticides and other OC compounds in marine ecosystems of Costa Rica. Exposure of species to different trophic levels from both Pacific and Caribbean coastal zones of Costa Rica were assessed and compared. Different lipid classes of the biota were sampled and analyzed in 1995. DDTs, lindane, and chlordane accounted for most of the total OC residues at different study sites in *Anadara tuberculosa* in the Nicoya Gulf during 1990-1991 (72%-91%).

Other studies of DDT levels in mussels for the region were established for Cuba in 1992-2001 (1.7-23.8 µg/kg) and in 1970 in Guatemala (4.53-15.84 mg/kg dw).

3.1.5.2. PCBs

Few studies exists for PCBs in marine biota. The International Mussel Watch Project mentioned previously, determined PCBs in bivalve samples collected in coastal areas of Central America during 1991-1992 (Farrington & Tripp, 1994). PCBs were detected in 18 of the 24 samples analyzed, the levels ranged from 1.7 – 144.2 µg/kg dw.

Mussels collected in mangroves of the Nicoya Gulf (Pacific coast) during 1988-1991 (de la Cruz, 1994) had levels 8.28-266 µg/kg dw (1988-1991). Oysters from the Morrocoy National Park in Venezuela sampled in 1998 had levels of PCBs ranging from 0.6 to 12 ng/g (Jaffe et al., 1998).

3.1.5.3. Endosulfan

Jamaica provides the only data sets on endosulfan levels in biota within this region. Mean α and β-endosulfan levels of 3.6 and 3.9 ng/g respectively were found in shrimp samples from Hunts Bay, and Kingston Harbour (Mansingh, 2000). While mean levels of 15.9 and 30.9 of α and β-endosulfan were found in biota in Portland, Jamaica.

3.1.5.4. Toxaphene

Klein (1988) found up to 800 µg/kg fw of toxaphene in fish muscle tissue and the compound was detected in 44 % of the samples. Calero et al. (1993) found toxaphene in 81% of the fish samples collected at Lake Xolotlan (1991) in concentrations ranging from 24 to 1131 µg/kg fw.

3.1.5.5. Other organochlorines

Limited data also exist on levels of lindane, chlordane, heptachlor, mirex, HCH, dieldrin, aldrin, and endrin at few locations. This data is presented in table 3.4.

Table 3.4. Organochlorine pesticides and PCBs in marine biota samples

Country / year	Environment	Results	Observations	Reference
Central America & Caribbean 1991	Pacific and Caribbean marine coasts	Several species of bivalves in dw ΣDDT 2.4-199.5 µg/kg (24/24) Σchlordane 0.46-16.0 µg/kg (16/24) ΣBHC 0.36-2.82 µg/kg (15/24) Lindane 0.28-4.2 µg/kg (16/24) Heptachlor <0.01-1.75 µg/kg (7/24) Aldrin <0.01-1.76 µg/kg (8/24) Dieldrin <0.01-4.73 µg/kg (5/24) Endrin <0.02-1.29 µg/kg (8/24) Mirex 0.32-0.85 µg/kg (5/24) ΣPCB 1.7-144.2 µg/kg (18/24)	OC levels below national or international recommended action limits for human consumption.	Farrington & Tripp, 1994
Colombia 1996	Coastal ecosystems Cartagena Former rice fields	Fish ΣDDT 0.7 – 0.78 ng/g	Fish levels lower than in bivalve organisms of the Colombian Pacific coast.	Castro, 1997
Costa Rica 1988-91	Marine estuarine Nicoya Gulf, Pacific Ocean	*Anadara tuberculosa* (mussel) (n=137)(µg/kg dw) ΣDDT 1.2 –134 Σchlordane 0.24-119 Lindane 0.24-706 Heptachlor 0.0-29.9 Mirex 0.0-2.28 ΣPCB 8.28-266	*A. tuberculosa* can be used as bioindicador in mangrove ecosystems. PCB levels low; OC levels higher in rainy season.	De la Cruz, 1994
Cuba 1992-2001	South coast of western provinces (9 years study)	Mussels, ΣDDT 1.7 – 23.8 µg/kg dw PCB residues detected in one sample only (5.9 µg/kg dw)	9-year study until 2004.	Dierksmeier, 2002

Country / year	Environment	Results	Observations	Reference
El Salvador 1977	Pacific Ocean Jiquilisco estuary cotton plantation area	Fish, bivalve, shrimp, starfish. OCs detected.	OC were detected in all samples, no specific data provided.	Lopez Zepeda, 1977
Guatemala 1970	Marine Pacific (estuarine and ocean) - coastal regions - cotton areas	Fifteen species of fish, four of crab, five of shrimp, two gastropods, one mussel (n=91) ΣDDT (84/91) : Fish 0.04 - 45.17 mg/kg fw Crustacea 0.01 - 3.56 mg/kg fw Mussel 4.53 - 15.84 mg/kg dw Gastropod 0.06 - 3.02 mg/kg fw Toxaphene in 53 % of samples	Most of the organisms had DDT levels higher in areas bordered by cotton fields. Pesticide application in cotton fields affects shrimp industry.	Keiser et al., 1993
Guatemala 1971	Pacific Southern Coast	Fish Mean (range) mg/kg lip wt ΣDDT (5/5) 16.8 (8.5-26.5) ΣHCH (5/5) 0.303 (0.028-0.94) Heptachlor epoxide (5/5) 0.064 (0.030-0.144) Aldrin (4/5) 0.251(0.036-0.784) Dieldrin (4/5) 0.021 (0.010-0.036) Endrin (2/5) 0.035 (0.015-0.054) Toxaphene (5/5) 4.2 - 7.6 *	* Quantification in 2 samples only.	Campos, 2002.
Honduras 1988	Utila Bay	Commercial marine fish DDT: 0.2-2.6 mg/kg lipid wt (60%; n=49) Lindane 0.03-0.4 mg/kg lipid wt (51%; n=49) PCBs not detected		Cescco, 1989 *in:* Sabillon, 2002
Jamaica 1982-96	Hunts Bay, Kingston Harbour	Shrimp (1995/1996) Mean ± SD (ng/g) 1995-1996 DDE 8.3 ± 4.2 Dieldrin 1.6 ± 2.1 α-endosulfan 3.6 ± 1.4 β-endosulfan 4.0 ± 2.1	The paper includes additional data for 1982/83 and 1989/90. Levels of DDE and dieldrin have declined; endosulfans are increasing	Mansingh et al, 2000

Country / year	Environment	Results	Observations	Reference
Jamaica 1990-91	Portland, northeast coastal waters	Biota, mean ± SD (ng/g) α-endosulfan 15.9 ± 1.6 β-endosulfan 30.9 ± 16 endosulfan sulphate 14 ± 14.7		Robinson & Mansingh, 1999
St Lucia 1985	Castries harbour, marine	*Brachidontes exustus* (mussel) *Mugil curema* (fish) *Crassostrea rhizophorae* (oyster) OC pesticides analyzed. Highest levels of chlordane (0.16 ng/g) and p,p'-DDE in the oyster (0.16 ng/g)		Ramsammy et al, 1985 *in:* Magloire, 2002
St Lucia 1992	Coastal sites	*Brachidontes exustus* (mussel) *Mugil curema* (fish) *Crassostrea rhizophorae* (oyster) ***Isognonon altus*** **(flat tree oyster)** Highest levels of chlordane in lipid samples *of M. curema, I. altus and C. rhizophoreae* (13.3-67 ng/g)		Singh and Ward, 1992, *in:* Magloire, 2002
Venezuela 1998	Morrocoy National Park, Marine 10 sampling stations	Flat tree-oyster (*Isognonon altus)* PCBs 0.6 – 12.0 ng/g p,p'-DDE <0.44 – 1.1 ng/g p,p'-DDD <0.32 - <1.1 ng/g p,p'-DDT <0.18 - <0.61 ng/g o,p'-DDT 0.52 – 1.1 ng/g		Jaffé et al., 1998

fw = fresh weight, dw = dry weight, wt = weight

3.1.7. Marine Mammals

Regional data on PTSs in marine mammals are scarce. Only two relevant studies were documented in this regard one in St. Lucia in 1974 (Simmonds et al, 1999) and one in Costa Rica in 2000 (Cubero et al., 2002). These results are presented in Table 3.5.

3.1.7.1. DDTs

Levels of DDT found in skin blubber from the spotted dolphin sampled in the Pacific coast of Costa Rica were 0.36 to 0.45 ng/g wwt, and 2.7 to 3.1 µg/g lipid wt. In the bottlenose dolphin sampled at the same location levels of DDT were 1.2 to 1.5 ng/g wwt, and 5.4 to 6.5 µg/g lipid wt.

In blubber samples of the short-finned pilot whale collected in the Caribbean Sea, St. Lucia, the levels of DDT were 1.3 to 2.3 ug/g wwt. In the long snouted spinner dolphin sampled at the same location the DDT levels found were 1.4 to 7.4 ug/g wwt.

3.1.7.2. PCBs

PCB levels found in the spotted dolphin sampled in Costa Rica (above) were 0.22 to 0.24 ng/g wwt and 1.5 to 1.8 ug/g lipid wt. In the bottlenose dolphin, the PCB levels were 1.5 to 1.8 ng/g wwt and 6.4 to 8.2 ug/g lipid wt. PCB levels for the bottlenose dolphin were low and withing the range reported for Australia and South Africa.

In blubber samples from the short finned pilot whale sampled in St. Lucia, the PCB levels were 0.7 to 1.6 ug/g wwt. In the long snouted spinner dolphin, the PCB levels were 2.0 to 5.0 ug/g wwt.

Table 3.5. PTS levels in marine mammals

Area / year of study	Results	Observations	Ref.
Costa Rica, Pacific coast (Golfo Dulce), 2000	Skin-blubber samples *Stenella attenuata* (spotted dolphin) N = 2 male and female ΣDDT 0.36 - 0.45 ng/g wwt 2.7 - 3.1 µg/g lipid wt ΣPCB 0.22 - 0.24 ng/g wwt 1.5 - 1.8 µg/g lipid wt *Tursiops truncatus* (bottlenose dolphin) n= 2 male and female ΣDDT 1.2 – 1.5 ng/g wwt 5.4 - 6.5 µg/g lipid wt ΣPCBs 1.5 – 1.8 ng/g wwt 6.4 - 8.2 µg/g lipid wt	First report of PCBs for spotted dolphin. No clear differences between male and female PCB levels. PCB levels for bottlenose dolphin low and within the range reported for Australia and South Africa. With the exception of congeners 101, 118 and 126 that are relatively abundant in the species in this study, the PCB pattern closely matches patterns reported for bottlenose elsewhere. Relative amount of metabolizable PCB found in bottlenose dolphin (22%) in agreement with those reported for similar PCB levels. The relatively low fraction of metabolizable PCBs in spotted dolphin may indicate a relatively well developed ability to metabolize PBCs. Congener 126 (dioxin-type toxicity congener) contributed about 95% to the total PCB-TEQ.	Cubero et al., 2002
St Lucia, Caribbean sea, 1974	Blubber samples *Globicephala macrorhynchus* (short-finned pilot whale) DDT 1.3 – 2.3 µg/g wwt PCBs 0.7 - 1.6 µg/g wwt S*tenella longirostris* (Long snouted spinner dolphin) DDT 1.4 – 7.4 µg/g wwt PCBs 2.0 - 5.0 µg/g wwt	3.1.7.3. Dieldrin was also detected DDT and PCBs determined through packed Columns PCBs were quantified probably as a Arochlor mixture.	Simmonds et al., 1999

* wwt = wet weight

3.1.7.4. Other OCs

One study was identified on aquatic birds. Hidalgo (1986) found OC compounds in eggs of 8 different bird species. Between 1983 and 1984, a total of 137 eggs were collected on Pajaros Island, a nesting site located in the Nicoya Gulf (Pacific Coast of Costa Rica). Residues of p,p'-DDE were found in all the eggs. The highest concentrations were found in wood stork eggs (*Mycteria americana)* and lowest in white ibis, *Eudocimus albus*. For all except two species, a strong correlation was found between shell thickness and p,p' -DDE residues. The author observed cracks in some of the eggs of *M. americana* with the highest concentrations of DDE.

Heptachlor epoxide, HCB, p,p'-DDT, and endrin were present in high proportions. The range of total OC pesticides was 0.16 to 4.2 mg/kg fresh weight. The results are summarized in Table 3.6.

Table 3.6. DDE residues and shell thickness in eggs of eight bird species, Isla Pájaros, Costa Rica, 1983-1984. (Hidalgo, 1986). R:Correlation coefficient between shell thickness and p,p'-DDE.

Species	N	Mean shell thickness (mm)	p,p'-DDE (mg/kg fresh weight)	R
A. anhinga	9	0.323	0.672	- 0.95**
N. nycticorax	25	0.293	1.502	- 0.68**
C. albus	17	0.324	0.898	- 0.70**
B. ibis	22	0.275	0.743	- 0.67**
C. cochlearius	10	0.276	0.556	- 0.76*
M. americana	25	0.572	3.194	- 0.69**
E. albus	15	0.359	0.092	- 0.13
A. ajaja	14	0.449	1.544	- 0.94**

N: number of samples; *p<0.05; **p<0.01

3.1.8. Freshwater Ecosystems

Most of the river and lake freshwater studies in the Region have been related to agricultural activities: former cotton growing areas in El Salvador, Guatemala, Nicaragua; banana plantations in Costa Rica; rice fields in Costa Rica and Colombia; citrus, coffee and vegetable growing areas in Jamaica; and vegetable and flower production areas in Colombia. Some studies were conducted at hot spots such as by a toxaphene factory in Nicaragua; paint factories in Haiti; and in the River Choluteca in Honduras after the hurricane Mitch.

Water and sediments, sometimes also biota (predominantly fish), were sampled. OC pesticides such as DDT, lindane and endosulfan were analyzed. Toxaphene was analyzed in Nicaragua. Other pesticides were included in some studies, as applied on banana, coffee, rice, and flowers. Most of the available data are summarized in Table 3.7.

3.1.8.1. Surface and ground water

Compounds such as DDTs, endosulfan and toxaphene are the most frequently reported PTSs reported in surface and ground waters. Triazines are also reported in studies from Barbados and Costa Rica. Most studies have been carried out in agricultural areas such as banana, coffee, cotton, vegetables and sugar cane plantations.

3.1.8.1.1.Atrazine

Presence of atrazine and ametryne, and degradation products of atrazine (diethylatrazine and diisopropylatrazine) were reported in groundwater (Brithish Geological Survey, 1991; Barbados Water Authority, 1997). Atrazine was found frequently at low concentrations and appears to be widespread in the island's groundwater at levels up to 2.9 µg/L from prolonged and extensive use in the cultivation of sugarcane. Atrazine levels in agricultural wells tended to be higher than in public wells. Ametryne, also a triazine, was found with a high frequency in water from agricultural wells in concentrations up to 0.54 µg/L. Ametryne was also detected in 12% of the stream samples collected during a study in a banana plantation area of the Atlantic coast of Costa Rica (Castillo et al., 2000). Maximum concentrations of ametryne in this study was 1.7 µg/L. Another study by Mortensen et al. (1998) in the same area reported a maximum concentration value for ametryn of 2.15 µg/L.

Atrazine was not detected beyond 0.5 µg/L in groundwater samples taken during the past 10 years in La Habana province, Cuba (Dierksmeier, 2001).

3.1.8.1.2.DDTs

DDTs have been detected in recent years in surface waters in Colombia (CAR, 1996; Galeano et al., 2001), Guatemala (Knedel et al., 1999), El Salvador (Gonzalez and Calderon, 2002), Nicaragua (Castilho et al., 2000) and Jamaica (Robinson & Mansingh, 1999, Mansingh et al., 2000). DDTs and toxaphene were the most frequent OC residues in the water and sediment samples of an old cotton producing area in the Pacific coast of Nicaragua. Frequency of detection for DDE in surface waters were of 90% in the rainy season and of 60% in the dry season of 1993 (Castilho et al., 2000).

3.1.8.1.3.Endosulfan

A 15-month monitoring program was carried in 1998-1999 in surface and ground water at watersheds in Guatemala. Several OC pesticides, some of them banned in 1988, were found frequently in the samples. The most frequent were endosulfan and HCH. The sampling frequency was too low to estimate trends (Knedel et al 1999) .

Several monitoring programs (Mansingh et al, 2000; Robinson & Mansingh, 1999) were implemented in Jamaica, the first starting 1982 in a number of watersheds, including water. The first study revealed OC pesticide contamination in water, sediment, and biota in 1982-1983. In later studies, OC compounds were found but to a lesser extent, DDT and dieldrin levels declining. Endosulfan was detected more frequently and at higher levels, due to widespread use. Levels of α-endosulfan, β-endosulfan and chlorpyrifos were found in many of the rivers sampled. Highest levels of α-endosulfan were found in Yallahs River (108.1 ng/g) and Great River (55.3 ng/g) (Chin Sue, 2002). Endosulfan was also detected in spring and well water in Milk River, Roaring River, Bulstrode Bluehole and Tulloch Spring (Chin Sue, 2002), levels ranged from 0.01 to 0.27µg/l of α- and β-endosulfan. The wells affected were Catherine Mount, Bellefield Hampden, Charles Town, Springfield, Southaven, Chancery Hall and Buildings with levels ranging from 0.10 to 0.42 µg/l (Chin Sue, 2002). During spraying and nonspraying periods for coffee berry borer control using endosulfan, samples were collected of water and sediment in Black River and Yallahs River. The results showed levels of α- and β-endosulfan, endosulfan sulphate and dieldrin. Ninety-seven samples of water collected during the spray periods resulted in 20% contaminated with α-endosulfan, 13% with beta endosulfan, 16% with endosulphate, and 6.9% with dieldrin. There was a higher concentration in the sediment: 38% α-endosulfan and 16% β-endosulfan, 24% endosulfan sulfate and 12% dieldrin.

In Colombia, the Ministry of Health (1996 in Nieto, 2002) reports samples from municipal water systems with endosulfan and endosulfan sulfate. Endosulfan was also present in 44.4% of water samples from a vegetable production area (Galeano et al., 2001).

3.1.8.1.4.Toxaphene

Castilho et al. (2000) assessed OC and OP pesticide residues in the Atoya river basin, Chinandega, Nicaragua. This hydrographic basin represents one of the major cotton producing regions in Nicaragua. It is intensively contaminated by pesticides. Samples of river waters and sediments, as well as strategically

selected wells were analyzed to assess variations in the concentrations of the target residues between the dry season (November-April) and the rainy season (May and June). Generally, higher concentrations of pesticides were detected in the river waters and sediment during the dry season. Toxaphene and DDTs were the most frequent OC residues in the water and sediment samples (Table 3.7).

3.1.8.1.5.Other PTSs in freshwater.

A study conducted by the national water company in Honduras (SNAA in Sabillon, 2000) in a small number of wells in 1998 revealed residues of lindane and dieldrin. In 46 groundwater samples taken in a former cotton production area in Honduras no residues of OC pesticides were detected (Tetra Tech Em Inc, 2000, *in* Sabillon, 2000). Calderon (1981 *in:* Calderon & Melendez, 2001) found residues of OC pesticides in 4 wells located in a cotton production area in El Salvador. Castilho et al. (2000) reported the presence endrin, dieldrin, lindane, ethion, methyl parathion and ethyl parathion in wells in Nicaragua.

There is almost no information on environmental levels of non-pesticide PTSs. A study in Barbados detected phtalates in five public water wells.

Table 3.7. PTS levels in surface and groundwater

Country / year of study	Environment	Results (positive samples/total samples or % positive samples) min – max concentrations	Observations	Ref.
Barbados 1988-1991	Groundwater Two locations N=111	Atrazine Belle catchment 0.21-1.14 µg/L Hampton catchment 0.19-2.86 µg/L		British Geological Survey, 1991
Barbados 1996	Groundwater N=204	Atrazine (177/204) <0.01 – 1.58 µg/L Mean 0.37 µg/L		Barbados Water Authority, 1997
Colombia 1995	Sources for municipal water systems ; surface and wellwater (N = 7)	Endosulfan (5/7) Max conc: 116.6 mg/L Endosulfan sulfate (1/7) 30 mg/L		Minsalud, 1995
Colombia 1996	Rivers and water reservoirs, cut flower area, Municipality of Madrid, Bogotá, Savanna	ΣOC 0.01 – 11.2 µg/L		Minsalud 1996

Country / year of study	Environment	Results (positive samples/total samples or % positive samples) min – max concentrations	Observations	Ref.
Colombia 1996	Bogotá River Surface water	2,4'-DDD 0.1 – 1.63 µg/L 2,4'-DDE 0.19 - 0.4 µg/L 4,4'-DDE 0.4 µg/L 4,4'-DDT ND Aldrin 0.12 – 2.56 µg/L β-BHC 0.1 – 90 µg/L Heptachlor epoxide 0.04 – 180 µg/L Lindane 0.1 – 0.9 µg/L		CAR, 1996
Colombia 2000	Santafé de Bogotá Vegetable production area. Water used for irrigation	samples above detection limit: DDT 3.3% Endosulfan 44.4% BHC isomers 44.4%		Galeano et al., 2001
Guatemala 1997-98	Surface and groundwater (80 samples)	OC pesticides detected in water samples, some as frequently as up to 12% of the samples. Compounds more frequently detected included aldrin, α-chlordane, γchlordane, op,DDE, p,p-DDE, o,p-DDT, p,p-DDT, endosulfan sulfate, endrin, HCH, heptachlor epoxide and methoxychlor.		Knedel et al., 1999
Guatemala 1998-1999	Freshwater - Amatitlán Basin and - Motagua River Monitoring (60 sampling sites, 7 times throughout the year) (420 samples)	Concentrations in µg/L Aldrin (6) 0.02 - 0.19 Chlordane (7) 0.7 - not given Endosulfan (25) 1.1 - not given Endrin (1) 0.09 - 0.33 HCH (16) 0.01 - 0.13 HCB (10) traces Heptachlor epoxide (6) Lindane (5) 0.06 - 0.17 p,p'-DDT (4) 0.06 - 0.13 p,p'-DDE (1) 0.05 - not given	Amatitlán basin more contaminated than Motagua River. Highest levels found during the rainy season.	Knedel, 1999.

Country / year of study	Environment	Results (positive samples/total samples or % positive samples) min – max concentrations	Observations	Ref.
		o,p'-DDT (1) 0.10 - 0.56 o,p'-DDE (2) 0.02 - not given		
Guatemala 2001	Surface and ground water (wells): Escuintla (Pacific coast)	Mean and range (µg/L) <u>Groundwater</u> Σ DDT (3/8): (nd - 0.0022) Endosulfan (4/8): (nd - 0.0008) <u>Surface water</u> Σ DDT (5/8): 0.003 (nd - 0.0085) Endosulfan (7/8): 0.015 (nd – 0.0134)	Heptachlor, lindane, aldrin, HCB detected in 1-2 samples in surface water	PlagSalud-Guatemala, 2001.
Honduras 1998	Ground water (well) Santa Marta, Rio Choluteca	Lindane 0.11 - 0.21 µg/L		SANAA in: Sabillón, 2002
Honduras 1998	Marcovia and Choluteca Wellwater 17 wells	Dieldrin 1-50 µg/L (14/17) Lindane 10-40 µg/L (7/17)		SANAA in: Sabillón, 2002
Honduras 1998	Watershed River Choluteca Wellwater (n=50) Surface water (n=85)	Detection frequencies: <u>Wellwater:</u> Heptachlor 20%; dieldrin and α-HCH 10-15%; endosulfan, chlordane and heptachlor epoxide 5-10% <u>Surface water:</u> Heptachlor and endosulfan 20%; heptachlor epoxide and dieldrin 10-15%; chlordane 6%		Kammerbauer & Moncada, 1998.

Country / year of study	Environment	Results (positive samples/total samples or % positive samples) min – max concentrations	Observations	Ref.
Jamaica 1982-1996	Cobre Rivera at Dam Head (citrus, coffee an vegetable growing areas)	1995/1996. Mean and standard deviation in µg/L: Dieldrin (100%) 1.29 ± 0.76 α-endosulfan (100%) 0.35 ± 0.33 β-endosulfan (60%) 0.67 ± 0.83 endosulfan sulphate (60%) 0.96 ± 0.5	The paper includes data from 1982-83 and 1989-1990	Mansingh et al., 2000
Nicaragua 1984-1987	Freshwater, Xolotlan lake (Toxaphene plant at lake border)	Toxaphene max 0.008 µg/L		Klein, 1988
Nicaragua 1993	Surface and groundwater (wells) Atoya River Basin (cotton producing area) Seasonal variation of pesticide residues 32 selected sites in rivers, and wells, 80 samples.	<u>Surface water</u> *Dry season* Toxaphene (60%) 63.2-332 ng/L DDE (60%) 1.3-46.4 ng/L DDD (40%) 2-24.6 ng/L Endrin (40%) 1.7-9 ng/L *Rainy season* Toxaphene (90%) 40-453 ng/L DDE (90%) 2.9-14.5 ng/L DDD (50%) 5.9-16.2 ng/L Endrin (50%) 3.0-22 ng/L <u>Wellwater</u> Toxaphene 13-1472 ng/L DDE 0.5-4.1 ng/L Endrin 2.5-9 ng/L	Endrin and toxaphene concentrations are higher than internationally accepted limits The levels of OCs in well water were lower in the rainy season.	Castilho et al., 2000

[a]n = number of samples analyzed

[b]OC = organochlorine pesticides; m/n = number of positives samples/number of total samples; dw = dry weight; fw = fresh weight.

Lake Xolotlán can be classified as a hot spot. It has been used during the last five decades as the recipient of domestic and industrial wastewater from the city of Managua. In addition, Lake Xolotlán receives a superficial runoff from its extensive drainage basin that is intensively cultivated. Toxaphene was produced in Nicaragua at the border of Lake Xolotlan from 1974 to June 1991. The plant discharged all its waste products into the ecosystem. Several studies were conducted in this area. No residue data were available for the maximum production period of the plant between 1974 and 1979. Levels of toxaphene found in sediments by Klein (1988) ranged between the detection limit and 1.4 mg/kg dry weight, while Calero et al. (1993) reported 359 µg/kg wet weight of toxaphene in a sediment sample from the discharge channel of the factory but did not find toxaphene in sediment samples from other locations in the lake. The detection limit was 200 µg/kg. In a second study by the same authors (Calero et al, 1993), in which the level of detection was 20 µg/kg, toxaphene was found in all sediment samples analyzed in concentrations ranging from 62 to 187 µg/kg wet weight.

3.1.8.2. Freshwater sediments and biota

3.1.8.2.1.DDTs

Fomsgaard et. al. (1993) carried out a study of toxaphene and other OC pesticides in fish and sediments in the Lake Xolotlán, Nicaragua. The levels of 11 OC pesticides were analyzed in samples for two fish species (*Sarotherodon mossambicus* and *Cichlasoma managüense*) and sediments. DDT or its metabolites DDE or DDD were present in almost all the fish and sediment samples in low concentrations.

Wu et al. (2000) studied organochlorine contaminants in crocodile eggs from two lagoons in northern Belize in 1998. Primary contaminants were p,p-DDE and methoxychlor, p,p-DDE was detected in 100% of the eggs examined. In the crocodile nest material p,p-DDT and methoxychlor were also the primary contaminants. p,p-DDT was found in concentrations between 22 and 120 ppb in the nest material.

3.1.8.2.2.Endosulfan

Residues of α- and β- endosulfan and endosulfan sulphate were detected in fauna of the Rio Cobre at Dam Head, Jamaica in at mean levels of 1.07, 1.67 and 1.8 ng/g respectively in 1995-1996. Mansingh and Wilson (1995 *in:* Chin Sue, 2002) reported α-endosulfan in oysters at levels of 0.26 ng/g. The Pesticides Control Authority (Chin Sue, 2002) receives reports of fish kills each year in reservoirs, streams and rivers associated with coffee producing areas and in seasons corresponding to the periods when endosulfan is applied. Unfortunately, there are no local laboratory facilities and this has contributed to a failure to confirm that these kills were due to endosulfan poisoning.

3.1.8.2.3.Toxaphene

In the study by Fomsgaard et. al. (1993) in fish and sediments in the Lake Xolotlán, Nicaragua, toxaphene was detected in over 80% of the fish specimens and in all the sediment samples analyzed. The presence of a-HCH and lindane (g-HCH) in fish and lindane in sediment was insignificant. Heptachlor, α-HCH, heptachlor epoxide, and dieldrin were detected neither in fish nor in sediments..

Klein et al. (1988) found up to 800 µg/kg fw of toxaphene in fish muscle tissue and the compound was detected in 44 % of the samples. Calero et al. (1993) found toxaphene in 81% of the fish samples collected at Lake Xolotlan (1991) in concentrations ranging from 24 to 1131 µg/kg fw.

3.1.8.2.4.Other organochlorine compounds

In the study by Fomsgaard et. al. (1993) in fish and sediments in the Lake Xolotlán, Nicaragua,

the presence of a-HCH and lindane (g-HCH) in fish and lindane in sediment was insignificant. Heptachlor, α-HCH, heptachlor epoxide, and dieldrin were detected neither in fish nor in sediments.
Endrin and endosulfan were detected in crocodile eggs in Belize in concentrations ranging from 1ppb (ng chemical/g egg) to 0.5 ppm (Wu et al., 2000). Total OC concentrations (sum of all OCs) for one egg collected from a nest at Gold Button Lagoon reached as high as 0.7ppm. Most eggs contained total OC concentrations

between 50 and 150 ppb. The most frequent OCs found in lagoon sediments were α and γHCH in concentrations ranging from 8 to 1900 ppb and 8 to 270 ppb for α and γHCH respectively. Aldrin and heptachlor epoxide were also detected in sediments. Methoxychlor was detected in 55% of the samples of crocodile nest material in concentrations ranging from 13 to 1300 ppb and in 29% of the eggs.

In Jamaica levels of endrin (0.006 ng/g were detected in sediments of the Martha Brae River and β-endosulfan concentration in sediments of Rio Minho at Alley, was 17.78 ng/g (Chin Sue, 2002).

The frequency of occurrence of OC compounds in fish samples in the banana production area and in Lake Arenal, Costa Rica in 1987 and 1988 (Düszeln, 1988) was 49% for HCB, 46% for dieldrin, 43% for heptachlor, 38% for DDE and 30% for lindane.

Residues levels in 11 fish samples collected in 1971 at Lake Atitlán, in the highlands of Guatemala, are shown on Table 3.8 (LUCAM in Campos, 2002). The area around Lake Atitlán is a coffee growing country. Maximum levels of aldrin, dieldrin, endrin, and toxaphene were higher than in the southern Pacific coast.

Table 3.8. Chlorinated pesticides in fish. Lake Atitlán, Sololá, Guatemala, 1971

Pesticide	N of positive samples	Mean mg/kg fat	Range mg/kg fat	Remarks
Total DDT	11	5.6	0.650 – 16.3	
Heptachlor epoxide	11	0.026	< 0.001 – 0.076	
Total HCH isomers	10	0.046	Nd* – 0.179	
Dieldrin	9	0.036	Nd – 0.221	
Endrin	9	0.163	nd – 1.3	
Aldrin	3	0.056	nd – 0.413	
Toxaphene	5	5.5	3.8 – 9.2	Toxaphene quantified in 4 samples only.

nd: not detected.

Source: LUCAM in Campos, 2002

3.1.8.2.5.Organic mercury

Studies on mercury contamination of freswater ecosystems were reported for Venezuela, Colombia and Costa Rica.

Widespread mercury contamination was revealed in freshwater, sediments and fish caused by small-scale gold mining activities in Bolivar State, southeastern Venezuela (Hamilton, 1996).

Ramos et al (2001) assessed mercury contamination generated by gold mining activities in the La Mojana region, Colombia, one of the world's richest area in biodiversity. Samples collected for inorganic and organic mercury analysis included surface waters, sediments, aquatic plants (e.g., eichhornia *E. crassipes*) and fish. Environmental samples were collected during dry and wet seasons. The concentration of the inorganic mercury in water was higher in the wet season. No methyl mercury levels were detected for the aqueous matrix but was found at relatively high levels in the first 20 cm of the sediment layer, with higher values in the wet season. Mercury content in *Eichhornia* was considerable, with a strong tendency to persist in the plant root, following the same seasonal variation with water and sediments. Fish samples were analyzed during the wet season only. Almost all the mercury content was in the organic form such as methyl mercury (Table 3.9.). The percentage of mercury available for bioaccumulation, which is harmful for living beings due to its capacity of migration through the food chain from the aquatic plants and animals to humans, was calculated at 3, 12 and 40% for *Eichhornia*, sediments and fish, respectively.

Table 3.9. Seasonal variation of mercury in environmental samples in La Mojana region, Colombia

		Total mercury		MeHg
Sample	**Unit**	**Wet season**	**Dry season**	**Wet season**
Water	µg/L	0.5 - 50.0	0.0 - 6.5	<0.02
Sediments	µg/kg*	35 – 236	2.1 - 4.6	30 - 99
Eichhornia	µg/kg*	110 – 1217	24.4 – 158	24.4 - 158
Fish	µg/kg*	ND	ND	49 - 109

*Dry weight ND: No data.

Source: Ramos et al., 2001

From 1987 to 1991, a study on pollution levels of metals and organochlorine compounds (pesticides and PCBs) in the bivalve *Anadara tuberculosa* inhabiting the mangrove ecosystems of the Nicoya Gulf was conducted (de la Cruz, 1994). The objectives of this study were to assess the state of the marine resources of the upper Nicoya Gulf of Costa Rica (Figure 1), to evaluate the use of *Anadara tuberculosa* as a sentinel organisms for water and sediment quality of mangrove areas and to understand the distribution and fate of the stable organic pollutants among them methyl mercury. The mean mercury concentrations in *Anadara tuberculosa* of the Nicoya Gulf from 1988 to 1991 were of 160 $\pm$ 67 ng/g dry weight of total mercury and 78 $\pm$ 39 ng/g dry weight of methyl-mercury. Between 11 % and 90 % of the total mercury was in the form of methyl mercury and its proportion varies among regions, being lower at Puntarenas and Punta Morales and higher at Jicaral and Colorado.

Methyl mercury contents varies among places but not between season. The station located at the mouth of the Tempisque (Colorado) river has the higher concentrations of methyl mercury (134 $\pm$ 44 ng/g dry weight) and Puntarenas, Punta Morales and Jicaral have similar concentrations, 73 $\pm$ 52 ng/g dry weight, 73 $\pm$ 22 ng/g dry weight and 72 $\pm$ 30 ng/g dry weight respectively. The total mercury also shows significant differences by site but not by season. *Anadara tuberculosa* from Jicaral (western coast of the Gulf) carries the lowest total mercury content (116 $\pm$ 28 ng/g dry weight) and Colorado the highest (214 $\pm$ 53 ng/g dry weight). Methyl and total mercury concentrations found in *Anadara tuberculosa* of the Nicoya Gulf are in the same range and sometimes lower than the concentration reported in mussel and *Andara* from other regions.

The levels are low considering the high volcanic activity and the fact that Costa Rica is located at the high mercury sediment belt of the East Pacific. Methyl ant total mercury seems to be biomagnified when the content in species from different trophic level were compared. The mercury concentrations found in the cockle from the Nicoya gulf is below the limits established for human consumption for some developed countries. The total mercury concentration measured in the sediments are within the range commonly reported in uncontaminated areas (less than 0.4 µg/g dry sediment). It seems that the main source of mercury in the Nicoya Gulf is the natural volcanic activity, possibly through atmospheric and river transport. Human mercury sources are suggested in Puntarenas, and Colorado (De la Cruz, 2002)

3.1.9. Soil Contamination

Concentrations of OC pesticides in soils have been assessed in a number of studies in the Region (Table 3.10.). The highest concentrations of OCs found in recent years were in the Panama Canal Zone. For toxaphene the highest levels were reported in Nicaragua.

3.1.9.1. DDTs

Soil samples taken in the three most important rice producing areas of Cuba showed DDT residues in the range 0.09 - 0.23 mg/kg in 1976. Seven years later the values were almost similar, 0.06 – 0.35 mg/kg (Dierksmeier, 2001).

In 2001, DDT residues were analyzed in 18 soil samples from the southern Pacific coast and 6 samples from the northern Atlantic coast of Guatemala (Campos, 2002). No DDT residues were detected on the Atlantic coast. On the Pacific, DDT residues were detected in 6 samples with a mean concentration of 0.383 mg/kg, and a maximum of 1.4 mg/kg dry weight. The maximum is about half of the maximum observed in 1997 in the same area.

Soils from an old cotton producing area in Nicaragua gave results of 193-977 ng/g dry weight for total DDTs (Carvalho et al., 1999).

A number of studies conducted in Panama revealed the presence of OC pesticides in soil. Soil samples in a rice cultivating area contained DDE, levels were in the range of 0.01-0.84 mg/kg (IDIAP, 1998 *in* Espinosa, 2002). High levels of DDT were found in soil in several areas of the Panama Canal Zone (Table 3.10). Some of the samples had DDTs levels exceeding values of remediation (PRODIMA, 1999a,b. USEPA Preliminary Remediation Goals).

3.1.9.2. PCBs

Colombia and Panama reported PCB residues in soils (Table 3.10). PCBs were detected in several studies in the Panama Canal Zone at levels up to 185 mg/kg, 3 of the samples had levels over remediation values.

3.1.9.3. Other PTS in soil

Soil samples in a rice cultivating area in Panama contained methoxychlor, heptachlor, DDT, lindane, (IDIAP, 1998). Albrook Airport area in the Panama Canal Zone had also high levels PAHs.

Colombian studies reported on soil concentrations of OC pesticides and heavy metals, including mercury. The studies were carried out in locations such as a tomato growing area in southwest Colombia (Nivia 2000), in a vegetable growing area near Bogotá (Quiroga et al, 2000) and in a former rice cultivation area in the northwest (Castro, 1997).

Table 3.10. PTS levels in soil

Country / study year	Environment	Results	Observations	Ref.
Colombia	Coastal ecosystems, Ciénaga de la Virgen, Cartagena former rice fields Soil	DDT 1.4 – 8.0 ng/g DDE 0.02 – 1.9 ng/g DDD 0.09 – 10.7 ng/g PCBs <0.01-21-7 ng/g		Castro, 1997
Colombia	Palmira, southwest of Colombia Tomato area Soil	Maximum concentrations (µg/kg) HCH 11.8 Heptachlor 18.6 Aldrin 11.9 Dieldrin 25.5 Endrin 3.3 Total DDT 3.1 Endosulfan 350		
Cuba	Rice production areas 1976	ΣDDT 0.09-0.23 mg/Kg dw		Dierksmeier, 2002
Cuba	Rice production areas	ΣDDT 0.06-0.35 mg/Kg dw		Dierksmeier,

Country / study year	Environment	Results	Observations	Ref.
	1983			2002
El Salvador	Agricultural areas: cotton, corn	Maximum concentrations (mg/kg) BHC 0.089 Heptachlor 0.056 Aldrin 0.74 DDT 1.8		Calderon, 2001
Guatemala 1971	Escuintla, Southern Pacific coast	Min - max (mg/kg dw) Σ DDT (2/2) 2.6 - 3.2 Toxaphene (2/2) 5.7 - 8.7 Dieldrin (2/2): 0.031 - 0.106 Endrin (2/2): 0.025 - 0.037		Campos, 2002
Guatemala 2001	Escuintla (southern coast), Izabal (northern coast)	Mean (min-max) Σ DDT (mg/kg dw) Escuintla (6/8) 0.383 (nd-1.4) Izabal (0/6)		Campos, 2002
Honduras 1998	Watershed River Choluteca	Frequencies of detection in soil: Dieldrin 30%; DDT 18%; endosulfan 18%; chlordane 7%; DDD 7%		Kammerbauer & Moncada, 1998.
Nicaragua	Soil in agricultural area	ΣDDT 193-977 µg/kg dw Toxaphene: 17-44 mg/kg dw Endosulfan: max 500 µg/kg dw		Carvalho et al., 1998
Panama 1996	Soils collected near buildings of an airport area in the Panama Canal Zone	α- -chlordane 330 mg/L γ -chlordane 220 mg/L p,p'-DDE 3.6-92 mg/L p,p'-DDT 1.2-1900 mg/L Endosulfan 2.9 mg/L Heptachlor 120 mg/L Phenanthrene 560 mg/Kg Pyrene 640-1300 mg/Kg Anthracene 560 mg/Kg Benzo(a)anthracene 840 mg/Kg Benzo(a)pyrene 490 mg/Kg		US Army, 1997

Country / study year	Environment	Results	Observations	Ref.
		Benzo(a)fluoranthrene 550 mg/Kg Benzo(g,h,i)perylene 690 mg/Kg Benzo(k)fluoranthrene 36 mg/Kg Butyl benzyl phthalate 3600 mg/kg		
Panama 1998	Soil samples, Corozal, Panama Canal Zone (N = 15)	α-chlordane 1.76-1560 µg/kg γ-chlordane 1.19-1630µg/kg DDE 5.06-2730 µg/kg DDT 7.45-4150 ug/kg Technical chlordane 2.95-3380 µg/kg Dieldrin: 6.58-160 µg/kg Endrin: 1.83 µg/kg	Chlordane 9/15; DDT total 100%; 5/15 of samples surrounding households: above the USEPA Preliminary Remediation Goals	PRODIMA, 1999a
Panama 1999	Soil samples (n=40) from Fort Clayton, Panama Canal Zone, 29 samples from housing area and 11 from parks	ΣDDT: 3.31-50160 ug/kg Σchlordane: 19.7-213000 ug/kg Lindane: 1.32-7.2 ug/kg	23% of the samples had residue values of DDT and chlordane exceeding values of remediation (5800 and 2020 ug/kg respectively)	PRODIMA, 1999b
Panama 1999	Soil samples and concrete platforms in Fort Clayton, Panama Canal Zone (N = 40)	PCBs (5/40) 0.037-26.2 mg/kg	Highest value in old electric substation	Tecnologia y Finanzas 1999

dw = dry weight

3.1.10. Vegetation

Standley & Sweeney (1995) and Espinosa & Campos (1998) sampled vegetation to estimate atmospheric transport of OC pesticides in Costa Rica and Colombia (Table 3.8). Espinosa & Campos (1998) determined OC pesticides in leaves of two species of mangrove (*Rhizophora mangle* and *Avicennia germinans*) in the Great Marsh of Santa Marta, Colombia. Samples were drawn between March and December 1993 at four stations at the marsh and at one station in Chengue bay Tayrona National Park. Pesticide accumulation was observed in both ecosystems. Lindane was found at highest concentrations (15.9 ng/g dry weight). Concentrations of lindane and heptachlor varied significantly between seasons, the highest concentrations occurring during the dry season. Mangrove was the species accumulating OC compounds at greatest proportion from the sediment.

Standley & Sweeney (1995) detected several OC pesticides in leaves and bark of deciduous trees in a primary forest in northern Costa Rica (Table 3.11.). Endosulfan compounds were the predominant compounds found. The authors attributed the contamination to long- and short-range atmospheric transport.

Table 3.11. Organochlorine residues in tree leaves and bark

Country/ period	Sampling sites/location	Results	Observations	Reference
Colombia 1993	La Ciénaga Grande de Santa Marta, Caribbean Colombia Leaves of 2 species of mangrove: *R. mangle* *A. germinans*	Maximum concentrations (dw): Lindane 15.1 ng/g Heptachlor 15.9 ng/g p,p'-DDE 12.8 ng/g p,p'-DDT 18.2 ng/g p,p'-DDD 20.1 ng/g Aldrin 6.8 ng/g	Pesticide accumulation observed. Levels varied significantly between seasons. Highest levels in the dry season	Espinosa & Campos, 1998
Costa Rica 1995	River catchments in mountain slopes Leaves and bark from deciduous trees Leaves n= 14 Bark n = 8	Mean concentrations (in dw) α-HCH 0.7 ng/g Lindane 2.6 ng/g Heptachlor-epoxide 2.3 ng/g α-endosulfan 0.8 ng/g Endosulfan sulfate 1.5 ng/g DDE nd DDT nd Aldrin nd Dieldrin 3.5 ng/g Endrin 2.4 ng/g Endrin aldehyde 2.0 ng/g	Leaves and bark from undisturbed catchments contained 10-fold lower levels of endosulfan than those from the eastern catchment.	Standley & Sweeney, 1995

dw = dry weight

3.2. LEVELS AND TRENDS IN THE ENVIRONMENT

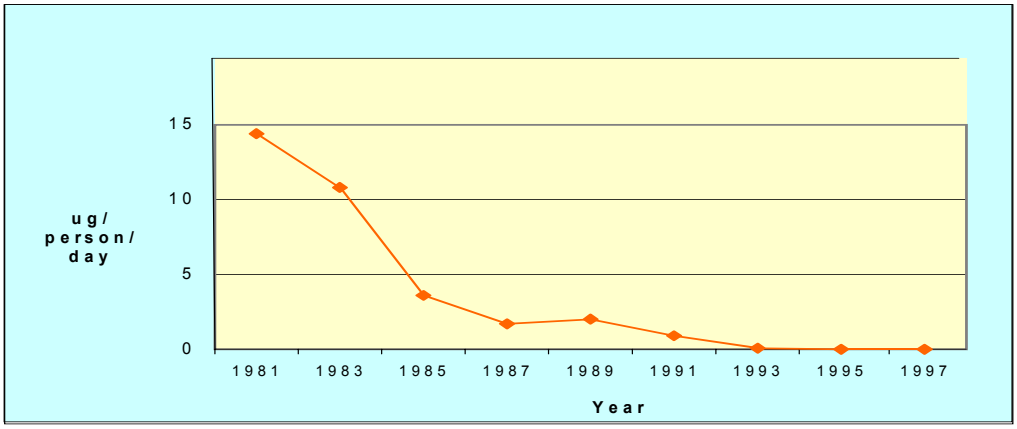
3.2.1. Residues in Food

Organochlorine pesticides have been studied extensively in the region. Most of the studies have been carried out in Central American countries in the 1970s and the 1980s. Endosulfan has been found in many samples analyzed during the last decade. Very few studies include other substances such as PCBs.

3.2.1.1. DDTs

In Guatemala during the 1970's, levels of DDT as high as 200 mg/kg were detected in the fat of meat intended for export. Residues of endrin, dieldrin and toxaphene were also frequently found. As the product did not comply with the requirements of the importing country, it was sold in the local market. In some other studies of diet contamination by DDT and other OC pesticides in the same country, contaminant burden in the total diet was assessed during 1981-1997 and 1981 - 1991. As can be seen in Figures 3.2 and 3.3, the levels have by now reduced to undetectable levels, an effect of the ban of many of these compounds in the seventies (Campos, 2002).

Figure 3.2. DDT in total diet µg ingested/ person/ day: annual mean of 10 values. Guatemala 1981 – 1997



Source: Campos, 2002

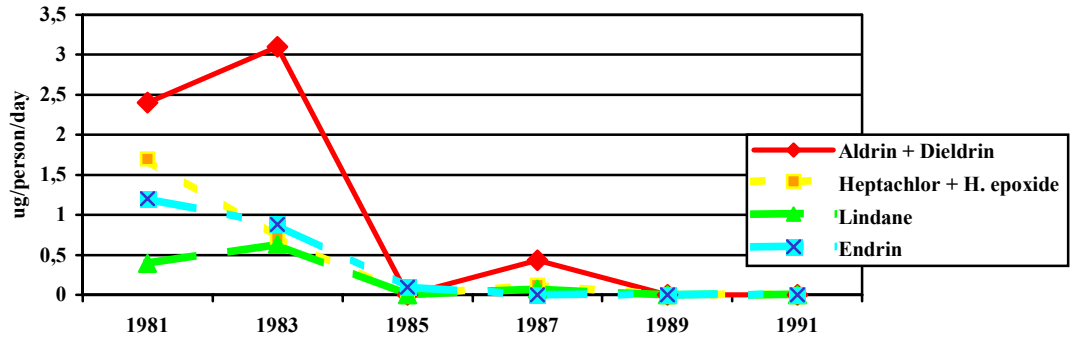


Figure 3.3. Organochlorine pesticides residues in total diets. Mean of 10 annual samples. Guatemala 1981-1991. Source: Campos, 2002

In Honduras, in 1982, concentrations of PTS pesticides in 10 samples of chicken fat and 30 samples of pork fat were measured. All samples contained DDT, but just one sample (8.6 mg/kg) exceeded the tolerance limit for this substance (7 mg/kg) (Myton, 1999, cited by RFI, 2002). In another study on PCBs and OC pesticides in edible fish in the Utila Bay carried out in 1988–1989, forty-nine fish of the families *Lutjanidae, Serranidae, Sparidae, Pomadasyidae* and *Carangidae* were analyzed. DDT was found in 60% of the samples (range: 0.2–2.6 mg/kg fat weight) and lindane in 51% (range: 0.03–0.4 mg/kg fat weight) (CESCCO, cited by Sabillon, 2002).

Also in Honduras, in 1997, 76 samples of vegetables including celery, red and white onion, green pepper, cauliflower, lettuce, cucumber, potato, cabbage, tomato and carrot were analyzed for OC and other pesticides. The samples were collected in 3 public markets and 3 supermarkets. Residues of pesticides (mostly OCs banned in previous years) were detected in 85% of the samples. Levels exceeded permissible levels in 10 samples. No differences were observed between public market and supermarket vegetables (Sabillon, 2002; RFI, 2002). Finally, a pesticide residue assessment in three selected agricultural production systems in the Choluteca river Basin found DDT and dieldrin in kidney tissue of cows, and DDT and lindane in cow milk (Kammerbauer & Moncada, 1998).

Residues of DDT were determined in 48 samples of green beans, tomato, cucumber, green pepper, lettuce and cabbage, obtained from distributors in Guatemala and El Salvador. The Guatemalan products had higher concentrations than those from El Salvador, with levels of DDT up to 0.038 mg/kg (Bonet, 1980, cited by Calderon & Melendez, 2001). Residues of the same substance were detected in all of an unknown number of samples of hen eggs collected in farms and small towns in the Salvadorean coast line in 1980, possibly due to former spraying of this pesticide in cotton fields located in the same area (Frances, 1980, cited by Calderon & Melendez, 2001). In 1983 lindane, heptachlor epoxide, dieldrin, and DDT residues were determined in 40 samples of edible oil and fat. Sixty percent of oil samples and 78% of fat samples revealed the presence of residues, some at concentrations above the admissible levels (Calderon, 1983, cited by Calderon & Melendez, 2001).

Some other studies on PTS pesticides in cattle products carried out in the 1980s in El Salvador are summarized in Table 3.13.

Table 3.12. Levels of PTS pesticides in cattle products in El Salvador, 1980–1988

Product	Number of samples	Pesticides analyzed	Results	Observations	Author and year of study
Blood, fat and liver	22	DDT Heptachlor BHC Aldrin Chlordane	Highest levels found: 796 ppb (liver), 3081 ppb (blood) 1481 ppb (liver) 336 ppb (fat) 400 ppb (fat) 346 ppb (blood)	All samples showed presence of one or more pesticides. All levels were below allowable levels.	Zelaya & Lazo, 1980 *in* Calderon & Melendez, 2001
Fat	Not given	DDT, lindane, heptachlor epoxide and dieldrin	100% of samples had DDT residues above allowable levels up to 82.65 mg/kg. It was calculated that each animal had ingested almost 353 times the ADI	Cotton straws, leaves and roots used to feed cattle were found to have levels of DDT up to 24.07 mg/kg (722 times the ADI).	Calderon, 1981 *in* Calderon & Melendez, 2001
Blood, fat and liver	Not given	DDT BHC Dieldrin Endrin Heptachlor epoxide	0.36–342 mg/kg (fat) 0.03–0.33 mg/kg (liver) 0.142-0.997 mg/kg (blood) 0.35-1.17 mg/kg (fat) 0.012-0.56 mg/kg (fat) 0.002 mg/kg (liver) 0.0046, 0.0069 mg/kg (blood)		Melendez & Bonilla, 1988 *in* Calderon & Melendez, 2001
Dairy products	140	Lindane Heptachlor epoxide DDT Dieldrin	Average levels (mg/kg) 0.04 (butter) 0.32 (cream), 0.44 (cheese) 0.80 (milk) 0.01 (butter) 0.10 (cream) 0.11 (cheese) 0.33 (milk) 0.37 (butter) 1.49 (cream) 2.15 (cheese) 2.71 (milk) 0.02 mg/kg (butter) 0.05 (cream) 0.16 (cheese) 0.65 (milk)	Residues of all pesticides detected in all milk samples, in more than 50% above allowable limits.	Calderon, 1981 *in* Calderon & Melendez, 2001

Studies carried out in Panama between 1973 and 1998 on OC pesticide levels in fish, vegetables, beef and cow milk products are summarized in Table 3.14 .

Table 3.13. Residues of PTS pesticides in food. Panama 1973-1998

Food-Stuff	Species	Residues detected	Levels	Author and year of publication
Beef	Beef cattle	Heptachlor Aldrin Chlordane Dieldrin Endrin DDT Toxaphene (29 samples)	0.1 – 8 mg/kg 1.0 – 3.6 mg/kg 0.1 – 3.6 mg/kg 0.2 – 1.7 mg/kg 0.1 – 8.1 mg/kg 0.2 – 2.4 mg/kg 1.7 – 21.8 mg/kg	Ambulo, 1973 *in* Espinosa, 2002
	Beef cattle	DDT Dieldrin Methoxychlor Heptachlor	10 – 20 mg/kg 2 mg/kg 0.2 – 10.5 mg/kg 0.1 mg/kg	Espinosa, 1988 *in* Espinosa, 2002
Cow milk products	Cattle	HCH, aldrin, heptachlor epoxides, chlordane Dieldrin and endrin DDT total	Less than 10 µg /kg Less than 20 µg/kg Less than 30 µg/kg	Espinosa, 1988 *in* Espinosa, 2002
Fish	Not available	DDT, endrin and chlordane	Residues detected in 40% of all samples	Rios, 1987 *in* Espinosa, 2002
	Stellifer colonensis, Trachiinus culveri, Centropomus parallelus, Lutjanus griseus, Tarpon atlanticus	Lindane DDT DDE/DDD Aldrin Dieldrin Endrin	1.9 – 45.5 µg/kg 1.9-30.7 µg/kg 10.6 – 74.1 µg/kg 0.7-4.3 µg/kg 0.8-1.3 µg/kg 1.0-3.1 µg/kg	Perez, 1995 *in* Espinosa, 2002
	Lutjanus argentiventris, Cynoscion phoxocephalus	DDE, DDT, dieldrin, aldrin, heptachlor	0.26 – 2.27 µg/kg (individual levels not available)	Silvera, 1997 *in* Espinosa, 2002
Vegetables	Melon Tomato Celery Celery Lettuce Carrot	DDT (4/54 samples) BHC (4/54) Endrin (3/11) Lindane, heptachlor (2/4) DDE (1/4) Endrin and DDT (1/4) Heptachlor (2 samples)	0.02 – 0.2 mg/kg 0.02 mg/kg 0.013 – 0.022 mg/kg 0.016 – 0.021 mg/kg 0.027 mg/kg 0.013 – 0.059 mg/kg 0.01 mg/kg	IDIAP, 1998 *in* Espinosa, 2002
	Vegetables	DDT and Dieldrin (227 samples)	Not available	Diaz & Lamoth, 1998 *in* Espinosa, 2002

Based on 105 samples analyzed in Costa Rica in early 1980s, 10% to 33 % of the different types of food items had OC levels over the maximum limits allowed in Germany: 10% of fruit and vegetables, 22% products of animal origin, 33% of dairy products, and 20% of eggs (Castillo, 2002). Another study conducted in a rural area (Pococí) in 1998 reported 11 out of 177 samples containing endosulfan residues (OPS/OMS, 2001).

Levels of OC pesticides in samples of fish collected both in the dry and the wet seasons were measured in La Mojana Region (Colombia). Out of all OCs analyzed, only pp'DDE and pp'DDD were present in fish in concentrations ranging 0.6 – 1.6 ppb for the wet season and 1.4 - 30.9 ppb for the dry season, well below the WHO accepted levels (Corpoica, 1996).

3.2.1.2. Endosulfan

Endosulfan residues were studied in samples of cabbage (*Brassica oleracea var. capitata*) in Las Pilas, El Salvador. The β-endosulfan isomer was present in concentrations between 0.0002 and 0.0075 mg/kg, well below the allowable level of 1 mg/kg, due to the low concentration of the pesticide used by the farmers (Novoa & Zambrana, 1997, cited by Calderon & Melendez, 2001). In another study, endosulfan was detected in 4 out of 16 samples of green pepper (*Capsicum annun*) from Zapotitan Valley in 2000, in concentrations ranging 0.001 to 0.048 mg/kg (Cañas, 2000, cited by Calderon & Melendez, 2001).

Endosulfan was analyzed in cow milk and cutflower residues used to feed cattle in the Bogotá savanna (Colombia. "High" (no quantification reported) concentrations were reported in cow milk, far exceeding WHO and FAO reference levels (Cardenas et al, 1997).

Contamination of tomatoes with endosulfan, HCH (alpha, beta, delta and gamma), heptachlor, aldrin, dieldrin, endrin, and DDT (total) in the rural area of Palmira, a city in southwestern Colombia, was assessed in 1997. The highest concentrations were found for endosulfan (65.15 ppb), but all residue concentrations found were well below the acceptable levels (Nivia, 2000).

3.2.1.3. Other organochlorines

OC pesticides were analyzed in cottonseed, celery, lettuce, cabbage, and onion samples from Almolonga in the province of Quetzaltenango (the biggest vegetable producing community in Guatemala) in 2001. Pesticide residues were found in 80% of the samples. DDT residues were detected in cottonseed at an average concentration of 0.091 mg/kg (range 0.050-0.172); HCH at a mean of 0.003 mg/kg (not detected – 0.006); aldrin and dieldrin at a mean of 0.002 mg/kg (not detected – 0.006); endrin at mean 0.001 mg/kg (not detected – 0.004); and heptachlor and heptachlor epoxide at a range from not detected to 0.001 mg/kg. Endosulfan was detected in one of the 10 cabbage samples at 0.29 mg/kg (Campos, 2002).

3.2.1.4. Other PTSs

PCBs were analyzed in 28 total diet samples between 1989 and 1991 in Guatemala. The median value was "not detected"; mean was <0.001 g/person/day (traces); and the 90th centile was 0.001 g/person/day. No PCB residues were detected in 36 samples of total diet between 1989 and 1991.

Total mercury was determined in fish and grain in Guatemala 1975-1987 (Table 3.12.). A closer scrutiny revealed that more than 90% of the total mercury in fish was organic.

Table 3.14. Mercury in food (mg/kg wet weight), Guatemala 1975-1987

Sampling period	N	Origin	Type of sample	Min	Max	Median	90% centile
06-07, 1975	14	Fresh water	Fresh muscle, different kinds of fish			0.31	0.39
03-12, 1986	49	Pacific coast	Fresh muscle, Shark, Sword fish	0.020	3.66	0.64	2.41
06-07, 1987	10		Wheat and barley	ND	ND	ND	

ND: not detected

Source: Campos, 2002.

In the study of La Mojana region (Colombia) refered to above, mercury and lead were also measured in fish. The concentrations of lead were below the detectable levels (<0.5 ppb), but the concentrations of mercury were above WHO or US EPA accepted levels with incremental risk up to 7 times (Corpoica, 1996). Fish samples from the same region taken in the wet season in 2001 were found to be contaminated by methyl mercury (Ramos, Estevez, Giraldo, 2001).

In a descriptive study done in 2000 in Bogotá, Colombia, broccoli, celery, lettuce, radish, salt-wort and sprouts irrigated with water coming from dams filled with rain, sanitary and river waters were analyzed for heavy metals and some OC pesticides during dry and wet seasons. Lead and mercury were detected in all samples of vegetables, as well as HCH, dieldrin and endosulfan in some of the samples, but details were not reported (Quiroga et al, 2000). In another study regarding organometallic mercury derivatives in fish samples from La Mojana region (Colombia) during the wet season, levels ranging 49-109 µg/Kg (dry weight) were found (Ramos et al., 2001).

3.2.2. Residues of PTSs in humans

Organochlorine pesticides have been by far the most extensively compounds studied in Region X, especially in human milk, fat and blood. However, there are very few studies concerning other PTS.

3.2.2.1. DDTs in human milk

In Guatemala several studies of DDT levels in human milk were carried out between 1971 – 1982. However only the study of 1974 includes samples in a broad scope of the country. Results of these studies are shown in Table 3.15. Total DDT was detected in all samples studied in 1971, 1974, 1979 and 1982 in different areas of the country. The highest value of total DDT (12.2 mg/kg of whole milk, almost 250 times the established Codex limit for cow milk) was found in 1971 in a mother who had been picking cotton for 25 years (Campos, 2002). The substance was prohibited in 1979, after a 5-year period of gradual decrease in imported quantities. As a result, the residue levels decreased over time. In Escuintla province on the southern Pacific coast where cotton was heavily grown for 30 years, the maximum level in 1982 was 36% of the maximum level found in 1974, but still 10 times higher than the Codex limit for cow milk. In this area a maximum level of 0.130 mg/kg total DDT was still found in 2001, three times the Codex limit of 0.05 mg/kg for cow milk. In 2001, four out of eight samples of human milk from the southern coast analyzed for DDT within a GEF/UNEP/PAHO-WHO/CEC-CCA-CCE joint project, exceeded the Codex limit for cow milk (Table 3.16; Campos, 2002). The levels found in 2001 in human milk form the Atlantic northern coast where no cotton was grown, were approximately 10 times lower.

Table 3.15. DDT in whole human milk (mg/kg), Guatemala 1971, 1974, 1979 and 1982.

N: number of samples.

Location, Major crops	1971				1974				1979				1982			
	N	Max	Min	Mean	N	Max	Min	Mean	N	Max	Min	Mean	N	Max	Min	Mean
Nebaj, Quiché Wheat, grains					28	.183	.035	.035								
Guatemala City					15	1.03	.025	.480								
Guatemala City					78	1.10	.015	.233	28	1.66	.033	0.236				
San Pedro Carchá, Alta Verapaz Coffee, cardamom					30	1.31	.003	.273								
Asunción Mita, Jutiapa Cattle, sorghum					31	2.51	.051	.490								
El Rosario Champerico, Retalhuleu Cotton, corn, sesame	27	4.97	.342	1.84	31	.912	.276	.276								
Livingston, Izabal Grains					30	5.68	.140	.864								
Morales, Izabal Banana, grains					10	6.60	1.14	2.55								
Escuintla, Escuintla – Cotton, cattle, grains					10	9.26	.600	3.54					64	3.37	<.001	.564
La Bomba Chiquimulilla, Santa Rosa Grains	10	11.3 a	.411 a	1.11	31	1.86	.089	.587								
Cerro Colorado, La Gomera, Escuintla Cotton	9	12.2 a	1.57	3.06	31	2.19	.041	.466								

Source: Campos, 2002

a = excluded from mean

Table 3.16. DDT residues in whole human milk (mg/kg), Guatemala, 2001

Location	N	Positive Samples	Min	Max	Mean
Tiquisate Escuintla	8	7	Not detected	0.130	0.055
Puerto Barrios Izabal	6	2	Not detected	0.010	0.003

Source: Campos, 2002

In a study carried out by Aguilar in 1976 in El Salvador (cited by Calderon & Melendez, 2001), milk from 19 lactating mothers in a cotton growing area (1976) was analyzed for DDT and other organochlorine pesticides. DDT was detected at levels ranging from 0.056 to 0.988 ppm. Calderon, in 1981, studied residue levels of DDT and other organochlorine pesticides, DDT was found in al samples with a mean of 0.25 ppm (Calderon, 1981, cited by Calderon & Melendez, 2001).

Milk obtained in 1989 from mothers of different regions in Honduras (292 samples) showed the presence of DDT (mean concentration 0.058 ppm of whole milk) and p,p'-DDE in 93% of samples. The mean daily ingestion of DDT for a baby of 3.4 Kg of body weight was calculated in 0.01 mg/kg, twice the FAO 1978 ADI (CESSCO, 1989, cited by Sabillon, 2002).

As part of the post-Hurricane Mitch CDC/Secretary of Health of Honduras/CECC project, analysis of pesticides in breast milk of 138 women in the south of the country was carried out. DDE was the most common pesticide detected, it was found in 130 of the samples at concentrations ranging from 1 to 160 μg/L. DDT was detected at 6 and 62 μg/L in 2 samples only. The study concluded that the concentrations in milk fat might be lower in Southern Honduras than in other Latin American countries due to the low consumption of meat and fish reported by a number of the women tested. Of the 120 milk donors who filled out a questionnaire, 49 indicated that they had consumed meat or fish only once in the previous week (RFI, 2002).

Four studies of OC pesticides in maternal milk, cord blood, veins and adipose tissue in Chinandega (Nicaragua) showed p,p'-DDE in 100% of the samples, p,p'-DDT in 74%, dieldrin in 20%, endrin in 9.4% and heptachlor epoxide in 8.9%. A significant correlation was established between concentrations of p,p'-DDE in maternal milk and cord blood ($r = 0.72$; $N = 24$; $p<0.01$) (RFI, 2002). The concentrations of OC pesticides in milk of 101 Nicaraguan mothers from the Basin of Atoya River were determined in two occasions during the first trimester of lactation during 94-95 (Lacayo et al., 2000). The samples were analyzed for 13 compounds (pp'-DDE, pp'–DDT, pp'–DDD, α, β, γ and δ-HCH, toxaphene, dieldrin, endrin, aldrin, heptachlor and heptachlor-epoxide), pp'–DDE was found in all samples, at the highest mean concentrations observed in the study. A mean concentration of 2.8 μg/g of milk fat and 0.129 μg/g for DDE and DDT respectively was reported. Total DDE concentrations exceeded the allowed daily intake set by the WHO in 5.9% of the samples.

The levels of residues of total DDT detected in 1984 in human milk in provinces of Costa Rica with intensive agriculture and vector control programs were ten times higher (mean 1.27 ppm) than in provinces with less agricultural use and without vector control programs (mean 0.11 ppm) (Umaña & Constenla, 1984).

In Panama residues of DDT in the fat of human milk were detected at levels between 0,07-7,3 μg/g fat. p,p'-DDT range was 0,01 - 4,3 mg/kg; and p,p'-DDE 0,07 - 2,4 mg/kg. The metabolite p,p'-DDD was detected only in samples of women with recent exposure, at levels in the range of 0.3 mg/kg (Espinosa, 1987 cited by Espinosa, 2002).

In a study carried out in a maternity establishment in 1984 in Dominican Republic, samples of breast milk from 60 mothers were analyzed for DDT. The compound was detected in 87% of samples (Abad & Diaz, 1984, cited by Porro, 2002).

Concentrations of total DDT and other OC pesticides were determined in 170 samples of human milk in Colombia, out of which 105 were obtained from lactating mothers living in Bogotá, and 65 from lactating mothers living in agricultural zones where these pesticides were heavily used. The results were compared with 75 samples of fresh cow milk, 10 samples of pasteurized milk, and 10 samples of powdered whole milk. The results are summarized in Tables 3.17 and 3.18.

Table 3.17. Organochlorine insecticides in human milk, Colombia, 1987

		Total DDT			Total HCH			Dieldrin		
Location	Number of samples	Mean ± SD (µg/L)	NPS[a]	NSALV[b]	Mean ± SD (µg/L)	NPS	NSALV	Mean ± SD (µg/L)	NPS	NSALV
Bogotá	105	0.048 ± 0.071	105	35	0.008 ± 0.015	20	6	0.007 ± 0.008	21	12
Espinal	25	0.131 ± 0.138	25	23	0.011 ± 0.006	17	13	0.003 ± 0.002	10	3
Guamo	25	0.118 ± 0.128	25	17	0.007 ± 0.006	12	5	0.011 ± 0.012	11	6
Girardot	15	0.095 ± 0.085	15	9	0.009 ± 0.007	10	6	0.008 ± 0.080	6	5
Total	170	0.075 ± 0.105	170	84	0.003 ± 0.010	59	30	0.001 ± 0.007	48	26

Source: Vallejo & Vargas 1991.

[a] NPS: Number of positive samples (those above 0.001 µg/L)

[b] NSALV: Number of samples above FAO-WHO limit value (0.050 µg/L for DDT, 0.003 µg/L for HCH and 0.045 µg/L for dieldrin)

Table 3.18. Organochlorine insecticides in cow milk, Colombia, 1987

		Total DDT			Total HCH			Dieldrin		
Zone and type of milk	Number of samples	Mean ± SD (µg/L)	NPS[a]	NSALV[b]	Mean ± SD (µg/L)	NPS	NSALV	Mean ± SD (µg/L)	NPS	NSALV
Bogotá, fresh milk	25	0.014 ± 0.017	25	2	0.008	20	0		0	0
Espinal, fresh milk	25	0.011 ± 0.008	25	0	0.010 ± 0.014	18	9	0.008 ± 0.016	5	1
Guamo, fresh milk	25	0.017 ± 0.010	25	0	0.005 ± 0.003	10	4	0.006 ± 0.005	4	1
		Total DDT			**Total HCH**			**Dieldrin**		

Bogotá, pasteurized milk	10	0.005 ± 0.004	10	0		0	0		0	0
Bogotá, powdered whole milk	10	0.026 ± 0.006	10	0		0	0		0	0

Source: Vallejo & Vargas 1991.

[a]NPS: Number of positive samples (above 0.001 μg/L)

[b]NSALV: Number of samples above FAO-WHO limit value (0.050 μg/L for DDT, 0.003 μg/L for HCH and 0.045 μg/L for dieldrin)

The authors concluded that the level of total DDT in human milk in the Bogotá zone exceeded the levels in cow milk in the same zone by a factor of 3.5. Human milk in Espinal and Guamo (where soy bean, rice and cotton are cultivated) was 2.7 and 2.4 times as contaminated as in Bogotá. The mean values exceeded the FAO-WHO values; the levels in DDT in some samples exceeded FAO-WHO values by a factor higher than 10. None of the samples of cow milk exceeded the limit values for DDT. The sources of contamination of the milk by OC insecticides are presumably contaminated foodstuffs and the use of these substances in domestic and agricultural pesticides (Vallejo & Vargas, 1991).

In Yaracuy, an agricultural state in Venezuela where DDT has been used in farming and for malaria control levels of this compound were studied in 145 human milk samples collected at 25 days post partum from women aged 16 – 40 living in various rural populations. DDT was determined as DDE by GC-ECD. All milk samples contained DDT ranging 5.1 – 68.2 μg/L and levels increased significantly with maternal age ($p < 0.05$). It was concluded that general population exposure to DDT in the study area is probably a result of widespread low-level contamination, the most likely source being food (Brunetto et al., 1996).

3.2.2.2. Other OC pesticides in human milk

Guatemala, other frequently found compounds in breast milk in Guatemala in studies performed in 1971 and 1974 are HCH, dieldrin and heptachlor epoxide. These studies are shown in Tables 3.19 and 3.20.

Table 3.19. HCH, dieldrin and heptachlor epoxide residues in whole human milk in some regions of Guatemala, 1971

Pesticide	El Rosario Champerico, Retalhuleu	Cerro Colorado La Gomera, Escuintla	La Bomba Chiquimulilla, Santa Rosa
HCH			
Number of samples	27	9	10
Positive samples	23	5	10
Mean (range) (mg/kg)	0.006 (0 – 0.019)	0.015 (0 – 0.057)	0.24 (0.010 – 0.035)
Dieldrin			
Number of samples	27	9	10
Positive samples	23	0	0
Mean (range) (mg/kg)	0.002 (0 – 0.010)		
Heptachlor epoxide			
Number of samples	27	9	10
Positive samples	19	0	3
Mean (range) (mg/kg)	0.007 (0 – 0.008)		0.003 (0 – 0.21)

Source: Campos, 2002

Table 3.20. Dieldrin and heptachlor epoxide residues in whole human milk in some regions of Guatemala, 1974

Pesticide	Guatemala City	Morales, Izabal	Escuintla, Escuintla
Dieldrin			
N samples	15	10	10
Positive samples	0	1	1
Mean (range) (mg/kg)		0.005	0.070
Heptachlor epoxide			
N samples	15	10	10
Positive samples	0	1	0
Mean (range) (mg/kg)		0.002	

Source: Campos, 2002

In milk samples collected from 19 lactating mothers in a cotton growing area in El Salvador (1976) levels ranging from nondetectable to 0.082 for heptachlor; and less than 0.01 ppm for endrin and toxaphene were reported (Aguilar, 1976, cited by Calderon & Melendez, 2000).

Residue levels of lindane, heptachlor epoxide, dieldrin and DDT in 87 samples of human milk from lactating mothers living in three agricultural areas of El Salvador were determined. Lindane and dieldrin were found in all samples and heptachlor epoxide was found in 78% of the samples above the Maximum Residue Levels. The mean concentrations were 0.0139 ppm for lindane; 0.0109 ppm for heptachlor epoxide and 0.0127 ppm for dieldrin (Calderon, 1981, cited by Calderon and Melendez, 2001).

As part of the post-Hurricane Mitch project mentioned previously (RFI, 2002) other pesticides besides DDTs were detected although in much lower frequencies. From the 138 samples of breast milk analyzed endosulfan sulfate was detected in 4 samples at 5 to 6 μg/L, heptachlor epoxide in 3 samples at 1 to 5 μg/L; and endrin in 2 samples at 1 to 2 μg/L.

The concentrations of OC pesticides in milk of 101 Nicaraguan mothers in the study by Lacayo et al. (2000) reported that twenty percent or less of the samples contained chlorinated cyclodienes (dieldrin > endrin > heptachlor-epoxide > heptachlor); α and δ-HCH were not found, whilst β and γ- HCH were found in less than 6% of the samples. No measurable concentrations of α-HCH, aldrin, pp'-DDD, or toxaphene were found.

In the study of human milk in Colombia by Vallejo and Vargas (1991) mentioned previously concentrations of total HCH and dieldrin were determined in 170 samples of human milk and the compared with 75 samples of fresh cows milk, 10 samples of pasteurized milk, and 10 samples of powdered whole milk. The results are summarized in Tables 3.20 and 3.21. The mean HCH values in human milk in Bogotá, Espinal, Guamo and Girardot exceeded the limit values. No contamination was detected in the cow milk from Bogotá, but the concentrations in Espinal and Guamo were above FAO-WHO recommended levels. For dieldrin, 20% of the Bogotá human milk samples had levels above recommended limits. No dieldrin contamination was found in cow milk from Bogotá, but it exceeded recommended levels in Espinal and Guamo. The sources of contamination of the milk by OC insecticides are presumably contaminated foodstuffs and the use of these substances in domestic and agricultural pesticides.

3.2.2.3. DDTs in adipose tissue samples

Adipose tissue samples have been analyzed for DDT residues in several countries of the region including Costa Rica, Guatemala, Nicaragua and Colombia.

The highest value found in the studies of 1981-1983 in Costa Rica were for men living in the rural area, 45.99 µg/g fat. In a study in 1984, 13 adipose tissue samples of patients from Choluteca Hospital (southern of the country) were analyzed having found DDT and lindane in all of them (Sabillon, 2002).

In a study on OC pesticides in adipose tissue of 93 Nicaraguan mothers living in the basin of the Atoya River, Department of Chinandega, DDT derivatives were present in all samples. HCHs (α, β, γ) as well as chlorinated cyclodienes (dieldrin, endrin, heptachlor-epoxide, heptachlor) occurred in less than 13% of the samples. The highest mean concentrations were found for p,p'-DDE and p,p'-DDT (1,662 µg/g and 0.082 µg/g of fat, respectively). Maternal age correlated significantly with p,p'-DDE (p=0.0004). No measurable concentrations were found for δ-HCH, aldrin, p,p'-DDD, or toxaphene. The rest of the pesticides had low mean concentrations that ranged from 1 to 3 ppb in the HCH family and in the order of 0 to 5 ppb in the cyclodiene group (Cruz-Granja et. al, 1997).

The first Guatemalan study, dated 1982, reported DDT in all samples from stillborns, children and adults from urban and rural areas. Dieldrin was found in 70% of the samples; heptachlor epoxide and endrin at a lower frequency. Maximum levels were as follows: stillborns, 55 mg/kg; in a one-year old child, 75 mg/kg; and in a 72-year old man, 191 mg/kg. In a second study (1987), 24 samples were obtained during surgery of rural subjects. The maximum DDT concentration was 15 mg/kg (Campos, 2002). See Figure 3.4.

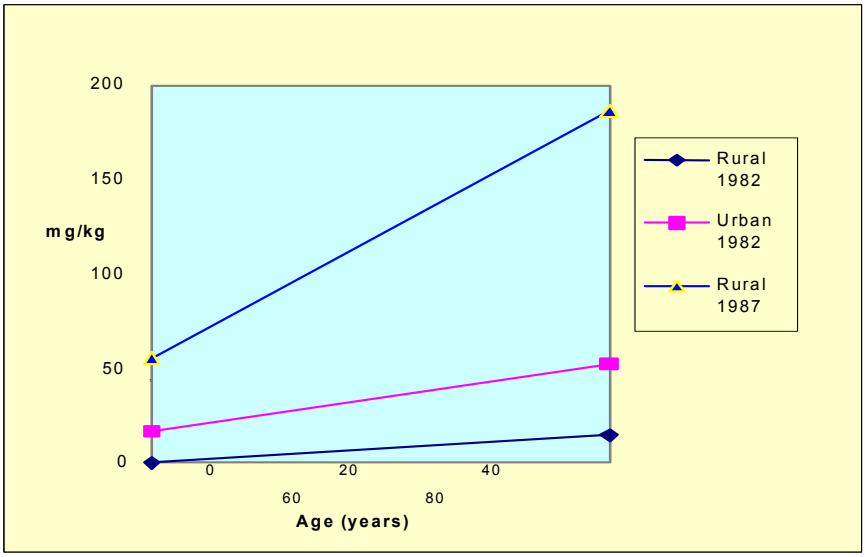


Figure 3.4. DDT residues in human adipose tissue. Guatemala 1982-1987

The Salvadorean study reports residue levels of lindane, dieldrin, heptachlor epoxide and DDT determined during 1988-1989 in 60 samples of adipose tissue of surgery patients. DDT was detected in 58 samples; lindane in 39, heptachlor epoxide in 14; dieldrin in 5, ranging from non detectable to 10.22 ppm. Mean total DDT concentrations were 3.75 and 3.93 ppm for the two rural areas studied (Mendez RM et al, 1989, cited by Calderon and Melendez, 2001).

3.2.2.4. Serum organochlorine levels

Serum DDT levels were detected up to 0.060 mg/L in 8 samples of human subjects living in the southern coast of Guatemala in 2001, while in six samples from the northern coast the levels were below 0.020 mg/L (Table 3.21) (Campos, 2002). This reflects the influence of cotton cultivation as cotton was extensively grown at the southern Pacific coast, not at the northern Atlantic coast.

Table 3.21. DDT residues in human serum (mg/kg), Guatemala, 2001

Location	N	Positive Samples	Min	Max	Mean
Tiquisate Escuintla	8	3	Not detected	0.060	0.031
Puerto Barrios Izabal	6	4	Not detected	0.020	0.010

Source: Campos, 2002

In El Salvador, serum concentrations of lindane, dieldrin and DDT were determined in 300 subjects from San Salvador City, Arce City, and cotton and coffee growing areas during 1980-1981. Levels of lindane and dieldrin were higher in Arce City (means 19.43 and 7.12 ppb, respectively), while the highest levels of DDT were found in the cotton growing areas (mean 100.89 ppb) (Calderon et al, 1984, cited by Calderon and Melendez, 2001).

In a population-based cross-sectional household survey in a suburb of Istoca, Department of Choluteca (Honduras), conducted after Hurricane Mitch (end of October 1998), blood and urine of 45 adolescents aged 15-18 years were sampled for residues of OC pesticides. Fifty-one percent of serum samples had p,p'-DDE levels in the range of 1.16-96.9 ng/mL (US reference mean in adults = 3.5 ng/mL). Dieldrin levels >0.2 ng/mL were present in 23% of the serum specimens (in US adolescents, <0.2 ng/mL). Elevated levels of OC pesticides suggested that they were still being used in the country, even if these substances were banned in Honduras 15 year before the study (Balluz et al, 2001).

3.2.2.5. Other PTSs in human serum

Studies done in the Dominican Republic between 1977 and 1979 on blood lead levels in subjects working in car battery repair, pottery and paint factories and gas stations showed that 90% of the study population had levels above 50 mg/100 mL (the allowable level) with a maximum of 250 mg/100 mL. There were 158 cases of anemia among the 500 persons examined. The highest levels were found in workers of the battery repair workshops (Porro, 2002).

The death of a two-year-old child in 1991 (with blood lead levels of 162 μg/dL) sparked investigations and controversy about lead contamination in Trinidad. Slag from a secondary lead smelter was deposited in a rural area in East Trinidad for land filling and road construction. This resulted in lead levels as high as 12% in the soil around homes, and lead blood levels reaching 217 μg/dL in some residents. Subsequent remediation of the contaminated soil by the Government in 2000-2001 revealed a significant reduction in blood lead levels in the population that was originally tested (6-166 down to 0-65 μg/dL). High lead levels have also been detected in human scalp hair and pubic hair (1-1671 μg/g) from persons exposed to road traffic and workers in a lead smelter (Rajkumar, 2002).

Lower Caroni is a Venezuelan gold mining area where 69% of miners and 37% of non-miners were contaminated with mercury in 1990. In Cristina IV concession hydrargirism (Hg contamination) was diagnosed in miners and surrounding population (Hamilton, 1996).

In a study carried out in Bogotá (Colombia) in year 2000 among an agricultural population using water contaminated with heavy metals for irrigation the investigators found that 98% of examined population was contaminated with lead and mercury, but none of the concentrations were above permissible levels (Quiroga et al, 2000).

3.3. EVIDENCE OF ADVERSE EFFECTS

3.3.1. Environmental Effects

There are almost no studies regarding environmental effects of PTS in the region. An exception is the study of OC pesticides in eggs and the relation of the levels with egg shell thinning mentioned earlier in this chapter in the section of aquatic birds (See Table 3.6).

A study in Jamaica showed that increased moisture in soils enhanced the toxicity of organochlorines. Toxicity of dieldrin and chlordane was increased in three Jamaica soils (Chudleigh Clay Loam, Syndenham Clay Loam and Maverley Sandy Loam) at three moisture levels, 5, 10 and 15% (Chin Sue, 2002).

Additionally there is anecdotical evidence about fish die-offs in agricultural areas where PTS pesticides have been in use. Such is the case of fish kills in Jamaica associated with coffee producing areas and periods of endosulfan application (Chin Sue, 2002). However, there are no confirmation studies.

3.3.2. Effects On Humans

Data availability on effects of PTSs on humans is limited in the Region and most of the studies address acute effects. Reports of delayed effects associated with exposure to PTSs are very scarce.

3.3.2.1. Acute effects of PTSs

Between 1986 and 1987 in Guatemala, 8.1% of all pesticide poisonings registered by the Ministry of Health and the Guatemalan Institute of Social Security (57 cases) were caused by OCs (aldrin and endosulfan). Three deaths were due to exposure to aldrin in the same period. Forty-two percent of all cases were associated with occupational exposure, 35.8% were associated to accidental exposure and 22.7% were suicide attempts (Samayoa et al., 1989). In 1999, endosulfan caused 26 poisonings (12% of all poisonings during the first half of 2001) (Campos, 2002). In 2000, 60% of the acute poisonings was due to occupational exposure, 27% to accidental exposure and 13% to suicide or suicide attempts. Lethality was 10%. Each year the majority of the cases are caused primarily by 5 compounds: paraquat, methamidophos, methomyl, phosphine and endosulfan. (Campos, 2002).

Serious massive accidents caused by organochlorine pesticides have also been reported in Guatemala. In 1982, 22 persons, of whom 5 died, were poisoned by food bought at a local market in Guatemala City. Endrin, at that time registered for agricultural use, has been used to control pests in the marketplace, contaminating chicken, fish and vegetables (Laboratorio Unificado de Control de Alimentos y Medicamentos, cited by de Campos, 2002).

During 1998-2000, the pesticide poisoning surveillance system in El Salvador received reports on 150 poisonings with OC pesticides, the vast majority caused by endosulfan, with 4 reported deaths. The Ministry of Health reported 72 cases in year 2000 and 31 cases in 2001 caused by OC pesticides, mainly endosulfan (60 cases in 2000 and 20 cases in 2001). No casualties were reported (Morán, 2002).

In Honduras the Ministry of Health reported 6 cases were due to exposure to an OC pesticide (endosulfan, aldrin, chlordane and HCH) with no deaths in 1987 (Aguilar, 1988).

Poisonings caused by OC pesticides decreased after their use was restricted in Costa Rica in 1980. Hospital registry of poisonings from 1980 to 1986 showed that 13% were caused by OC pesticides including aldrin, DDT and chlordane (69, 13 and 10 cases in that order, the majority after occupational and accidental exposures). The share of PTS pesticides as cause of poisoning in the registry of hospitalization of the Costa Rican Social Security Institute between 1976 and 1985, decreased from 9.9% in 1976 to 2.3% in 1985 (Wesseling et al, 1988). The Organizacion de Investigaciones Judiciales (the official forensic agency) identified endosulfan as one the substances causing deaths during 1980-1986. In 1986, the Occupational Accident and Disease Registry reported that 8% of the registered poisonings were related to exposure to pesticides different from paraquat, organophosphates and carbamates, including endosulfan. The register of the CNCI (telephone reports) reported 29 (3.7% of total) poisonings as caused by OCs in 1984 (Wesseling et al, 1993). Table 3.22. summarizes the data on acute poisonings by PTS substances from the surveillance

system of the Costa Rican Ministry of Health in Costa Rica from 1993 to 1997 and 2001. This data, however, is severely biased by under registration and under reporting of poisonings (Wesseling, 2002).

Table 3.22. Number of poisonings due to PTS pesticides, reported to the Pesticide Poisoning Surveillance System of the Ministry of Health of Costa Rica, 1993-1997 and 2001.

Pesticide	1993	1994	1995	1996	1997	2001	Total
Endosulfan	6			4	3	2	15
Organic mercury						1	1
Pentachlorophenol				1			1

Source: Wesseling, 2002

The proportion of registered cases of acute poisonings by OC pesticides in the Central and Western regions of Panama in 1993 was 4% and 6%, respectively. There is a clear trend towards the reduction of the number of cases caused by OCs (Diaz-Merida & Lamoth, 1998).

In a study of 3,998 cases of pesticide poisonings registered in 121 municipalities of the Antioquia province in Colombia during a 10-year period, it was found that 3.6% of the cases were caused by OC compounds. All age groups and both genders in both rural and urban areas were affected. There were 568 deaths caused by pesticides; 1.4% due to OC compounds (Nieto-Zapata, 1988). In another study carried out in Valle del Cauca, the country's largest agriculture producer, endosulfan was the substance identified as the cause of 57 poisonings (41 work-related, 9 voluntary, and 7 accidental) (Morales et al., 1998). Seven cases of acute intoxication by "organochlorines" and 14 cases caused by endosulfan were recorded in the coffee growing region of the country between 1999 and 2000 (Nieto, 2002).

Unpublished data on deaths associated with chemical substances compiled by the Central Region of the Colombian National Forensic Institute by a contractor of the Ministry of Environment showed that between 1998 and 2001 out of a total of 204 deaths caused by chemicals found, 20 were caused by endosulfan, one by mercury and one by toxaphene (Fonseca J.J., Inst. Nacional de Medicina Legal, Colombia, personal communication).

In Jamaica the Pesticides Control Authority (PCA) analyzed data for four years (1997-2000) to identify the types of pesticides which were accountable for pesticide poisonings as well as the locations where the highest incidences have occurred. The data represent approximately eighty percent (80%) of cases nationally since all hospitals are not yet reporting to the central system. Results showed that halogenated pesticides (possible OCs) accounted for just two cases in that period, both of them in 1998 (Chin Sue, 2002).

According to the National Bureau of Health Statistics of the Ministry of Public Health of Cuba, between 1990 and 1997 (8 years), there were 1205 deaths caused by pesticides, 11 of them caused by organochlorines (Gonzalez & Conill, 1999, Gonzalez et al, 2001).

3.3.2.2. Delayed effects of exposure to organochlorine pesticides

Regarding delayed effects of PTS exposure, in Guatemala (1976 - 1980), 2 groups of urban women of low and high socioeconomic classes and one rural group of low socioeconomic class, aged between 18 and 35 years with oral, dermal and respiratory exposure to DDT, were studied for liver physiology and hematological parameters. The rural group of low socioeconomic class had levels of unmetabolized DDT lower than the urban groups (87% of the levels of the urban low class group and 79% of the levels of the high class group (Dary, 1980 *In*: ISAT, 2001).

A case-control study was carried out in Bogotá, Colombia, with 153 incident breast cancer cases and 153 age-matched controls, in order to assess the association between breast cancer risk and serum DDE levels. Sociodemographic and reproductive data, diet, and past exposure to pesticides were obtained through a structured questionnaire. Chemical analysis of samples was performed by high resolution gas chromatography-ECD. Odds ratios (OR) were estimated with logistic regression models, adjusted for first-child breast-feeding, family breast cancer history, body mass index, parity, and menopausal status. OR for

exposure to serum DDE suggested an increased risk of breast cancer in the higher category of DDE exposure (OR = 1.95; CI 1.10-3.52). A trend test for dose-response (p=0.09) did not quite reach conventional statistical significance. (Olaya-Contreras et al., 1998).

Finally, chronic nervous system effects of long-term occupational exposure to DDT were investigated in Costa Rica comparing the neurobehavioral performance of retired malaria control workers with a reference group of retired guards and drivers. DDT exposed workers did worse than controls on tests assessing neurobehavioral functions. Performances deteriorated with increasing years of DDT application. The results could not be explained by exposure to cholinesterase-inhibiting pesticides or other confounders (van Wendel et al, 2001).

3.4. SUMMARY

Regional evidence of PTSs in air, marine, freshwater and terrestrial ecosystems, foods, and human biological samples is scattered in time, location, and methods. Incomparability between surveys and lack of monitoring and surveillance programs hamper obtainment of an overall picture.

For atmospheric concentrations, samples in both inland and coastal Belize in 1995-1996 indicated elevated levels of DDT and dieldrin and low for heptachlor. In 2002-2002, inland concentrations were comparable, while Costa Rican mountain samples had much lower p,p'-DDE and p,p'-DDT concentrations.

Coastal marine sampling indicated contamination by a number of organochlorine pesticides in 3 Pacific estuaries in Honduras in 1995-1997, though concentrations were mostly low (from 0.01 mg/L of heptachlor epoxide to 0.03 mg/L of α-endosulfan). PCB and DDT were detected in Colombia in 1996; α and β-endosulfan, dieldrin and DDTs in Jamaica in 1982-1986 and in 1990-1991. A St. Lucia coastal sampling program in 1986-1991 detected lindane, dieldrin and DDT.

In sediments and biota, OC residues have been reported at various time periods since 1970 in Guatemalan coastal areas bordered by cotton fields, in coastal ecosystems near former rice fields in Colombia; in Pacific Costa Rica; in an agricultural coastal area in Cuba; Pacific El Salvador; Pacific Honduras; Jamaica; St. Lucia; and Venezuela. PCB residues have been occasionally determined and detected. OC pesticides and PCBs have been reported in mammal samples in Costa Rica and St. Lucia, crocodile eggs in Belize and in aquatic bird eggs in Costa Rica. In six species of aquatic birds, a strong correlation was found between eggshell thickness and p,p'-DDE residues. Cracks were observed in some of the eggs of *M. americana* with the highest concentrations of DDE.

Freshwater, groundwater, soil and vegetation studies have identified a wide variety of pesticide, PCBs and mercury residues in the Region. Atrazine, DDTs, endosulfan and toxaphene have been the most relevant compounds reported in surface and groundwaters. DDTs, chlordane, heptachlor, toxaphene, PCBs and PAHs were some of the relevant PTS reported in soils. Some soils samples from the Panama Canal Zone had DDT and chlordane levels above the USEPA Preliminary Remediation Goals.

High residues of DDT were detected in human milk, especially in the early 1970s, but traces were found in Guatemala still in 2002, more than 20 years after DDT was banned. OC pesticide residues have been found in varying amounts in human blood samples.

OC residues have been reported in a variety of foodstuffs. High levels of OC pesticides have been measured in the fat of exported meat in Guatemala in the 1970s. DDT in total diet has decreased to practically zero by the year 2000. OC residues have been reported in a variety of foodstuffs. The incidence of acute pesticide poisonings in humans is high in Central America, however there is scarce information on poisonings with OCs pesticides for the period in which these compounds were used more intensively. Acute poisonings by endosulfan are reported for several countries. For chronic health effects regional data suggest neurobehavioral deterioration following exposure to DDT; and an association between breast cancer and DDE.

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4. MAJOR PATHWAYS OF CONTAMINANT TRANSPORT

4.1. ASSESSMENT OF INPUT AND OUTPUT OF POLLUTANTS

The magnitude and rate of the input and output of PTSs depend on the dimensions and physical characteristics of each country in the Region. Climatic conditions are similar. All have coastline, 12 are islands, and the rest are continental countries, some of which have coasts to two oceans. Ocean currents are therefore very important in the input and output of PTSs.

Some pollutants, such as radioactive materials, by-products of nuclear testing or nuclear power generation and OC compounds such as DDT and the PCBs, may eventually reach a worldwide distribution. Among the small group of ubiquitous substances, the most frequently found are DDT and PCBs. This is due to the following:

- Resistance to degradation;
- Historical production and release, which exceed the amount of other PTSs;
- Dispersion and movement at local, regional and global levels;
- Physical and chemical properties of these compound;
- Form of release (vapour, solution or suspension, and waste);
- Interactions with the environment (distribution in water/sediment, air/water);
- Bioconcentration (favouring or retarding movement, depending on the species);
- Climatic conditions (ambient temperature, winds, marine currents).

Dispersion of PTSs is spontaneous and will reach a steady state when substance concentration becomes equalized in all environmental compartments. Because strong dilution, some contaminants remain undetected with the instrumentation generally available. Since degradation always takes place and its rate varies by compartment, the movement of PTSs will continue for a long time.

4.1.1. Ocean currents

The ocean currents that move through the Caribbean region are part of the global ocean currents. They originate in the Indian Ocean and move westward joining the Antarctic current. A part of the Antarctic cold water mass moves north through the Atlantic Ocean (Figure 4.1). The flow following the confluence of the Guyana and the North Equatorial streams in the Tropical Atlantic divides before it arrives near the Lesser Antilles. One current goes up toward the north of the Antillean Arch (Current of the Antilles). This current takes a northwestern direction through the area.

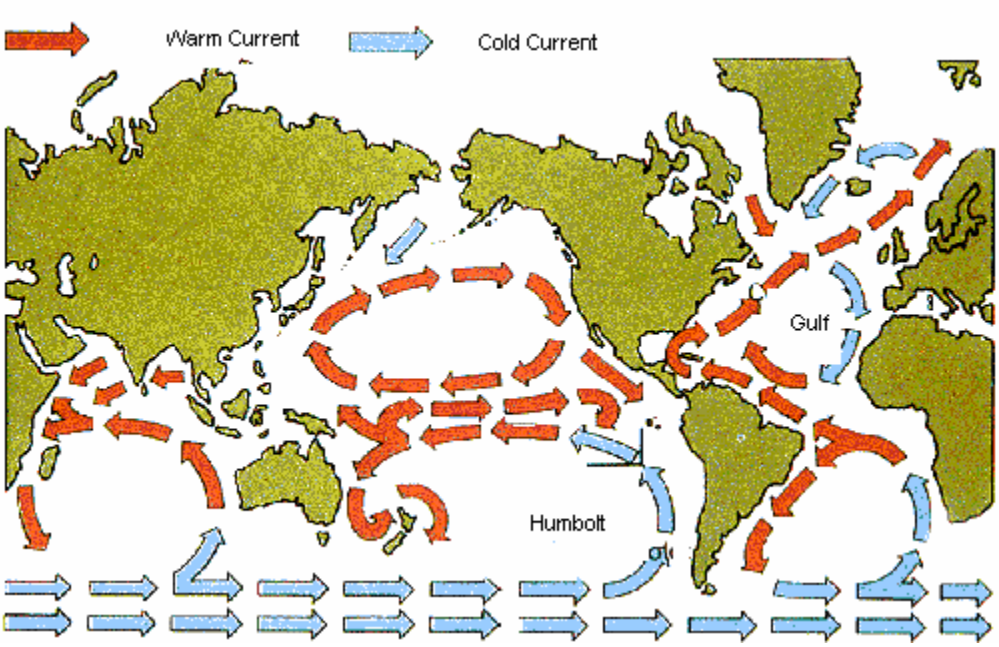

Figure 4.1. Ocean currents

The other part of the North Equatorial Stream enters the Caribbean Sea and accumulates inside the basin. From there, it moves in a poorly defined and highly variable Caribbean Stream, flowing westward from the southern end of the Great Caribbean, in front of the coast of South America, to finally reach the eastern coast of Central America. There, it bifurcates and changes direction. A part moves to the North. The other part moves to the southeast, passing along the coast of Nicaragua, Costa Rica, Panama and Colombia, completing a cyclic movement every two months, and moving along 3 000 km of coast line (Figure 4.2).

Figure 4.2. Cyclic current at the Western Caribbean

The portion of the current moving North is forced into the Gulf of Mexico through a narrow and fairly shallow channel (Yucatan Strait). There it bifurcates near Yucatan peninsula and moves partially eastward in front of the northwest coast of the middle of Cuba, and joins the current coming westward from the current of Antilles and moves North, running near the eastern coastline of USA. From there, it heads northeast until the current arrives at the west coast of Europe and the Northwest coast of Africa. There it bifurcates again, and a part moves northeast and the other part turns to the south until it meets the current coming from the Lesser Antilles. The other part of the current moves along the east coast of Mexico and the south coast of USA, moving eastward until the Florida Strait, where it joins the current heading north from Cuba (Figure 4.1).

Throughout this runover, the ocean currents may bring various dispersed and dissolved contaminants, nutrients and microorganisms to the countries of the Region. The influence of these currents is well known in the countries in the Caribbean region. Trinidad and Tobago and Barbados particularly suffer from contaminants brought by the currents influenced by the Amazon and Orinoco river discharges. Jamaica reports the influence of the water that comes from the Magdalena River, which is particularly strong during August to October, when the rainy season reaches its maximum and salinity level of the seawater bordering these countries is lowest.

Furthermore, during its movement, this ocean current incorporates contaminants that afterward are partially brought to the Region due to the cyclic movement in the North Atlantic Ocean. The continuous washing of the coast of the United States may explain the reduced PTS concentration in sediments and biota in its coastal region. No data were available of the quality and concentrations of the contaminants brought by ocean currents to the Region. It is well known that DDT is actually produced and used intensively in crop protection in some Far East countries. Due to the global ocean current network, PTSs banned years back in the Region may be encountered in its coastal biota and sediments. The same ocean currents carry the PTSs and other contaminants released in the Region and move them abroad. The movement of PTSs to the coast and their further transport with the ocean currents is relatively easy in many countries of the Region. Some are small and mountainous islands, with numerous watersheds and rivers. It usually takes a short time for the contaminants to arrive directly by runoff or through the rivers or channels to the coast. This transport is easier during the heavy rainfalls that occur during May to October. Average annual rainfall is high (more than 1800 mm) in most of the countries in the Region.

Rainfall is however unevenly distributed in time and place. More than 75% falls during the rainy season. The approximately 200 events of 15 minutes to 2 hours rainfalls are heavy; this exceeds the infiltration capacity of soil and causes strong runoff of various contaminants adsorbed on eroded matter. This holds for most of the PTS pesticides commonly used in the Region such as atrazine, endosulfan, and lindane. However, DDT residues from previous applications before the banning at the end of the 1980s in most Caribbean islands may also move and be found in river sediments of some countries of the Region. Furthermore, the leachate from landfills and dumping sites may move because of the lack of adequate management of solid wastes.

Oil spills are frequent. Some countries are heavy crude oil producers and the dense tanker traffic in the region contributes significantly to the hydrocarbon contamination. Offshore oil exploration adds to the contamination. Ocean currents carry part of all these contaminants out of the Caribbean.

The situation is similar for the South and Central American countries of region X. In general the countries are bigger, the rivers are longer and carry much water that bring contaminants to the coast, mainly adsorbed on particulate matter. This is an area of intense agricultural activity. Twenty-three % of Panama's, 45% of Costa Rica's, 90% of Nicaragua's and 70% of Colombia's territory drain to the southeast Caribbean Sea. The cultivated land volume in these 4 countries amounts to some

3 000 000 ha of different crops. PTS pesticides commonly used in the Region such as atrazine, endosulfan, and lindane, as well as other PTS residues from applications before the banning of these products, may be brought to the regional sea through the rivers and direct runoff.

Cumulative and cyclic effects are observed, and finally, as the cyclic current (See fig. 4.2) comes in contact with the main North Easter current, the pollutants may enter this main current and impact other countries of the region. It may also move out of the Region with the current that reaches the Yucatan peninsula (See fig.

4.1). Honduras, Belize and Guatemala receive the influence of the marine current from the east Caribbean, which may bring pollutants released by neighboring countries or by countries in other regions.

Colombia, Panama, Costa Rica, Nicaragua, Honduras, El Salvador and Guatemala are under the influence of the Pacific currents (Fig. 3). An upward movement of the coastal water, induced by the winds (up-welling) prevails in this part of the Region, favoring dilution of pollutants and their movement away. As in the Caribbean coast, the Pacific currents near the coasts of these countries are important for the transport of contaminants released by rivers and by direct discharges and runoff emissions.

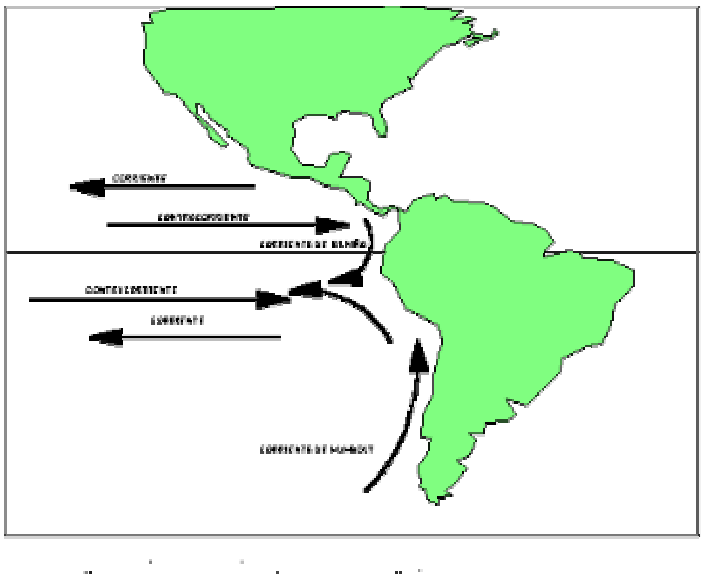

Figure 4.3. Currents at the Pacific Ocean

The input-output dynamics of contaminants from the region by ocean and marine currents are valid only under normal climatic conditions. As is known, the countries of the Region are exposed every year to abnormal climatic conditions, with the possibility of development of hurricanes. When this materializes, the countries affected receive continuous heavy rainfalls during several days, surpassing the annual average rainfall, causing dangerous flooding and high erosion. Joined to the high wind velocity, the disturbed marine and ocean currents move away quantities of substances, including pollutants and solid wastes. As a consequence, the countries lose valuable soil and at the same time discharge high quantities of pollutants into international waters.

On the Pacific side, two climatic phenomena ("El Niño and La Niña") disturb the normal climatic pattern, increasing or decreasing the rainfall rate and causing flooding or long drought to the Region. Results of flooding are similar to the effects of hurricanes, while prolonged droughts reduce the pollutant release, at least through and into water. An increase of output by volatilization and by winds is a possibility, however.

4.1.2. Atmospheric circulation

The intensity of solar radiation is high at the Equator. The air mass near the Equator is heated while that in the poles remains cold. The hot air has low density and ascends, causing a partial vacuum or zone of low pressure, which allows the cold air mass of the poles to move to the Equator. In the Northern Hemisphere, the wind movement has a westward deviation caused by Carioles force due to the rotation of the Earth around its own axis. This deviation is greater, the higher the wind speed.

At the same time, during its ascension, half of the hot equatorial air mass moves toward the North Pole, the other half toward the South Pole. During this movement, the air mass comes in contact with the polar air that is heading toward the Equator, cools down and increases its density. At 30° of northern (or southern) latitude, the air mass moving down is compressed and finally arrives at the Earth surface where it divides moving northward to the Pole or southwest to the Equator (trade winds). As a consequence of the continuous

temperature changes of the global air mass, an atmospheric circulation is established. In the Northern Hemisphere, the winds complete a cycle each 120-150 days according to the season, under normal climatic conditions.

Region X, located in the North Hemisphere, is under the influence of the Northeast Trade winds, which bring every year huge masses of cold air to the Equatorial region. Under normal climatic conditions, the trade winds are constant and soft with speed in the range of 3 m/second to 8 m/second. However, these steady winds may be disturbed during the hurricane season (June- November), changing their direction and intensity. Also during the rainy season, which begins in May, trade winds change their normal pattern. In the western Caribbean, the climatic pattern is influenced by the North-South displacement of the inter-tropical convergence zone. When this zone moves to its extreme southern position at the beginning of each year, the northeastern trade winds blow with a higher intensity in the whole western coastline. This is apparently due to the displacement of polar air masses toward the Caribbean region. In this air mass, the PTS vapours and PTSs adsorbed to dust particles arrive to countries at the Caribbean and Central America. By fallout, especially of dust particles, the PTSs cover uniformly the local environment. However, until now, the contribution of this Aeolian transport mechanism to the contamination has not been assessed quantitatively.

Associated with the air, transport of contaminants takes place through the rainfalls. This phenomenon cleans the atmosphere and carries with it atmospheric pollutants, which may arrive in soil, water and fields.

As a result of the North Atlantic trade winds, a long-range transport of North African (Saharan) dust takes place. The dust is brought by the trade winds to Region X and is reported by some Caribbean countries as dust fallout through rain. PTSs may be adsorbed on the dust; this may explain the occurrence of residues of pesticides banned in the Caribbean countries.

While the trade winds are a continuous source of PTS input into the countries in the Region, they are also a way for the output of some of gaseous releases. An important source of PAHs in the region is the combustion of fossil fuel for energy generation. The combustion of leaded gasoline is a source of organic lead compounds. The low temperature of open burning of plastics, municipal solid wastes and of plant material emits dioxins, furans, and PAHs. All these sources release contaminants directly to the atmosphere and the emission is moved away by trade winds. This is an evident mechanism of output transport of PTSs. Many PTSs present in soil, plant and water bodies may, due to fallout or dust deposition released locally or due to agricultural applications of pesticides, transfers slowly to the gaseous phase, according to their physical and chemical properties, their interaction with the ecosystem, and the weather conditions.

PTSs usually have low water solubility (Table 4.1.) and low polarities. For these reasons, the adsorbed PTSs on matter can be desorbed by water. Under normal conditions, the soils of several of the mainland countries of the region are wet during more than 6 months each year (rainy season). The slowly desorbed PTSs may then be taken away by the winds.

Table 4.1. Solubility and Vapor Pressure of Selected Persistent Toxic Substances

PTS	Solubility in water in mg/L	Solubility ranking*	Vapor pressure in Pascal at 20^o C	Volatility Ranking*
Aldrin	0.027 / 25-29^o C	13	0.05	1
Atrazine	70 / 20^o C	2	0.00004	10
Chlordane	0.056 / 25^o C	11	0.0011	6
DDT	0.0055 / 25^o C	14	0.00002	11
Dieldrin	0.195 / 25^o C	10	0.0005	9
Endosulfan	0.51 / 20^o C	7	0.0011	6
Endrin	0.26 / 25^o C	9	0.00002	11
HCH	10 / 20^o C	4	0.003	3

Heptachlor	0.03 / 25° C	12	0.03	2
Mirex	0.00007 / 22° C	15	0.0001	8
Pentachlorophenol	18 / 27° C	3	0.002	4
Phenyl mercury acetate	4370 / 20° C	1	0.0008	7
Toxaphene	3 / 25° C	6	0.0005	9

* Lowest number corresponds to highest solubility and volatility

Aerial spraying of pesticides represents another form of PTS release. The drift moves long distance, and part of the sprayed pesticides may be transported out of the country with the winds. Some contaminants move around during months until they degrade, mainly through photolysis. However, some PTSs such as DDT and PCBs may be found in sediment and biota (wildlife and human fat) in far-off places where they never were used, which is a consequence of the atmospheric transport.

No quantitative data is available for a quantitative assessment of these transboundary movements of PTSs.

4.1.3. River And Groundwater Flow

It was described previously that a considerable part of the contaminants of the countries of region X arrives to the coast via river flow, and that the Amazon River as the only one that may influence the inputs of contaminants into the region. The other rivers with flow high enough to influence at regional level are the Magdalena and the Orinoco rivers, both from countries of region X. For this reason, their influence is discussed in the assessment of transport within the region. Table 4.2 shows the drainage area and average flow of some of the rivers in the Region.

Table 4.2. Drainage area and average flow of some rivers of Central America and the Caribbean

River / Country	Drainage area (Km^2)	Average flow (m^3/sec)
Usumacinta* (Guatemala-Mexico)	35 900	-
Lempa / Guatemala-El Salv.-Hond.	18 235	-
Matagua / Guatemala-Honduras	16 600	252
Ullua / Honduras	22 500	526
Patuca / Honduras	25 600	825
Coco / Honduras-Nicaragua	26 700	950
Choluteca / Honduras-Nicaragua	8 135	-
Grande de Matagalpa / Nicaragua	19 700	762
San Juan / Nicaragua-Costa Rica	38 900	1 620
Changuinola / Costa Rica-Panama	3 390	204
Sixaola / Costa Rica-Panama	2 840	-
Magdalena / Colombia	235 000	7 500
Atrato / Colombia	35 000	4 900
Sinu / Colombia	4 200	700
Orinoco / Venezuela	950 000	30 000

Source: CEP, 1992; Lopez, 2002.

* Only the drainage area within Guatemala has been considered.

No data is available for the influence of the groundwater flow in the input/output of PTSs in the Region.

4.1.4. Biotransport

Biotransport takes place as PTS transport in animal and plant tissues. Biota move in and out of the Region, carrying measurable quantities of pollutants. They move by their own force or are moved by ocean currents. The important species include marine mammals, fish, migratory birds and plankton.

The cetaceans are important mammals that move in and out of the region. The fat of these animals are contaminated with high quantities of DDE and PCBs and other PTSs. These animals are therefore releasers and/or receptors of PTSs. When cetaceans move freely, they eat other species containing PTSs and are thus receptors of PTSs, which then can move out of the region with the cetaceans. No quantitative data is available on the significance of this form of pollutant movement.

Migratory birds move during winter from the USA and Canada to Region X. During summer, other birds arrive from South America. All bring PTSs that will remain in the region if these animals die, or if they are hunted. During their stay in the Region, they ingest PTSs in the local feed and water, which will then move out when they return to their countries.

Finally, plankton arrives to the coast of the Region, brought by the marine and ocean currents. These microorganisms have a high bioconcentration factor and may therefore carry considerable quantities of pollutants. When plankton dies or is consumed by local species, it will contribute to the local contamination (input); when it feeds, reproduces and grows during its movement in the region, it will contribute with the pollutant output.

4.1.5. Qualitative assessment of transport within the region

The coastal marine area of the Caribbean Sea is a critical region. Most of the economic activities and biodiversity are directly related with the coast. A rapid urban development is taking place and activities such as manufacturing and agrochemical industries, petroleum refinery, mining, fishing, and maritime activities (ship traffic, harbors, loading and offloading, shipyards and terminals) are increasing. These activities are embedded in complex and fragile coastal ecosystems that include coral reefs, islets, coastal lagoons, mangrove swamps, beaches, sand dunes, marine algae beds, sea grass meadows, wetlands, estuaries, and bays. The pollutants enter these complex environments and enter the marine currents through groundwater and river discharges or by surface runoff. Once in the coastal waters, pollutants are moved away by marine currents.

4.1.5.1. Marine currents.

As illustrated in Fig. 4.4, the marine currents in the Region head west. Local currents therefore move pollutants released by the east Caribbean countries toward the west. By consequence, contaminants impact only countries located west of the pollution sources such as oil spills or the crude oil industry of Trinidad and Tobago, Barbados and particularly Venezuela, which impact other Caribbean countries, including the continental ones. The same is true of organotin compounds used for boat painting in local shops of the eastern Caribbean Islands.

In the southwest Caribbean, the westward current reaches the Central American east coast and begins a counterclockwise cyclic movement that involves Nicaragua, Costa Rica, Panama and Colombia. Part of the cyclic currents may abandon this movement and reach the marine current that moves northeast affecting Honduras, Guatemala, and Belize, and also Jamaica and Cuba.

Further cyclic movement affects the Dominican Republic, Haiti, Cuba and Jamaica, though to a lesser extent. The marine current that moves between Haiti and Cuba and Puerto Rico and the Dominican Republic arrives at western Cuba, where a part of the current takes a turn and returns moves eastward south of Cuba, with partial cycling (Figure 4). These currents transport the pollutants released in the above-mentioned countries. The cyclic transport takes place from August to December.

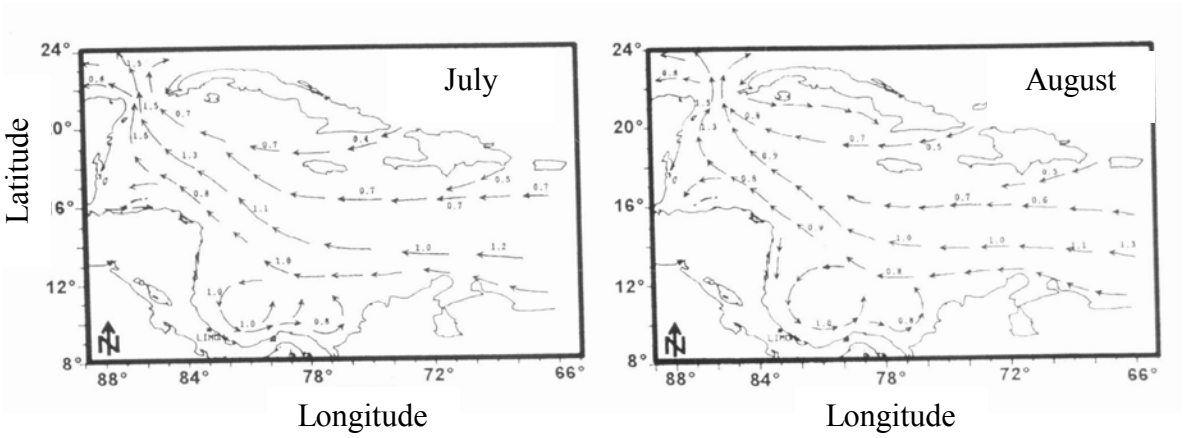

Figure 4.4. Marine Currents at Caribbean Sea

4.1.5.2. Wind movement.

Winds move within the Region following the pattern described for the atmospheric circulation. Some aspects deserve emphasis. First, the trade winds blow continuously during daytime at a fairly constant speed (3-8m/s), but wind speed reduces at sunset and stops completely for 2-3 hours, followed by a breeze blowing from land to the sea until daybreak.

During daytime and under normal climatic conditions the trade winds may change direction as they arrive to an island or mainland. The wind is forced around mountain barriers that in some countries reach high elevations and cover large part of their territories (Jamaica, Haiti, Dominican Republic, Costa Rica, Honduras, Guatemala, Colombia). In flat countries such as Cuba, Panama, or Barbados, wind moves freely. Local tropical storms may change the speed and direction of the prevalent winds, though only temporarily. Hurricanes can change the normal wind pattern during several days or weeks, however.

Some normal seasonal variations deserve mention, in particular, the enormous masses of cold arctic air that move southeast of North America and Canada and arrive sporadically at the Caribbean Islands during winter months.

4.1.5.3. River and groundwater flow.

River flow is an important vehicle of PTS transport within the Region. Almost all countries involved have numerous watersheds with many rivers that discharge their waters directly in the coastal zone (Table 4.2). During their pass through the country the rivers receive direct runoff of pollutants and discharges of industrial, domestic and agricultural wastes that may be completely untreated. The movement of PTSs by river flow is rapid, due to the shortness of them especially in the island nations, but also in the continental countries, because of powerful streams.

On occasion, rivers have a direct influence on neighboring countries, as many of them move in one country until they discharge into the coast. However, Central America has several rivers that are shared between countries (Table 4.2), some of them forming the border between them. This strengthens the need of collaboration between countries to study and control the sources of PTSs.

The relative importance of groundwater in the PTS movement in countries of Region X is unknown. No country reports or assesses, even qualitatively, the movement by groundwater flow. Some Caribbean and Central American countries report the presence of low concentrations of PTS pesticides such as atrazine,

endosulfan and DDTs in underground water, which reflects vertical movement of these compounds (leaching, especially in sandy agricultural soils) or movement within the country. There is no data on the contribution of groundwater movement to the output of PTSs from any country in the Region.

4.1.5.4. Biotransport.

Within-country biotransport is somewhat different from regional transport. Due to the relative small distances among the Caribbean islands, some birds and other animals can move from a country to another, seeking for feed. Trinidad and Tobago reports the presence of mercury in their environment due to the migratory feeding pattern of the scarlet ibis. These birds fly every day to the mainland (Venezuela) seeking for feed. Mercury is present in the Venezuelan coastal zone due to the mining activities. Measurable quantities of mercury enter Trinidad and Tobago by returning birds.

The same takes place with gulls that feed on fish elsewhere, returning home bearing pollutants with them. Analogously, some biotransport takes place by fish, human fishing activities contributing to it. Biotransport takes place also in the mainland countries, since animals may cross borders, carrying pollutants in all directions.

4.2. DATA GAPS

Regional data on PTSs transport are limited and incomplete for most PTSs. No data on flows are available.

4.2.1. Concentrations

In addition to flow data, concentrations of pollutants are important for the quantitative assessment of the movement of PTSs to and through the environment. Most countries have reported data on concentrations of most of the persistent toxic pesticides, especially DDT in several matrices and in different ecosystems. Most of these data pertain to the period when these pesticides were used. Few recent data are available on these compounds. For the PCBs, dioxins, furans, PAHs, nonyl-phenols, octyl-phenols, organometals and some others, the situation is worst. Only few countries reported data on PCB concentrations in sediments. No concentration data for the rest of the pollutants was reported.

Solid waste generation in the region is in the range of 0.7-1.0 kg/person per day, and as it is known the low temperature burning of this waste is a source of dioxins, furans and PAHs. Data gaps may be due to a lack of priority for monitoring these pollutants in many countries and lack of infrastructure and trained staff.

4.2.2. Flows

Flow data are needed for a quantitative assessment of pollutant release and transport. No single country report flow data for any of the 27 PTSs considered under this regionally based assessment. For industrial pollutants, however, indirect assessment based on production data may be considered. Indirect assessment may be possible also for PAH release due to fires, traffic density, and industrial sources. Some cities monitor important air pollution indicators, which may be used in the local estimation of PAH burden due to diesel engine exhaust and may then be translated into flow estimations by models using additional data on the determinants of dispersion.

Pesticide application data do not directly measure flow. Nontarget concentrations due to drift during pesticide application or to later movement caused by runoff, volatilization or biotransport, are lower than target concentrations. Furthermore, it was impossible to establish a clear-cut relationships among factors that determine flow, such as initial concentrations; time elapsed since application; distances to the ecosystems where the sample was taken for analysis; and climatic conditions (rainfalls, wind). Measurement of flow requires an adequate infrastructure and a trained staff, not always available in most of the countries in the Region.

4.2.3. SUMMARY

Four major pathways are fundamental for the transboundary movement of PTSs to and from the Region: ocean currents, atmospheric circulation, river flow, and biotransport. The magnitude and rate of the input and output of PTSs depend also on the dimensions and physical characteristics of each country in the Region. Further determinants include production and release, dispersion and movement at local, regional and global levels, physical and chemical properties of the compounds, form of release, interactions with the environment, bioconcentration, and climatic conditions. The Region lacks data on environmental concentrations of a number of pollutants. In particular, flow data are nonexistent.

The coastal area of the Caribbean Sea is a critical region for contamination transport. Trinidad and Tobago and Barbados receive contaminants brought by the ocean currents influenced by the discharges of Amazon and Orinoco rivers. Jamaica reports the influence of the water that comes from the Magdalena River in Colombia. Oil spills are frequent. A dense tanker traffic and offshore oil exploration contribute to the hydrocarbon contamination. In relation to intense agricultural activity, 23% of Panama's, 45% of Costa Rica's, 90% of Nicaragua's and 70% of Colombia's territory drain to the southeast Caribbean Sea. PTSs can be brought to the regional sea through rivers, some pesticides have been measured in river water.

The Region is exposed every year to abnormal climatic conditions, with the possibility of hurricanes. The countries may receive abnormally heavy rainfalls during several consecutive days, with a result of dangerous flooding and erosion, accompanied by high wind velocity. Disturbed marine and ocean currents move away pollutants and solid wastes. PTSs possibly arrive at the Region from elsewhere in the air mass of the Northeast Trade Winds, as suggested by data in Barbados, Trinidad and Tobago, and Jamaica. Transport of contaminants takes place also through rainfalls. Combustion of leaded gasoline and wastes, and aerial spraying of pesticides release contaminants directly to the atmosphere.

No regional data are available on groundwater influence on PTS transfer. Cetaceans, migratory birds, fish and plankton are releasers and receptors of PTSs. As an example, the migratory feeding pattern of the scarlet ibis transports mercury to Trinidad and Tobago from mainland Venezuela.

The Region would benefit from strategic monitoring systems of environmental contaminants for PTSs, coupled with quantitative estimations of trans-boundary movement. This implies creation of adequate infrastructure and a trained staff.

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5. PRELIMINARY ASSESSMENT OF THE REGIONAL CAPACITY AND NEED TO MANAGE PTS

5.1. MONITORING CAPACITY OF PTSs

The capacity to monitor PTSs across the Region varies from country to country with the larger and/or more affluent countries having more sophisticated facilities. Thus in Panama, Cuba, Costa Rica, Trinidad & Tobago, and Jamaica, elaborate facilities for monitoring selected PTSs are occasionally encountered. However, no country has facilities to monitor all the PTSs of concern in this study. No country has facilities for the routine monitoring of dioxins and furans. There is general concern with respect to the small numbers of internationally recognized accredited laboratories and reference laboratories in the Region.

In the smaller countries of the Caribbean, limited facilities are available for the analytical monitoring of PTSs. In these countries there has been a move towards shared regional facilities. This option has gained favor for economy reasons.

The regional monitoring capacity monitor is assessed separately for Central America, Cuba, and English-speaking Caribbean. Information has not been received on Dominican Republic, Haiti, and other countries not mentioned in this section.

5.1.1. Central America

The capacity of OC pesticide sampling appears to be limited in relation to the number of laboratories, the matrices that they sample, and particularly accreditation of reference laboratories. A few countries have national laboratory accreditation bodies (e.g. Costa Rica, El Salvador, Panama) but it is not clear if procedures consistent with international accreditation bodies are applied. Virtually none of the countries has the technical capacity to determine emissions of dioxin and furans in air utilizing high-resolution analysis.

The RFI draft report (2002) on Sound management of POPs in Mexico, Central America and the Caribbean concludes that most countries in the Region lack reference laboratories for the majority of POPs. These laboratories make available a known standard in a sample for a particular substance for which the concentration has been evaluated utilizing high-level quality assurance/quality control (QA/QC) techniques. Other laboratories use these reference samples as a reference standard against which they assess the capacity of their own laboratory to obtain the same or very similar results. In this way they are able to assure their own QA/QC. Reference samples are also utilized for calibrating analytical equipment.

Where laboratories possess the capability to conduct testing for PTSs in most cases the information provided was not sufficiently detailed to determine the level of detection to which laboratories are able to sample with confidence and whether these levels are meaningful in terms of the measurements required for POPs substances (RFI, 2002).

There are several laboratories in Panama capable of conducting testing of PTSs. The major laboratories are based within (a) the Ministry of Agriculture, (b) the Ministry of Health, (c) the National Environment Authority, (d) Institute for Agricultural Research of Panama, (e) the University of Panama, and (f) the Institute for Advanced Research and High Technical Services. The laboratories are well equipped, equipment available includes: (i) Capillary Gas Chromatographs with different detectors (GC/FID/ECD/NPD), (ii) Liquid Chromatograph (HPLC/UV/Fluorescence), (iii) Atomic Absorption Spectrometers (AAS) and (iv) Gas Chromatographs with Mass Spectrometer (GC/MS). The laboratories have well trained staff.

In most of the other Central American countries there exist one or more laboratory facilities capable of conducting analysis of PTSs. The major laboratories are based within (a) the Ministries of Agriculture, (b) the Ministries of Health, and (c) Universities. Costa Rica has one laboratory performing quality control of formulations, but it does not control impurities in the formulations (Castro, 2002).

5.1.2. Colombia

The technical infrastructure of laboratories that support the management of chemical substances in the country are scattered among different organizations such as universities, vigilance and control services of the office of the Public Prosecutor and Secret Services, and NGOs. Vegetable and cattle samples are evaluated at agencies such as the Ministry of Agriculture through a public research institute "Corporación para la Investigación en Ciencias Agrícolas" (CORPOICA). Monitoring and control of foods and drugs is the responsibility of the Ministry of Health through the National Institute of Vigilance of Medicines and Foods. There are few networks of laboratories such as those of CORPOICA that develop standardization of monitoring methods for pesticides. This activity does not reach a suitable level of articulation, however. Universities develop focused activities, particularly in the identification of chemical compounds, both natural and artificial; development of techniques of decontamination; and the use of microorganisms to accelerate decontamination processes.

5.1.3. Cuba

In Cuba, the laboratory infrastructure for the testing of PTSs is located with three Ministries: Agriculture, Health, and Transport.

Ministry of Agriculture: Within this Ministry is the Plant Health Research Institute (INISAV). The Division of Chemistry of INISAV has two laboratories. One focuses on the quality control of formulation of pesticides. This laboratory has two Gas Chromatographs, two HPLCs, and complementary equipment and other ancillaries. The staff consists of 5 University-level chemists and 4 middle-level technicians with an average of 10 years of experience. The other laboratory is the residue testing laboratory with the responsibility of establishing post-harvest intervals of all pesticides used in Cuba. In addition, this laboratory is responsible for the monitoring of residues in areas impacted by pesticides, and the investigation of the behavior of pesticides in soil, water, and sediment. This laboratory has three GCs with Electron Capture Detector (ECD), TI, and Flame Photometric (FPD) Detectors, and two HPLCs with Ultraviolet Detectors. It also conducts testing for PCBs in environmental samples. It has skilled staff composed of 4 university level chemists and 5 middle level technicians, with more than 15 years of experience.

Ministry of Health: This Ministry has a laboratory at the National Institute of Medical Hygiene and Epidemiology (INHEM), that monitors pesticide residues in food and biological samples (e.g., human milk). The laboratory possesses two GCs with ECD and TI detectors. The staff is composed of two university level chemists.

Ministry of Transport: The laboratory of CIMAB is located in this Ministry. CIMAB has the responsibility of monitoring the contamination of bays in Cuba. The laboratory possesses a GC with ECD and TI for analysis of chlorinated pesticides, and another GC with FID for the determination of hydrocarbons in environmental samples. The technical staff is composed of two university level chemists and two technicians with an average of 10 years of experience.

5.1.4. English-speaking Caribbean

Monitoring capacity for PTSs vary from country to country in the English-speaking Caribbean. Six of the eleven possess some laboratory capacity to conduct monitoring of selected PTSs: Trinidad and Tobago, Barbados, Jamaica, Bahamas, Guyana, and St. Lucia (through the Caribbean Environmental Health Institute). The other countries (St. Vincent and the Grenadines, Antigua and Barbuda, St. Kitts and Nevis, Grenada, Dominica) possess limited capabilities. However, very few laboratories are accredited for testing of PTSs of concern. No capabilities exist within the Region for the measurement and analysis of dioxin and furan emissions.

The issue of capability and capacity to monitor pesticides in the Caribbean especially within the countries of the Organization of Eastern Caribbean States (OECS) has been the subject of some concern. The Caribbean Environmental Health Institute (CEHI) and the Food and Agricultural Organization (FAO) have both recommended a regional approach to monitoring. In this approach, regional centers with capabilities to perform sophisticated instrumental analysis were recommended and complemented by capabilities at the national level for sampling, preservation and extraction for instrumental analysis. It was proposed that the

regional centers would be used for conducting instrumental analysis. The centers identified to service Grenada, St. Vincent and the Grenadines, St. Lucia, Antigua and Barbuda, St. Kitts and Nevis, Barbados, and Dominica, were at CEHI and the Barbados Government Analytical Facilities. CEHI is a Caribbean Community (CARICOM) affiliated intergovernmental organization serving 15 countries in the English-speaking Caribbean. The Barbados Government Analytical Facilities is a nationally operated laboratory.

St. Lucia. The Caribbean Environmental Health Institute (CEHI) laboratory is equipped with some of the instrumentation required to undertake pesticides, other organic compounds, and inorganic analysis. The equipment includes GC, HPLC and AAS. The laboratory possesses a variety of detectors but does not currently have a MS. The laboratory also has well trained staff for analytical services but will need additional staffing if the demand for testing increases. The laboratory is currently not accredited for conducting testing on PTSs although the process for gaining accreditation for identified pesticides is currently being undertaken.

Barbados. The Barbados Government Analytical Facilities (BGAF) possesses some equipment needed to conduct analytical testing. It has similar equipment as the CEHI laboratory (GC/ECD/FID/FPD, HPLC/UV/F). The personnel is also well trained for pesticide residue testing. However, as for the CEHI laboratory, if the demand for testing increases, the level of staffing will also need to be increased.

Antigua & Barbuda, Dominica, Grenada, St. Vincent and the Grenadines, St. Kitts and Nevis. Some capacity for pesticide residue testing exists in some of the other OECS countries. All countries possess some capabilities for sample collection and preservation, with some capacity for sample preparation and extraction. However, these capabilities will need to be reinforced with additional training.

Trinidad and Tobago. Although there are a number of governmental and private laboratories that carry out environmental sampling and analysis, only three (CARIRI, TTBS, PETROTRIN) have been accredited to perform certain tests. The recent launching of a laboratory improvement program (LABQUIP) focuses on the improvement of the quality and reliability of data. While the basic instrumentation and technical competence to detect and identify many PTS exist, specialized training and equipment may be required for the more complex and difficult tasks of analytical measurement of substances.

Jamaica. Commercial laboratories for monitoring and analysis of PTS do not exist locally. The University of the West Indies possesses the analytical equipment but conducts a limited number of studies with graduate students using research laboratories. However, this work is dependent on the availability of interested students, types of equipment in the department, and financial resources to support the students.

5.2. REGULATION AND MANAGEMENT OF PTSs

The import, export, transport, storage, use and eventually disposal of toxic chemical compounds, including the PTSs, are in general regulated by all countries in the Region by means of laws, decrees and other legal instruments, with the common aim of minimizing the negative effects on the environment and human health. Legislation is however in a scattered form between and within the countries of the Region and may even contain contradictions within one country. In general, allocation of specific human resources for the management of the chemical substances is nonexistent in the Ministries involved. Instead, these activities are an additional responsibility of persons that fulfill other duties. For example in Colombia Table 5.1 shows the number of human resources for management of chemical susbstances in two ministries.

Table 5.1. Human resources for management of chemical substances in two ministries. Colombia.

Type of personnel	Ministry of Agriculture	Ministry of Environment	Total
Technicians	5	_	5
Professionals	6	_	6
Postgraduates	13	11	24

Source: Ministerio de Salud, Ministerio del Medio Ambiente, Ministerio de Trabajo y Seguridad Social, Ministerio de Agricultura y Desarrollo Rural. Perfil Nacional para una Gestión Racional de las Sustancias Químicas. Bogotá (Colombia), Ministerio de Agricultura y Desarrollo Rural, 1998.

There is a tendency in all the countries of the Region to consider PTSs in two groups: pesticides and non-pesticide PTSs. Due to the economic importance and considering the known adverse effects of some of them, regulations have been developed for pesticides. Most countries have pesticide registration offices or departments. While these carry out different functions and duties in each country, they have the same general objective: to allow the use of each pesticide in the country after it reaches approval in a registration that in many cases overrides considerations of health and environment.

As a legal basis for the registration procedures and for the general management of pesticides, the Governments of the Region have, through the ministries involved with pesticides (Agriculture, Environment, Health among others), promulgated a number of laws, decrees, regulations and standards that allow the sound management of these agrochemicals, according to the characteristics and requirements of each country. As a general trend the governments have placed greater emphasis on regulations focused on controls and permits, and with some exception, little or not at all concerning other important aspects like educating and raising awareness about pesticide use.

Pesticide registration in the Region is summarized in Table 5.2 and Table 5.3 shows the important laws, decrees, standards and regulations applied for the use and management of pesticides and other toxic substances in countries of the Region. In some cases more than one ministry considers the same issue.

It is evident that basic legislation exists for the implementation and adequate control of pesticide management in the Region, but there is space for improvement and for harmonization, as has already been done by some Central America countries. Basic legislation concerning pesticides has been harmonized in order to make the enforcement easier according to the FAO project TPC RLA/4953 on harmonization of legal instruments for registration and control of pesticides in Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama, published in (1995). This first step of harmonization includes common requirements for registration, common labeling, toxicological classification, and protocols for biological efficacy testing. Harmonized legislation for pesticides and toxic chemicals has been initiated already in the Caribbean OECS countries.

For the second group of PTSs, the industrial and involuntarily produced toxic substances, the situation is quite different. In the majority of countries there is no registration office for these compounds and for that reason, no registration is required for the import and use of chemicals, including PTSs. Import, export and use of these compounds is however carried out in the majority of these countries according to the Rotterdam Convention.

In some countries such as Barbados, Cuba, Jamaica and Colombia, there are specific regulations for a reduced number of industrial PTSs. The regulations are general, and few allow an effective management of PTSs and adequate enforcement. The situation is worse in relation with emission of dioxin and furans and solid waste disposal. Only Jamaica, reports national regulation of dioxin and furan emissions, to be implemented in 2004. Costa Rica is developing sample procedures and analytical methods for PTSs emissions (dioxins and furans), however, at the moment there is no regulation of these compounds.

For solid waste disposal the situation in the Region is no better than with the industrial emissions, in spite of the fact that it is a common problem in the countries of the Region and a known source of PTSs (dioxins, furans, PAHs). Only Barbados reports that open burning for garbage disposal is illegal, but does not quote the particular law or regulation). In Jamaica, collection, transport and disposal of solid wastes is legally regulated. Trinidad & Tobago indicates only the daily quantity of garbage produced in the country per person and its rough composition, but the final disposal is not described. Honduras has a draft resolution on solid waste management that includes municipal solid wastes.

With the few exceptions mentioned, no other countries of the Region reported assessment of quantity and disposal methods for solid waste. Legal instruments exist in most of the countries regulating the import and export of PTSs, often reflecting the guidelines of the Basel Convention for the control and transboundary movement of dangerous substances. Not all the countries have implemented the Prior Informed Consent (Rotterdam Convention), however.

5.2.1. Enforcement

The operative structures and efficiency of the institutions in charge of monitoring the compliance of regulations related with the management of PTSs in the Region are complex and depend on the characteristics of the particular country. With exceptions, especially in some Caribbean countries where enforcement is adequate, weak compliance is generally reported and, in the worse cases, lack of compliance with the laws. This in part is due to weak enforcement with no adequate sanctions for failure to comply with the regulations. Additional factors influencing compliance include:

- In some countries there is an excess of regulations and standards that make their interpretation and correct application difficult. However, in other countries the regulations are scarce and in some cases outdated.
- Some legal instruments are complex and difficult to understand at the application
- Problems related with the competence of legal instruments and in some cases insufficient institutional coordination (in worse cases, overlapping of jurisdiction between agencies or ministries).
- Ignorance of laws, due to insufficient use of alternatives of divulgation, among others: publications, use of mass diffusion media and training courses.
- Lack of personnel and in some cases continuous turnover of trained personnel.
- Weak sanctions for infractions and in some countries lack of penal law for infractors.
- Insufficient budget for laboratories in charge of analyzing samples, and for other needs for the management of PTSs.
- Inadequate inter-institutional coordination.
- Weak custom vigilance and in consequence, the possibility of illegal movement of PTSs.
- Insufficient infrastructure for enforcement in remote areas of big countries.

Table 5.2. Pesticide registration in Region X.

Country (reference)	**Ministries involved**	**Major duties**
Barbados (Singh, 2002).	Agriculture Environment Labor	• Issuing licenses for importation of agrochemicals and inspectorate to oversee labeling, handling, use, storage, formulation and disposal of pesticide.
Belize (Serrut, personal communication)	Pesticide Control Board	License for import, handling and use of pesticides.
Colombia (Bonilla et al., 2001).	Agriculture Health Environment	• Chemical, toxicological and environmental evaluation of pesticides before registration. • Permits for import-export. • Quality Control of pesticides. • Evaluation of health and environment impacts. Permits for air application of pesticides
Costa Rica	Agriculture	• Emission of certificate of registration and free sale

(RFI, 2002; PNUMA/MINAE, 2001; Castro, 2001; González, 2001; OIRSA, 1996; OIRSA, 2000)	Health Transport Environment	of pesticide in the country. • Publication of authorized pesticides after evaluation. • Quality control of pesticides. • Enforcement of rules and regulation of the Phitosanitary law.
Cuba (Abó, 2002)	Agriculture Health Environment Interior Others	• Chemical, biological and environmental evaluations of pesticides before authorization for use in the country. • Publication of authorized pesticide (annually). • Withdraw the permit of pesticides according to recent evaluation by WHO and/or after recognized environmental and/or Health adverse effects.
El Salvador (González, 2001; OIRSA, 1996; OIRSA, 2000)	Agriculture Health Labor	• Licensing for importation after testing for efficacy. Regulate labeling, storage, transport, sale and safe use of pesticides.
Guatemala (OIRSA, 1996; OIRSA, 2000; Cifuentes, 2002)	Agriculture Health Labor	• Approve all pesticide for agricultural use, issuing licenses for importation, distribution and use after the Ministry of Health analyze and approve the toxicological data submitted for registration. • Licensing for import after testing for efficacy. Controls of label, storage, sale, formulation and safe use of pesticide.
Honduras (Sabillón, 2002; González, 2001; OIRSA, 1996; OIRSA, 2000).	Agriculture Health Labor	• Licensing for import and use after evaluation of efficacy and approval by health and labor Ministries (toxicological data and worker impact).
Jamaica (Chin Sue, 2002)	Agriculture Health	• Licensing for import and use, according to the national laws and regulations (pesticide act).
Panama (Autoridad Marítima de Panama, 2001; González, 2001; OIRSA, 1996; OIRSA, 2000).	Agriculture Health Environment Transport	• Regulate import-export of pesticides. • Permits of agricultural application of pesticides (aircraft-helicopter). • Quality control of formulated pesticides. • Withdraw the permit for toxic and environmental hazardous pesticides.
República Dominicana (Porro, 2002)	National Office of Industrial Property.	• The pesticide must be tested for efficacy before licensing for use. Regulate also the labeling with adequate information of use and risk.

Saint Lucia (Magloire, 2002)	Pesticide Control Board	• Regulate importation, production, use, handling, storage, transportation and disposal of pesticides.
Trinidad and Tobago (Rajkumar, 2002)	Pesticide and Toxic Chemical Board	• Regulate the import, handling and use of pesticide and toxic chemicals.
Venezuela	Agriculture Health Environment	• Regulate the import, handling and use of pesticide according to the national laws.

Table 5.3. Major legal instruments for the management of pesticides and other PTSs in the region.

Country (reference)	**Legal instruments and features**
Barbados (Singh, 2002).	• Health services act Chap 44 of Health Ministry. Promotion and preservation of health of inhabitants of Barbados. • Pesticide control act (cap 395) Agriculture Ministry. Provide basis for control of import, sale, storage and use of pesticides. • Factory act (cap 347) Ministry of Labour, General provisions for occupational health and safety issues and factory inspections. • Marine pollution control act 1999-40. Prevent, reduce and control pollution of the marine environment. • Rotterdam convention of prior informed consent procedure.
Belize Serrut (personal communication); Fernández,2002)	• Pesticide control act chapter 181 B of the Law of Belize Gazetted 1988. • Legal instrument No.8. Registered and restricted pesticides (manufacture, import and sale) regulation. Gazette 1988. • Legal instrumental No. 30. Registered and restricted pesticides (manufacture, import and sale) amended regulation. Gazette 1996. • Legal instrument No.112. Registered and restricted pesticides (certified users) regulation. Gazette 1996. • Legal instrument No.8. Registered and restricted pesticides (registration) regulation Gazette 1995. • Legal instrument No.77. Registered and restricted pesticides (registration) regulation gazette 1995. • Legal instrument No.71. Registered and restricted pesticides (sale and confiscation) regulation Gazette 1998. • Environmental Protection Act (1992) • Pollution Regulations, No 56 (1996) • Environmental Protection (Effluent Limitation) Regulations, No 94 (1995) • Solid Waste Management Authority Act No 13 (1994)
Colombia (Bonilla, et al., 2001).	• Law 9 (1979) or national sanitary code, implemented by health ministry by mean of Decree 1843 (1991) Applied to pesticides (production, formulation storage, distribution, transport, air application and human and environmental protection measurements.

	• Law 33 (1986) Ministry involved: Health Applied to transport and storage of pesticides. • Decree 1843 (1991) Ministry involved: Health Applied to pesticides (Control and epidemiological vigilance in the use and management of these compounds. Introduce the toxicological aspect of a pesticide as pre requisite for emitting the sell license by ICA. • Law 99 (1993) and the complementary decree 1753 about the environmental licenses. Ministry Involved: Environment Applied to pesticides and other toxic substances (production and import, transport and storage of substances and dangerous wastes. • Resolution No.30 (1995) Ministry and Organism involved: Agriculture and ICA (Instituto Colombiano Agropecuario) Applied to pesticides: Technical procedures manual for accreditation and sampling agrochemicals. • Resolution 1068 (1996) Ministry involved: Agriculture Organism: ICA Applied: to pesticides, assign responsibilities to farmers and owner of vegetable ware that recommend or prescribe pesticides for agriculture use. • Law 253 (1996) About the Basel Agreement in relation with the transboundary movement of dangerous wastes. • Law 203 (1988), which rules the inspection and control of commerce and the application of insecticides and fungicides and the required equipment. • Decree 1795 (1950) Prescribe sanctions for the infractors of the agropecuary health resolutions (cancel of sell licenses) • Resolution 1300 (1950). About the import, manufacture, commerce, use and application of pesticides. Include also damage to third persons. • Decree 557 (1957). Regulate the pesticides registration procedure. • Resolution 351 (1963). Regulate sell and application of pesticides. • Decree 219 (1966). Regulate the technical assistance and the written authorization of an agronomist for carrying out pesticide applications. • Decree 779 (1967). About the pesticide efficacy certificate, and some important

	definitions concerning pesticides. Also toxicological requirement (Ministry of Health). • Law 23 of 1973. About the prevention and control of the contamination of the environment. • Resolution 10834 (1992) • Decree No. 475 (1998). Quality requirement for drinking water. Pesticide maximum residue limits in drinking water.
Costa Rica (Proyecto RFI, 2002; PNUMA/MINAE, 2001; Castro, 2002; González, 2001; OIRSA, 1996; OIRSA, 2000)	• General Law of Health, Article 239. Decree No. 5395 • Decree 18323.TSJ/1999 • Decree 20345-S/1991 • Regulation 28659-D/2000 • Law 24715-MOPT • Organic Law of the environment. • Decree No.7664. Phitosanitary protection law. La Gaceta No.83, 1997. • Legal instrument No. 24337-MAG-S. Rules about registration, use and control of agricultural pesticides and coadjuvants. La Gaceta No. 115, 1995. • Executive decree No. 20013-S. Regulation for sale and storage of pesticides. La Gaceta No. 209 (1990). • Executive decree No.24874-TSS Rules and regulation about sanitary permits for carry out synthesis, formulation and repack of agrochemicals. La Gaceta No.25.1986. • Executive decree No. 24175 MOPT-MEIC-S. Regulation for the terrestrial transport of dangerous substances. La Gaceta No. 207 (1995). • Executive decree No. 24456 MAG. Regulations for the quality control of chemical biological substances used in Agriculture. La Gaceta No. 154.(1994) • Executive decree No.15846.regulations for the activities of agricultural aviation. La Gaceta No.244, (1984). • Executive decree No. 18323-S_TSS. About the compulsoriness of medical examination. La Gaceta No. 149, (1988) • Executive decree No. 9934-A-SPPS-TSS. Set up of the National advising commission for pesticide use. La Gaceta No.84 (1979) • Executive decree No.13. Prohibit of mercury compounds. La Gaceta 279 (1960). • Executive decree No.17846.Prohibit of 2,4,5-T. la Gaceta No. 39 (1988). • Executive decree No.18346-MAG-S-TSS. Prohibition of aldrin, dieldrin, toxaphene, chlordecone, chlordimeform, dibromochloropropane, ethylen dibromide, dinoseb and nitrofen. La Gaceta No. 151 (1998) • Executive decree No. 18345-S-TSS-MAG. Prohibit of DDT. La Gaceta No. 151 (1998) • Executive decree No. 19446-S-MAG- Prohibition of pentachlorophenol. La Gaceta No. 26 (1990) • Executive decree No. 19447-S-MAG. Prohibit of Endrin. La Gaceta No. 19 (1990)

	• Executive decree No. 19748-MAG-S. Prohibit of Cihexatin. La Gaceta No. 122 (1990) • Decree No.20107-MAG. Permit of operation of selling stores of pesticides. La Gaceta No.2 (1991) • Executive decree No.25534-S-MTS-MAG- Prohibit of Lindane. La Gaceta No. 205 (1996). • Other decrees and regulation about specific methods of pesticide analysis
Cuba (Abó, 2002)	• Law No. 81/1997. Concerning the Environment Ministries involved: Environment, Health, Agriculture, labor and Social Security and others. Applied to: industrial chemicals, pesticides and dangerous wastes. • Resolution No. 77/1999. Regulation for assessment and authorizing environmental license. Ministry involved: Environment. Applied to: Agrochemicals, industrial chemicals and dangerous wastes. • Resolution No. 130/1995. About the state environmental inspection. Ministry involved: Environment. Applied to: agrochemical, industrial chemicals and dangerous wastes. • Resolution No. 87/1999. About the Transboundary movement of dangerous wastes. Ministry involved: Environment. Applied to: dangerous wastes according to the National classification. • Law No. 13/1997. On the protection and hygiene at working place. Ministries involved: Health, Labor. Applied to: Agrochemicals, industrial chemicals and dangerous wastes. • Resolution 1/2001. Ministries involved: Agriculture, Health. Applied to: pesticides. • Resolution No. 49/2001. Banning of pentachlorophenol, chlordane, mirex, hexachlorobenzene and ethylen dibromide for use in Cuba. Ministry involved: Health. • Law 200/2000. Violations concerning the environment. Ministry involved: Environment. Applied to: Agrochemicals, industrial chemicals and dangerous wastes. • Decree No. 169/1992. Violation of the plant protection regulations. Ministry involved: Agriculture. Applied to: pesticides. • Cuban Standard 20-03/1986. Ministry involved: Health. Applied to: pesticides. • Cuban Standard No. 19-01-2/1985. Ministry involved: Agriculture. Applied to: pesticides. • Cuban Standard No. 19-01-49/1985. Pesticides Classification and Security requirements. Ministry involved: Agriculture, Sugar Industry. Applied to: pesticides. • Resolution No. 159/1995. Concerning the application of the PIC procedure to industrial chemicals. Ministry involved: Environment. Applied to: Industrial chemicals. • Resolution No. 41/2001. restrictions of use of Industrial Chemicals. Ministry involved: Environment. Applied to: PCBs, PCTs, PBBs, and tris(2,3 npropyldibromide)phosphate. • Resolution No. 27/2000. National System of Environmental recognizance. Ministry involved: Environment. Applied to: Agrochemicals, Industrial Chemicals and dangerous wastes. • Resolution No. 2 1/1996. Transport of toxic substances. Ministry involved:

	Transport, Interior. Applied to: toxic chemicals and dangerous wastes. • Resolution No. 2/1996. About work illness. Ministry involved: Health, Labor and Social Security. Applied to: high risk chemicals in working places: lead, mercury, asbestos, benzene. • Resolution No. 23/1997. Methodology for risk identification. Ministry involved: Labor and Social Security. Applied to: Chemical compounds. • Regulation about PCBs management. Ministry involved: Basic Industry. Applied to: PCBs. • Cuban Standard No. 19-01-2/1985. Ministry involved: Health. Applied to: Chemical compounds. • Cuban Standard No. 19-01-42/1984. Lead and lead compounds. Classification and Safety requirements. Ministry involved: Basic Industry. Applied to: Lead and its compounds. • Resolution 268/90 Prohibit the agricultural use of aldrin, toxaphene, chlorobenzylate, arsenic and mercury inorganic compounds, DDT, dibromochloropropane, dieldrin, endrin, heptachlor, leptophos, sodium monofluoracetate, thallium sulfate, 2,4,5-T. Ministry involved: Health. • Resolution 181/95. Prohibit the agricultural use of dinoseb at its salts, fluoracetamide, hexachlorocyclohexane, cihexatin, nitrofen and mercury organic compounds.
Honduras (Sabillón, 2002; González, 2001; OIRSA, 1996; OIRSA, 2000).	• Decree 09-91. About the banning of use and import of PTS. • Code of health, Decree 65-91. • Code of commerce, Decree 73-49. • Code of labor, Decree 189. • Penal Code, Decree 59-97. • Phitosanitary Law. Decree No. 157-94. La Gaceta No.27-552 (1995). • General Environmental Law. Decree No. 104-93 • Law of representants and commercial Distributors. • Regulation about Registration, use and control of pesticides and similar substances. Agreement 642-98. • General regulations related to the environmental law. • Regulations about the National Evaluation System of the Environmental Impact. • General Regulations of Environmental Health. Agreement 0094,1997. • Resolution 09-91. About the banning of aldrin amitrole, 2,4,5-T, dieldrin, heptachlor, lindane, mirex and toxaphene among other pesticides. • Resolution 014-99. About the banning of chlordane. • Basel Agreement on the control of transboundary movement of dangerous wastes and their disposal. • Rotterdam agreement: PIC procedure for pesticides and PTSs subjected to international trade. • Stockholm agreement about PTSs. • Resolution 005-98. Use of harmonized label and brochures. • Agreement No. 1132-99. About the set up of the inter institutional pesticide

	commission. • Resolution No. 015-99. Authorization for import, use distribution and sell of high toxic and extremely toxic pesticides under strict security measurements. • Resolution No. 014-88. Authorizations for sell and use of endosulfan. • Resolution about the solid wastes management (draft). • Resolution about the solid wastes in the health sector (draft) • Chapter 5, International code for the distribution of pesticides; quarantine regulations; regulations of handling of solid residues.
Jamaica (Chin Sue, 2002)	• Pesticides Act (1975). Authority to prohibit importation of pesticide. • Pesticides Amendment of Schedules Order (1999). About the ban of importation of the PTS pesticides in the POPs list. • Pharmacy Act: power to prohibit import of industrial PTSs. • Public Health Act 1985, among others regulate vector control. • National Solid Waste Management Act 2000. Regulate collection, transport and disposal of solid wastes. • Natural Resource (Hazardous Waste) Regulation (2000). Control of movement of hazardous wastes (draft). •
Nicaragua (Cruz and Flunky, 2002; González, 2001; OIRSA, 1996; OIRSA, 2000)	• Basic Law 274/1998 for regulation and control of pesticides, toxic and hazardous substances and other similar. La Gaceta No.30 19/2/1998. • Decree No. 49-98. Related to law 274. (Rules of this law). La Gaceta No.142 (1998). • Decree No. 33-95. Discharge of wastewater, domestic, industrial and agrochemical waters. • Decree No. 13-73. Regional resolution of transboundary movement of dangerous wastes. • Law 192. Related with worker health, technical information for workers and child protection. • Law 290. Art. 154. Penal Code in relation with damage caused to persons. • Decree No.291. Basic law of animal and plant health. La Gaceta No. 136 (1998).
Panama (Autoridad Marítima de Panamá, 2001; González, 2001; OIRSA, 1996; OIRSA, 2000).	• Law 47. Law of plant health. Gaceta Oficial 23,078 (1996). • Decree No.63. Regulation for registration, application activity and services of pesticides and fertilizers in Panama. Gaceta Oficial No.23372 (1997). • Executive Decree No.19. Coordination between health Ministry and the Ministry of agropecuary development for the control of pesticide. Gaceta Oficial No,23265 (1967). • Resolution MIDAS-023 ADM. Standard procedures for registration of pesticides. • Gaceta Oficial No.23538 (1997). • Resolution MIDA- ALP- 051- ADM. Procedure Manual for pesticide registration. Gaceta Oficial No. 23654 (1998). • Resolution MIDA- ALP- 69- ADM. Establish the principles, requirements and procedures for the aerial application of pesticides in banana fields in Panama. Gaceta Oficial 31/12/1998

	• Resolution MICI No.287. Technical rules 1-134-98. Labeling of pesticides. Standard COPANIT 2-405-98. Technical procedure of pesticide brochure. Gaceta Oficial 1998.
República Dominicana (Porro, 2002)	• Law 311/68 and the regulation 1390/71. About the import, fabrication and management of pesticides. • Law 218/84. Prohibit import of wastes, (organic, industrial). • Decree No.217/91. Prohibit import, formulation, trade and use of organochlorinated PTSs and other toxic pesticides. • Environmental law 2000 and its Resolution No. 08/2000-2001. Control the import, use, management and disposal of oil containing PCBs. • Law 64/2000 of the environment Ministry. Regulate the disposal of wastes and prohibit the elaboration and sale of leaded gasoline.
Saint Lucia (Magloire, 2002)	• Pesticide control act No.7 of 1975. Concerning control of pesticide: production, use, handling, storage, transportation and disposal. • The toxic chemicals and pest control act (2000). Cover not only pesticides but toxic chemicals in general. • Public health act No. 8 (1975). Concentrates on the promotion and the protection of human health. • Fishers act No.10 (1984). Protect and preserve marine reserves from chemicals.
Trinidad and Tobago (Rajkumar, 2002)	• Pesticide and toxic chemical act (1979), amended 1986. Establish the legal regime for regulating toxic chemicals and pesticides. • Section 4 (2) of the trade ordinance No.19 (1958). Ministry of Trade. Creates the legal authority to ban the importation of chemicals. • Section 59 and 60 of the environmental management authority. Establish legal regime over hazardous substances. • Section 44 of the customs act CH 78.01 of 1980. Enforced by the Custom Division. Authorizes the president to prohibit the import of goods. • Rotterdam convention for prior informed consent procedure (PIC), implemented.
Venezuela	• Decree 3220.01/2000. About the Environment and renewable resources. • Resolution 32881/23/1983. About the banning of organochlorine pesticides. • Resolution No. 181 of Ministry of Health and Social Security, about banning of organchlorine pesticides. • Resolution 408 of MAC (Ministry of Agriculture and Rear), about banning of organchlorine pesticides. • General Regulation on Pesticides. Technical Commission of Pesticides. Gaceta Oficial No. 34877/1992. • Environmental Penal Law. Gaceta Oficial No. 34358/1992. • Environmental Law. Decree 2211/1992, on the management of dangerous wastes. • Basel convention on transboundary movement of dangerous wastes and its disposal. (1998)

	• Standard for the control of generation, and management of dangerous wastes. Decree No.2211 (1992). • Rotterdam convention for prior informed consent (PIC). Implemented . (2000)

5.2.2. Deficiencies In Regulation, Management, And Enforcement

Deficiencies were found in the Region such as lack of some specific laws and regulations, and weakness in the legal framework that needs to be improved for good management of PTSs and satisfactory enforcement. Some of these deficiencies are:

- Poor dissemination of the FAO Code of Conduct related with the management of pesticides.
- Overlapping of legal instruments in use, and lack of standards for special aspects of the management of some pollutants.
- Lack of harmonization and simplification of the existing legal instruments, with exceptions in special issues in Central America and Caribbean countries.
- Deficient dissemination of the legal instruments at all levels.
- Need to improve the inter-institutional coordination.
- Need to strengthen enforcement by (i) assigning financial support for the institutional strengthening, qualification and technical assistance; (ii) publishing and divulgation of all legal instruments; and (iii) supporting improvement of the infrastructure of analytical laboratories and sampling.
- Lack of common policy, for example, of a unique list of PTSs banned for import and use in the Region. This is already well underway in some Caribbean Countries, through the formulation and activation of an OECS pesticide control group.
- Need of formulation of laws and regulations for solid waste management and safe disposal of PCBs containing oil, and guidelines for industrial emissions.
- Need of penal laws for violators in the countries with lack these legal instruments.
- There is no public right to know about the releases of PTS in general in the region. This is a limitation in the public participation in the enforcement of the regulations.
- Legislation is focused mainly in the control and management of PTSs but little in the prevention and substitution of PTS in products and process to alternative production processes.
- The recommendation of the Health Ministries of Central America for urgent drastic reduction and elimination of chemical pesticides as a measure to reduce and prevent the poisoning of workers and communities has not been materialized yet.

5.3. ALTERNATIVES AND REDUCTION OF PTSs

Based on the need to reduce and/or eliminate the use and release of agricultural, industrial and commercial products that are persistent and toxic, a set of actions is necessary, such as hazard identification, identification or development of alternatives or measures for reduction, implementation and control, communication to the public, and cooperation within the Region and with international organizations.

Inventories. An inventory of sources of PTSs must be carried out with the support of international organizations. This includes an inventory of industries for the control of the activities and products that they use or apply. Development of inventories and control of chemical products imported and establishment of databases using the international classification of the chemical products are urgent tasks in the Region.

Monitoring and control. It is necessary to improve technical capacity for the analysis of PTSs and to develop regional programs to control and monitor PTSs.

Introduction of alternative techniques. Experiences are accumulating for reduced or eliminated dependence on chemical pest control in agriculture by the use of biointensive pest management practices, agro-ecological pest control, and organic agriculture. Obstacles to elimination of pesticide use seem to be more commercial and political than technological. In countries that still use DDT to control malaria and others that rely in the use of chemicals for vector control, it is necessary to introduce alternative control measures, among them the improvement of waste water management.

A parallel development in industry involves introduction of clean technology and less pollutant raw materials. Use of incentives can be used to facilitate development and introduction of alternatives to PTSs. Cost-benefit and more general socioeconomic analyses are needed.

Improvement of legal regulations. The mandatory control of industries is necessary, especially of industrial establishments that use or generate PTSs in different processes of importation, raw materials, management, and commercialization. It is necessary to develop regional programs and harmonization of laws to control activities that produce dioxins and furans, hexachlorobenzene and PCBs.

Ratification of international conventions related to PTSs such as the Stockholm and Rotterdam Conventions is called for.

Educational programs. Development of educational programs is required in all sectors, including policy makers, industry and civil population, in order to promote a regulation of PTSs and to protect public health and the environment.

Agricultural extension services should be augmented by training programs in alternative methods of pest control. In general, PTS and clean production topics should be included in the curricula of academic programs of the universities and colleges, even in basic education.

Elimination of obsolete stocks and reservoirs. Adequate elimination of PTSs must be ensured in accordance with the requirements of the Stockholm Convention, including regional application of non-combustion technologies for the treatment of obsolete stocks. Agreements with countries that have facilities for adequate destruction of PTSs should be pursued.

5.4. TECHNOLOGY TRANSFER

5.4.1. Status of technology transfer in the control of PTSs

There are a number of causes for the continuing use of certain pesticide PTSs in the Region, in spite of the fact that their adverse effects on the environment and human health are well known. In the first place, the dissemination of information about these substances is inadequate. Secondly, legal regulations and enforcement were deficient. Thirdly, economic factors encouraged the use of these substances.

After the ban of some PTSs, stockpiles appeared in many countries, which yet today are potential sources of contamination because there is no adequate disposal technology available in the Region. A number of unintended PTSs are continuously released into the environment. Waste disposal is another PTS source. The dimensions of these problems vary by country, as does the level and extent of technological potential of coping with these problems.

Although there are valuable human resources and scientific knowledge in the Region, there is a lack of qualified personnel at different levels. There is a lack of trained scientists and technicians in the analysis of non pesticide PTSs such as dioxins, furans, short chain paraffins, flame retardants, PCDFs, phthalates, etc. Deficient infrastructure and funding, do not allow an effective technology transfer in the abatement of PTSs. Enhancement of the infrastructure and funding is therefore necessary in four important sectors, namely, agriculture, industry, environment, and health.

Environment. With regard to PTSs in the environment, it is necessary to quantify the contamination levels and incidence of adverse outcomes as functions of time on a scale of years and decades. This is equally necessary for both the PTSs that have been banned and those that are still used.

Agriculture. The use of PTSs in agriculture was due, among other causes, to the fact that alternative sustainable technologies were not known or not available at the time. The Green Revolution, with its intensive use of chemical fertilizers and pesticides, is inappropriate for cultural and biological diversity. Integrated pest management (IPM) reduces the use of agrochemicals. Along with improved knowledge it is possible to plan for environmentally compatible chemical, biological, and management alternatives for PTSs.

Health aspects. Knowledge of health problems from use and involuntary contact with PTSs are overwhelmingly reduced to treatment and notification of acute intoxications. Attention should be extended to neurobehavioral and psychological effects and on delayed effects on reproduction and endocrine damage of PTS, not just pesticides.

Industry. One of the pressing problems in the Region is the lack of data on PTSs released by the industry. Furthermore, industrial wastes are not always treated and when they are, the procedures tend to be inefficient. Sometimes the environmental fate of some PTS is unknown.

It is necessary to widen the knowledge of clean technologies and procedures for the control of emissions in order to support Governments to become aware of the necessity to update local industries.

5.4.2. Steps in technology transfer into the Region

Due to socioeconomic, geographic reasons and natural resources, the scientific-technological development and the capacity for a rapid and efficient technological transfer have been uneven among the 23 countries in the Region. Regional technology transfer in the entire Region must cover all countries, beginning with a wide share of knowledge and experiences about PTSs. This involves:

- Harmonization and upgrading of registration for all PTSs, including procedures and general guidelines for particular features of each country. This entails interdisciplinary approval for the use of new chemical compounds. Advance environmental tests may be necessary previous to the decision for authorization or non-authorization. A withdrawal mechanism for permits is necessary when available data indicate an unnecessary risk to the environment, human and wildlife.
- Harmonization of national legislations on emissions levels of PTSs and on the disposal procedures of urban and hospital wastes. Efficient enforcement must be secured.
- Requirement of environmental and health permits for each new industry and/or technology that may imply toxicological and/or environmental risk.
- Creation of regional monitoring programs for selected PTSs, including identification of strategic location of sampling points in time and space that includes important sites and assessment of Tran boundary movement.
- Long–term monitoring of selected PTSs in food and water of each country, combined with surveillance of selected health parameters in selected populations.

5.4.3. Technology transfer within the Region.

This involves the following items, applied to agriculture, industry, environment and health matters in the Region:

- Identification of the needs of knowledge transfer, according to the level already achieved in the Region and the specific problems faced. This will include training in analytical techniques of PTSs that until now have not been addressed such as dioxins, furans, and phthalates. QA/QC procedures need to be implemented for such compounds. Research training in delayed long-term adverse effects of PTSs on humans and wildlife needs to be intensified.

- Contributions to update existing equipment and analytical procedures, and when required, setting-up reference laboratories with capability and capacity to provide assistance to countries where demand does not justify development of national laboratory.
- Adoption of existing agro-ecological methods of pest control and alternative treatment of wastes.
- Facilitation of setting up networks for a long-term flow of technology and information into and within the countries of the Region.

5.5. IDENTIFICATION OF NEEDS

5.5.1. Human Resources

- Training in suitable techniques for analysis of PTSs, mainly for PCBs, PCDDs, PCDFs, short chain paraffins, PCDEs, organotin compounds and phthalates. Training in audits for substitution of toxic inputs, processes, and products.
- Improving ability to obtain comprehensive information.
- Technical training in environmental management, access to resource materials, etc.
- Building capacity for managing toxic and dangerous waste as well as domestic, municipal and medical waste.
- Strengthening toxicological resources within universities, official bodies and private sector.
- Making human and ecotoxicological and industrial PTS release information widely available.
- Designing improved outreach materials and delivery methods for a wide audience of materials provided by international organizations to developing countries.
- Working with and strengthening environmental NGOs with regard to their role in the dissemination of PTS-related information as well as information on alternative techniques and technologies for avoiding and/or reducing releases of PTSs to the general public.
- Improving the knowledge of official and private sectors on cleaner production and alternatives to PTSs as well as alternatives to materials, practices and technologies that are major precursors for the formation of unintentional PTSs.

5.5.2. Laboratory Capacity

- Updating of equipment and analytical techniques, especially for industrial and unintentionally produced PTSs.
- Setting up national and regional reference laboratories. Strengthening regional laboratories both in terms of capability and capacity to provide analytical services to countries where size and demand for testing does not justify developing national laboratories.
- Supporting the upgrading of existing laboratories on QA/QC and accreditation processes.
- Increasing the budget for carrying out analyses of PTSs.

5.5.3. Legislation And Coordination

- Reviewing legislation to ensure that it enables the countries to phase out and regulate existing uses as well as existing technologies, materials and practices that create unintentional byproduct PTSs.
- Mandatory registration of import, use, releases and transfer of PTSs.
- Harmonization within the region.
- Harmonization of national and regional legislation with international treaties and conventions.

- Strengthening enforcement infrastructure.
- Establishing and/or strengthening the collection and sharing of information relevant to the agricultural and industrial releases of PTSs, including those that are unintentional.
- Developing of standards for PTSs in the environment.
- Monitoring of environmental levels.
- Coordinating official agencies involved in PTS management within the countries and in the Region.
- Improving registration, reporting, and reinforcing the surveillance system at the primary health care level.
- Ensuring the right to know, including public access to PTS inventories.
- Legal restriction of sales of PTSs, for example, for domestic fumigation.

5.5.4. Alternative Practices

- Strengthening of practices that prevent the formation and releases of PTSs.
- Building of capacity of non-combustion technology for the treatment of PTS wastes.
- Supporting agro-ecological methods of pest control.
- Creation of a database or clearinghouse of alternatives to PTSs.

5.5.5. Transboundary Movement Of PTSs

- Setting up of infrastructure for detecting, preventing and controlling transboundary movement.
- Harmonization of legislative framework.
- Designing and implementing regional monitoring programs which will provide information to determine priority pollutants to be addressed through regional strategies.

5.5.6. PTS Inventories And Models

- Definition of common procedures for collection, analysis, and reporting of PTSs data.
- Application of emission/transmission/deposition models for the prediction of contamination.
- Training of people involved.
- Establishment of inventories and databases for emission sources, use patterns and storage sites of PTSs.
- Using of geographical information systems.

5.5.7. Public Awareness, Participation, And Risk Communication

- Including public awareness and participation in all issues related to PTSs.
- Programs of minimization of health risks from PTSs in vulnerable exposed groups and high-risk communities.
- Increasing capacity to inform the population of risks associated with PTSs and ways to prevent exposure. Developing materials geared to target audiences.
- Sharing of information and experiences, both at regional and inter-regional levels.
- Exposing of technical people in charge of PTS management to improve outreach materials from developed countries.

- Developing risk communication programs within agencies for PTS management, including strategies for identifying vulnerable populations and assessment of channels best adapted for reaching target populations.

5.5.8. Miscellaneous

- Inclusion of the social dimension of PTS management (see also 5.6.1. and 5.6.7.).
- Developing sustainable mechanisms for disposal of PTS wastes and containers. Enhancing cooperation for environmentally sound final disposal of obsolete and banned PTSs.
- Studying alternatives to PTSs, mainly to organochlorine pesticides still in use and industrial PTSs.
- Building capacity to set up a database on environmental levels of PTSs and their effects on living organisms.
- Reviewing and developing protocols and training programs for handlers of chemical substances in the Government, small-and medium-sized industry and larger industries; firemen; customs officials, and employees in storage sites, laboratories, hospitals, etc.
- Promoting and requiring producer responsibility at national, regional and international levels (training; outreach; labeling; provision of "take-back" containers, etc.).

5.6. SUMMARY

An assessment of the regional capacity and needs to manage PTSs within the Region was conducted by reviewing and evaluating information compiled on (i) the monitoring capacity; (ii) legislation and other regulations and management structures; (iii) status of enforcement; (iv) alternatives and other measures for the reduction of PTS use; and (v) technology transfer. Following the assessment, the existing regional capacity was used for the identification of the major needs for the improvement of PTS management.

Monitoring capacity of PTSs across the Region varies between countries. Occasional facilities for the monitoring of selected PTSs are available in several countries of the Region. However, no country has facilities to monitor all the PTSs of concern. In particular, there are no facilities in the Region for the routine monitoring of dioxins and furans and a number of emerging PTSs of concern, such as PBDEs. The number of internationally recognized, accredited reference laboratories is low. A few Central American countries have national laboratory accreditation bodies. Most countries lack reference laboratories for the majority of POPs. Sampling capacity is limited. Cuba has a number of laboratories capable of testing PTSs. Six of the eleven English speaking Caribbean countries (Trinidad & Tobago, Barbados, Jamaica, Bahamas, Guyana, and St. Lucia) possess some laboratory capacity to monitor selected PTSs. Import, export, transport, storage, use and disposal of PTSs are legally regulated in all countries in the Region, with a tendency to consider pesticides separately from the rest of the PTSs.

Legislation exists for the implementation of control and management of pesticides. Harmonization of legal regulation and registration has been undertaken in Central America and initiated in the Organization of Caribbean States. For non-pesticide PTSs, there is little registration and regulation of import, export and use, with the exception of the Rotterdam and Basel Conventions and a few national regulations of a reduced number of industrial PTSs. Jamaica is the only country in the Region reporting legal control of dioxin and furan emissions. Only Barbados reports that open burning of garbage disposal is illegal. Honduras has a draft resolution concerning solid waste management. Implementation of regulations on the management of PTSs in the Region is complex and depends on the characteristics of the particular country. With exceptions, especially in some Caribbean countries, compliance is weak or lacking. Deficiencies in regulation derive from lack of specific laws and regulations; weak enforcement; insufficient trained human resources; unsatisfactory dissemination of the legal instruments at all levels; poor inter-sectorial and inter-institutional coordination; insufficient financial support for the institutional strengthening, qualification, and technical assistance, including the infrastructure of analytical laboratories and for sampling; lack of regional policy; insufficient regulation for solid waste management and disposal of pesticides, PCBs and other PTSs; and insufficient control of agricultural and industrial emissions.

In view of these deficiencies, the following measures need to be developed: a) inventories and control of industries and chemical products imported, produced and used; b) improvement of technical capacity for sampling and analysis of PTSs and development of regional programs to control and monitor PTSs; c) introduction of alternative, clean technologies for agriculture, industry, and waste management; d) improvement and harmonization of legal regulation and its implementation concerning import, use, production and emission of PTSs; e) facilitation of technology transfer; f) ratification of relevant international conventions; g) implementation of educational programs to all sectors; h) training of agricultural extensionists in alternative methods of pest management; i) inclusion of PTS issues and clean production technology in the academic programs of the universities, college and basic education; and j) implementation of an appropriate elimination system of obsolete stocks of PTSs.

A major immediate regional goal is to increase and strengthen the bonds among universities, national science and technology organizations, and other research and education entities. Environmental problems within the common watershed at the Caribbean require multidisciplinary international cooperation and research on cleaner technologies.

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6. CONCLUSIONS AND RECOMMENDATIONS

6.1. PRIORITAZITION OF CHEMICAL ISSUES

Prioritization of chemicals issues in Region X was carried out by 40 experts from 21 countries from academic, governmental and industry sectors, as well as NGOs and International Agencies during a meeting held in San Jose, Costa Rica in October 2002. This prioritization was reviewed and summarized during the Regional Team Meeting held in November 2002. The results are shown in Table 6.1 and Table 6.2.

In general concerns of PTSs were not identified by participants on issues of human health and ecotoxicological effects. This can be explained by the fact that there is a lack of information on these issues in the region. Priority sources of regional concern are atrazine, endosulfan, PAHs, PCBs, and toxaphene. But it was considered that there were data gaps regarding sources for all PTSs, this is in agreement with the fact that there are no comprehensive inventories of PTSs for any country of the Region.

Regarding environmental levels chemicals of concern are endosulfan, PAHs and DDT. At the local level, PTSs of concern are atrazine, aldrin, chlordane, dieldrin, endrin, heptachlor, mirex, PCBs, HCH, HCB, organic lead, mercury and tin, octyl- and nonyl-phenol.

Table 6.1 Scoring for Sources, Environmental Levels, Effects and Data Gaps

Data Gaps	Ecotox Effects	Data Gaps	Environ Levels			Data Gaps	Human Effects	Data Gaps
Aldrin	0	2	1	0	0	0	0	0
Chlordane	0	2	1	0	0	0	0	0
DDT	1	2	2	1	1	1	1	1
Dieldrin	0	2	1	0	0	0	0	0
Endrin	0	2	1	0	0	0	0	1
Heptachlor	0	2	1	0	0	0	0	0
HCB	1	2	1	0	0	0	0	0
Mirex	0	2	1	0	0	0	0	1
Toxaphene	0	2	2	1	0	2	0	1
PCBs	2	2	1	1	0	1	0	1
Dioxins	2	2	0	2	0	2	0	2
Furans	2	2	0	2	0	2	0	2
HCH	0	2	1	0	0	2	0	2
PCP	0	2	1	0	0	2	0	2
PAHs	2	2	2	1	0	2	0	2
Org. merc. cmpds.	1	2	1	1	0	1	1	0
Org. tin cmpds.	1	2	1	1	0	1	0	0
Org. lead cmpds	1	2	2	1	0	1	1	0
PBDE	1	2	0	2	0	0	0	0

Phthalates	2	2	1	1	0	2	0	2
Endosulfan	2	2	2	1	0	2	2	1
Atrazine	2	2	1	1	0	2	0	2
Chlordecone	0	2	0	0	0	0	0	1
Octylphenol	1	2	1	1	0	2	0	0
Nonylphenol	1	2	1	1	0	2	0	0
CPs	1	2	1	1	0	0	0	0

As in the previous table, compounds can be assigned to a group because of lack of information or studies.

Table 6.2: Regional Prioritization of Selected PTS

Item	Regional Concern (2)	Local Concern (1)	No Concern (0)
Sources	PCBs, PAHs, endosulfan, atrazine, toxaphene	DDT, HCB, HCH, PCP, org. mercury, org. lead, org. tin, CPs,	aldrin, chlordane, chlordecone, dieldrin, endrin, heptaclor, mirex. Data gaps for PTSs of potential regional concern: PBDE, dioxins, furans, phtalates, octylphenol, nonylphenol
Environmental. Levels	DDT, endosulfan,, PAHs,	aldrin, atrazine, chlordane, , dieldrin, endrin, heptachlor HCB, mirex, toxaphene, PCBs, HCH, org. mercury, org. lead, org. tin	None Data gaps for PTSs of potential regional concern: PBDE, dioxins, furans, phtalates. octyl - nonylphenol
Ecotox. Effects.	None	DDT	aldrin, chlordane, chlordecone, dieldrin, endrin, heptachlor, mirex. Lack of data but of potential concern: atrazine, endosulfan, toxaphene, HCH, dioxins, furans, PAHs, PCP, phthalates, nonyl – octyl fenols

Human Effects.	Endosulfan	DDT, org mercury, org lead	Aldrin, chlordane, chlordecone, dieldrin, endrin, heptaclor, mirex. Lack of data but of potential concern: atrazine, HCH, PAHs, PCP, phtalates, toxaphene, PCBs dioxins, furans

Considering the data on sources, transport, deposit, effects on health and the environment, control, regulation, monitoring, research and risk assessment, communication and training of PTSs in Central America and the Caribbean, described in Chapters 1-5, the following conclusions were reached for the reduction of the PTS load in the Region:

6.2. DEVELOPMENT OF HUMAN RESOURCES

Training at different levels is needed, including scientists, technicians, policy experts, administrators and managers in universities, in the public and private sectors and NGOs. Necessary contents of training include risk assessment, alternative technologies, pest management, toxicology, epidemiology, environmental and industrial hygiene, environmental management, techniques for analysis of PTS, waste management, and the social dimensions in the containment of PTSs. A major immediate regional goal is to increase and strengthen the bonds among universities, national science and technology organizations, and other research and education entities. Participation between major stakeholders is necessary.

6.3. RISK ASSESSMENT AND RISK COMMUNICATION

Risk assessment covers both systematic monitoring and establishment of inventories of sources, emissions, movement and contamination, surveillance of biological and environmental effects of PTSs, and hot spot studies of episodes of contamination or poisonings. PTS monitoring should cover atmospheric and aquatic (marine, freshwater, groundwater) environment, soil, food, and organisms.

Risk communication is necessary at all levels in the form of training, dissemination of information, information transfer to public agencies and regulators, the research community, private sector, investors, trade unions, communities, NGOs and the general public. Risk communication needs to be expanded to communication of contamination control and cleaner and less toxic technologies for agriculture, industry, and waste management.

6.4. ENHANCEMENT OF LABORATORY CAPACITY

Laboratory capacity needs improvement by way of: a) updating equipment and analytical techniques including industrial and unintentionally produced PTSs; b) setting up national and regional reference laboratories; c) strengthening regional laboratories both in terms of capability and capacity to provide analytical services to countries where size and demand for testing does not justify developing national laboratories; d) ensuring budgetary provisions for the necessary infrastructure and analytical functions; and e) supporting the upgrading of existing laboratories on QA/QC and accreditation processes.

6.5. ENHANCEMENT OF CLEAN TECHNOLOGIES

This is a key issue in the reduction of the PTS load in the Region, it includes among other measures: a) the development, application and appropriate modification of clean technologies for agriculture, industry, and waste management; b) the strengthening of practices that prevent the formation and releases of PTSs; c) the safe disposal of waste oil and obsolete stocks of PTSs and transformers containing PCBs; d) building of capacity of non-combustion technology for the treatment of PTS wastes; e) containment of diesel engine emissions; and f) creation of a database or clearinghouse of alternatives to PTSs.

6.6. REGULATORY DEVELOPMENT AND ENFORCEMENT

This is another area with a need for major improvements, including creation and harmonization of effective legal regulation and its implementation concerning import, export, transport, use, production, emission, storage and disposal of PTSs; ratification of relevant international conventions; harmonization within the Region and with international treaties and conventions; strengthening the weak inspection and enforcement infrastructure; definition and enforcement of allowable concentrations of PTSs in the environment and workplaces; legal framework for PTS monitoring; coordination between official agencies involved in PTS management within the countries and within the Region; empowerment of the primary health care sector in prevention, diagnosis and treatment of adverse health effects of PTSs. Regional and national intersectorial coordination of administrative regulation and implementation is necessary.

LIST OF ABBREVIATIONS

ACS:	Association of Caribbean States
BFR:	Brominated Flame Retardant
CACM:	Central American Common Market
CP:	Chlorinated Paraffin
DDE:	Diclorodiphenyldichloroethane
DDT:	Dichlorodiphenyltrichoroethane
GEF:	Global Environmental Facility
HCB:	Hexachlorobenzene
IARC:	International Agency for Research on Cancer
FAO:	Food and Agricultural Organization
HIPS:	High Impact Polystyrene
INC:	Intergovernmental Negotiating Committee
IPM:	Integrated Pest Management
NAFTA:	North American Free Trade Agreement
NGO:	Nongovernmental Organization
OECS:	Organization of Eastern Caribbean States
PAHO:	Pan American Health Organization
PAH:	Polycyclic Aromatic Hydrocarbon
PBB:	Polybrominated Biphenyl
PBDE:	Polybrominated Diphenyl Ether
PBDD:	Polybrominated Dibenzodioxin
PBDF:	Polybrominated Dibenzofuran
PCB:	Polychlorinated Biphenyl
PCBE:	Polybrominated Diphenyl Ether
PCP:	Pentachlorophenol
PCDD:	Polychlorinated Dibenzodioxin
PCDF:	Polychlorinated Dibenzofuran
POP:	Persistent Organic Pollutant
PBB:	Polybrominated Biphenyl
PTS:	Persistent Toxic Substance
RBA:	Regionally Based Assessment
TEL:	Tetraethyllead
TML:	Teteramethyllead

UNEP: United Nations Environmental Program

UNDP: United Nations Development Program

WHO: World Health Organization

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UNEP Chemicals is a part of UNEP's Technology, Industry and Economics Division

Printed at United Nations, Geneva
GE.03-00159–January 2003–500
UNEP/CHEMICALS/2003/10