HEALTH CONDITIONS IN THE CARIBBEAN

Scientific Publication No. 561

PAN AMERICAN HEALTH ORGANIZATION
Pan American Sanitary Bureau, Regional Office of the
WORLD HEALTH ORGANIZATION
525 Twenty-third Street, N.W.
Washington, D.C. 20037, U.S.A.

1997

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Key to symbols used in tables

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.. Not applicable
– Magnitude zero

HEALTH AND THE ENVIRONMENT

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In 1979, the Fifth Conference of CARICOM Ministers Responsible for Health expressed concern about the defence and protection of the region's human and environmental health by approving the Caribbean Environmental Health Strategy.[1] The preparation of the strategy was motivated by the need to remedy the environmental health hazards that threatened the inhabitants of the Commonwealth Caribbean. It set goals for the supply of safe water and the provision of approved facilities for the sanitary disposal of liquid waste, excreta, and solid waste; called for standards and criteria for the design of water supply and waste disposal systems; and advised that agencies be set up to monitor and regulate environmental pollution. It also included proposals for community participation and education in the implementation of the strategy.

A key element of the strategy was establishment of the Caribbean Environmental Health Institute (CEHI), which was founded in 1981 in Saint Lucia. Its programmes include strengthening national institutional capability in the areas of water supply and waste management and developing standards and guidelines for marine environmental monitoring. The Institute conducts courses, seminars, symposia, and workshops at either its headquarters or other regional institutions and responds to its member states' requests for technical and advisory services

These efforts on the part of the Caribbean governments to promote environmental health in the region were reinforced by the Declaration of Barbados (1994), which was the outcome of the Global Conference on Sustainable Development of Small Island Developing States.[2] Among the topics addressed in the Declaration were the following:

- the protection of coastal zones and oceans against the effects of land-based pollution;
- pollution prevention, waste management, and the transboundary movement of hazardous materials;
- the constraints of scarce land resources and limited fresh water, the need for education and training, and requirements related to health and human settlements, and
- the vulnerability of the states to natural as well as environmental disasters and their limited capacity to respond to and recover from such disasters.

Many of these issues are discussed in Part I of this chapter, which describes environmental health services in the Caribbean, as well as existing environmental problems and the countries' efforts to protect human health and the quality of the environment. Part II provides information about hazards and disaster management in the region.

PART I: ENVIRONMENTAL HEALTH SERVICES AND ISSUES

Water Supply and Sanitation

Drinking Water Coverage

Drinking water supply in the Caribbean exhibits high coverage levels in terms of the percentage of the population with access to piped water, particularly in urban areas. The percentage of the population served by house connections (around 50%) is considerably less than the total coverage, which means that a large number of people are receiving water through standpipes

Figures collected as part of the evaluation of the International Drinking Water Supply and Sanitation Decade (1981–1990) indicated that for the Eastern Caribbean states of Antigua and Barbuda, Dominica, Grenada, Montserrat, Saint Kitts and Nevis, and Saint Lucia the percentage of the population with easy access (including house connections) to a safe drinking water supply varied from 80% (Grenada) to 100% (Antigua and Barbuda, Montserrat, and Saint Kitts and Nevis) (Table 1). The Bahamas reported that 97% of the total population had access to public water supply; the figure was 100% in Barbados. Coverage of

TABLE 1. Coverage of water supply and sanitation in the Eastern Caribbean, 1980 and around 1990.

Country	Population with access to drinking water supply (%)[a]		Population with access to sanitation (%)[b]	
	1980	1990	1980	1990
Anguilla	...	90	...	96
Antigua and Barbuda	100	100	...	89
Dominica	85	85	56	98[c]
Grenada	80	80	65	85
Montserrat	97	100[c]	80	80
Saint Kitts and Nevis	100	100[c]	96	98
Saint Lucia	80	85	75	70
Saint Vincent and the Grenadines	65	90[c]	90	100[c]

[a]Water supply includes house connection and easy access.
[b]Sanitation includes sewerage and other excreta disposal systems.
[c]Applies to 1992.
Sources: Pan American Health Organization report to the Regional Conference on Water Supply and Sanitation, 1990 (see reference 3), updated with PAHO indicators (1992–1994).

97% of the population with pipeborne or truckborne water was reported by Trinidad and Tobago in 1990,[3] but more recent figures give urban coverage as 83% and rural as 80%.[4] In Jamaica, 59% of the country's urban population is served with potable water by house connections; another 33% of the urban population is deemed to have reasonable access to a public standpipe, and 54% of the rural population also has reasonable access to safe water.[5] In Guyana, although nationwide coverage is as high as 78.5%, supply is inconsistent, as economic constraints have hampered maintenance of existing infrastructure.[6]

Coverage in rural areas has improved in many countries, notably Jamaica, Trinidad and Tobago, and those of the Eastern Caribbean. However, standpipes continue to exist, particularly in the Eastern Caribbean, resulting in considerable wastage of water.

Population increases and industrial growth, combined with high levels of growth in the tourism sector in much of the Caribbean, have put more pressure on existing water utilities to provide increased quantities of safe potable water. In addition to domestic uses, water is now being used in manufacturing processes, in swimming pools, and even for irrigation of golf courses, putting greater demands on the limited water resources in the region.

Sources of Water Supply

Public and private sources of water vary among the islands and consist of groundwater (including springs), surface water, rainwater (including roof catchment systems), and desalinated water, or a combination.

Groundwater is the main source of public water supply in the Bahamas, Barbados, the island of Barbuda, and Montserrat.[3] Surface water is the main or only public source in Dominica, Saint Kitts, Saint Lucia, and Saint Vincent, while a combination of surface water, groundwater, and, to a lesser extent, public artificial rainwater catchment systems comprises the public water supply in Antigua, Jamaica, Grenada, Guyana, and Trinidad and Tobago. Desalinated water is becoming more and more important as a source of the public water supply, particularly in Antigua and the British Virgin Islands, while artificial catchment systems for both public and private use are common in Anguilla and the Turks and Caicos Islands.

Rising demand for water resources in Anguilla and the Bahamas has resulted in overexploitation of groundwater, which in turn has led to saltwater intrusion and high salinity. In Barbados the water supply is threatened by urbanization pressures. In many countries, watersheds are being deforested to make way for agriculture and residences. Deforestation has led to silting of streams and reservoirs and also to periodic flooding (for example, in Jamaica and Trinidad) instead of aquifer recharge.

Water Treatment

In urban areas, treatment consisting of at least chlorination is generally carried out. However, less is done to treat water in rural areas, particularly groundwater supplies. In fact, Guyana reported in 1989 that some 169 of 171 existing systems were without disinfection facilities.[6]

Most water agencies/authorities are conscious of the need for water quality control and maintain laboratories for that purpose. However, analyses are not always carried out on a regular and systematic basis. Few countries have institutions that rigorously fulfill the role of surveillance of water quality.[7] However, Jamaica and Trinidad and Tobago, as well as other countries in the region, have attempted to develop appropriate networks for water quality testing to overcome this deficiency.

Water Sector Organization and Infrastructure

The water supply sector in some countries falls under a government ministry (for example, in the Bahamas, the Ministry of Consumer Affairs, through the

Water and Sewage Corporation; and in Barbados, the Ministry of Transportation, through the Barbados Water Authority). In other Caribbean countries under consideration, a local Water and Sewage Authority (WASA) is responsible for water supply. These countries include Belize, Grenada, Saint Lucia, and Saint Vincent and the Grenadines. Responsibility rests with the Water Authority in Montserrat and Anguilla and the Water Department in Saint Kitts and Nevis.

One of the main constraints to sector development that has been identified is institutional weakness of agencies responsible for water management. These agencies are largely semi-autonomous, but their autonomy (particularly financial) is limited, considering that many are subsidized by the central government. Other constraints that have been identified include the inability of countries to provide counterpart funding for local project costs and the lack of adequate capacity for project implementation.[3]

Institutional strengthening and improvement has taken place in many Caribbean countries recently, including those of the Eastern Caribbean as well as Guyana, Jamaica, and Trinidad and Tobago. In the latter country the WASA was privatized in recent years In Dominica a private company (DOWASCO) has had responsibility for managing the water supply since 1989. (Legislation relating to water supply management in some countries is cited in the chapter *Health Legislation and Policy.*)

Antigua and Barbuda reported that 58 8% of the population was metered, and Montserrat reported 5,000 metered customers in a population of 11,000. These proportions are significantly higher than those in Dominica, Grenada, and Saint Vincent and the Grenadines, which reported that less than 10% of residential consumers were metered. Levels of metering reflect the level of organization of the sector and have implications for wastage of water.

In most distribution systems* throughout the region, operations and maintenance are not given adequate attention and systems are in need of repair.[8] For example, in Guyana resources earmarked for infrastructure maintenance are mainly devoted to repairs and only rarely are used for preventive maintenance.[8] In Trinidad and Tobago, the numerous leaks that are known to exist are not repaired for reasons which include lack of financial resources and materials A reliance on imported equipment and parts aggravates maintenance problems, particularly as Caribbean countries face foreign exchange shortages. Some distribution systems do not have sufficient carrying capacity to meet increased demands (e.g., Saint Lucia), and many lack adequate storage (e.g., Antigua).[8]

A high level of investment in infrastructure is needed to keep pace with development, but most territories do not have the large amount of capital to invest and therefore may be unable to provide optimum levels of service.

As water resources are finite and are already being overused, measures to control wastage by metering consumption and improving the maintenance of the distribution system merit urgent attention.

Water Supply Programmes

The International Drinking Water Supply and Sanitation Decade (IDWSSD), which began in 1981 and ended in 1990, provided a unique opportunity for the Caribbean countries to articulate specific targets for population coverage which they would each seek to achieve by the end of the Decade. These targets were related to either ongoing programmes or planned programmes as well as to the global target recommendation, which urged "achieving the universal provision of potable water and adequate sanitation services by 1990."[9] In Guyana, national goals of provision of safe drinking water to 100% of the urban population and 93% of the rural population were established. In some cases (for example, Trinidad and Tobago), no specific national goals were established for 1990, but the theme of providing "all people with water of safe quality in adequate quantity" was endorsed by the Government. More recently, the target of the Caribbean Cooperation in Health (CCH) initiative[10]—that each country should ensure that safe potable water is available in adequate quantities 24 hours a day by 1995—has also been borne in mind by the countries.

Plans for significant investment in capital works were prepared to various levels of detail during the Decade, but the actual investments seldom reached the levels projected. For example, in Trinidad and Tobago, projected investments in the water sector for 1981–1989 totalled TT$ 1,500 million, but actual investments amounted to TT$ 373 million.[5] These figures are representative of regional trends

In Antigua and Barbuda between 1984 and 1987, a consulting firm prepared a master plan for a five-stage improvement program for the Antigua Public Utilities Authority,[11] which represented a blueprint for development of the Antigua Water Supply System.[8]

*A distribution system is a series of interconnected pipelines (mains) which carry water from transmission lines and distribute it throughout a community. These systems also include storage tanks, booster (pump) stations, valves, hydrants, and service lines

TABLE 2. Coverage of sanitation services in urban and rural areas, selected Caribbean countries, 1992.

	Population with sewage and excreta disposal services (%)			
	Urban			
Country	House connection	Other[a]	Total	Rural[a]
Bahamas	10	88	98	100
Barbados	4	96	100	100
Belize	46	30	76	22
Guyana	29	58	87	30
Jamaica	19	70	89	59
Trinidad and Tobago	22	38	60	50

[a]Individual systems such as septic tanks and latrines

Source: Pan American Health Organization. *Health Conditions in the Americas, 1994 Edition.* Washington, D C · PAHO; 1994: Vol. I, p 278 (Scientific Publication No 549)

The plan recommended capital investment amounting to US$ 10.95 million by 1990 in Stage I, and further investment of US$ 11.04 million during Stage II (1991–1995).[8] Very little of this investment has been possible to date.

During the period 1983–1988, water supply projects totalling EC$ 4 1 million (US$ 1 = EC$ 2.70) were funded by the British Development Division (BDD), Caribbean Development Bank (CDB), United States Agency for International Development (USAID), and the Central Water Commission in Grenada.[5] Saint Lucia has also received funding to finance various projects, most notably the Roseau Water Supply Project, currently under way. This project, which involves construction of dams and treatment works as well as transmission lines, is designed to meet the water demands of Castries and northern Saint Lucia up to the year 2005.[8] The total cost is EC$ 115 million.

Water projects in the countries of the Caribbean have benefitted from various sources of financing in recent years. The Inter-American Development Bank has looked at watershed management in Jamaica, upgrading of water supply systems in Guyana and the Bahamas, water conservation in the Bahamas, and water resources (surface and underground) quality and quantity in Barbados.[12] The water supply systems of several countries have recently been improved through the assistance of the Canadian International Development Agency (CIDA) and other agencies. In the Eastern Caribbean, these countries include Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines. In Saint Lucia, new raw water pumping stations and a recently opened water treatment plant have improved the reliability of the water supply. In Antigua and Barbuda, the construction of desalination units by the Public Utilities Authority and a more recent initiative by a private firm to provide fresh water using a reverse osmosis plant have improved tremendously the available supply of potable water. These projects are a sample of the types of ongoing or proposed activities being undertaken to improve the quality of the water supply service throughout the region.

Sanitation Coverage

While a significant degree of progress has been achieved in recent times in water supply, the same does not apply to sewerage. Most countries must strive to simply maintain existing sewerage infrastructure and have not managed to expand sewage disposal services much in recent years. Sewerage systems generally only serve the centre of urban areas, for example, Kingston (Jamaica), Port of Spain (Trinidad and Tobago), Bridgetown (Barbados), Georgetown (Guyana), and Castries (Saint Lucia). Some existing systems were built about 50 years ago during colonial times, such as those in Dominica, Grenada, and Saint Lucia. In 1992 only about 10% of the population of the Caribbean lived in housing connected to a sewer system.[13]

Notwithstanding the limited sewerage services, overall sanitation coverage in urban and rural areas remains very high, particularly through individual excreta disposal systems. Coverage above 80% is reported in both urban and rural areas in many countries,[4] although coverage is generally lower in rural areas (Table 2). In the Eastern Caribbean, significant improvement in sanitary excreta disposal has been realized in Grenada, Montserrat, and Saint Vincent and the Grenadines[14] over the last decade. However, several areas of poor sanitation in both urban and rural areas are known to persist.

Sanitation Sector Management and Maintenance

Sewerage management, when it exists at all, generally falls under the agencies/authorities responsible for water management (e.g., the WASA). Sector development is constrained by factors similar to those mentioned for water supply management, such as lack of financial autonomy and inadequate capacity for project implementation.

For financial reasons, the public sewerage systems are not adequately maintained, and many discharge inadequately treated effluent, with consequent pollution of rivers and coastal water. Although some treat-

ment facilities do exist in conjunction with large sewerage systems such as those of Port of Spain and Bridgetown, they are predominantly in poor operating condition. A recent study[13] revealed that a high percentage of sewage treatment plants in the Caribbean do not meet adopted effluent criteria, although those operated by national water and sewerage authorities had a significantly better operational status. In many cases (e.g., Dominica, Saint Lucia) no treatment is effected prior to discharge of effluent from sewers.

Sanitation Programmes

The CCH goals and targets related to liquid waste and excreta disposal, as well as the goals established during the IDWSSD (that is, adequate sanitation services by 1990), form the backdrop for initiatives and programmes ongoing in the sanitation sector in the Caribbean. In Guyana the national goal for 1990 was to provide sewerage and excreta disposal to 97% of the urban population and 95% of the rural population, but, as was the case with regard to water supply services, achievement of these goals was hampered by the economic crisis which began in 1981. Nevertheless, the sewerage system in Georgetown was rehabilitated during the IDWSSD.

As part of the improvement of the St. George's (Grenada) sewerage system during the IDWSSD, a sewage pumping station and new marine outfall were constructed. However, no major wastewater treatment facilities were constructed in the Commonwealth Caribbean during the Decade.[5] With the dearth of public sewerage systems, privately owned package treatment plants are becoming more numerous.

Sewerage systems are being installed in the Negril area and Montego Bay, Jamaica, and on the South Coast in Barbados.[15] There are also systems being planned, installed, or extended in the Bahamas,[12] Barbados, Belize, Guyana,[12] Saint Lucia, Saint Vincent, and elsewhere. A sewerage system was recently completed in the Grand Anse area of Grenada in an effort to halt the deterioration of Grand Anse Beach and reduce the pollution of the near-shore and coastal marine waters, and in Jamaica, the treatment and disposal of sewage has been upgraded to arrest the degradation of the ecosystems in Kingston Harbour and adjacent marine areas. A study in December 1992 in Saint Lucia looked at the Central Castries Northern Corridor service area and recommended sewerage improvements that included sewerpipes, pump stations, and treatment facilities for the country's major population centre.[16] There has also been much discussion of the need for sewerage facilities in St. John's, Antigua and Barbuda.[17]

Pollution of Water Resources

Water resources are not well managed or protected in most of the Caribbean. Numerous environmental studies done in the region have established that there is serious pollution of rivers and streams, as well as the coastal and marine environment, from sources such as sewage effluent, industrial waste, agrochemicals, wastewater runoff, and sedimentation, with resultant health risks, depletion of fisheries, and destruction of marine ecosystems.

Health Risks

Contaminated drinking water and the inadequate and insanitary disposal of sewage and excreta continue to pose a threat to the health of many communities in the Caribbean. While gastroenteritis and diarrhoeal diseases are no longer leading causes of death, their frequent occurrence in most Caribbean countries signals problems with the quality of water used for drinking and domestic purposes, especially in areas where the piped water supply is intermittent or absent and communities must resort to local wells, springs, and rivers. Intermittent supply is accompanied by low water pressure, which can allow backflow of contaminated water into the distribution system. Poor water quality can result in waterborne gastrointestinal infections and poor food hygiene, as well as additional health risks such as conjunctivitis and skin infections, while infrequent washing of the skin and hair predisposes to scabies and other infestations. Table 3 shows recent data on gastroenteritis in children under 5 years.

Another water-associated disease, schistosomiasis, has received special attention in Saint Lucia, where a unit was set up to bring this disease under control. Water storage for domestic purposes also increases the availability of potential breeding sites of *Aedes aegypti*, the vector of dengue (see the section on vector-borne diseases later in this chapter).

Typhoid fever occurs in the region as isolated cases and occasional outbreaks. Between 1992 and 1994, Guyana reported 154 cases; Jamaica, 37; Dominica, 23, and Trinidad and Tobago, 10. In 1990 a typhoid-endemic area in Jamaica experienced a large outbreak in two waves: 26 cases and 3 deaths in July/August

TABLE 3. Gastroenteritis cases and rates per 1,000 population under 5 years of age, selected Caribbean countries, 1992–1994.

Country	Cases reported			Rate per 1,000 children < 5		
	1992	1993	1994	1992	1993	1994
Barbados	104	48	34	5 2	2 3	1 6
Belize	69	9	456	2 2	0 3	13.6
Bermuda	64	0	26	16.0	0 0	5.8
Cayman Islands	39	34	72	15 9	14 7	30.4
Dominica	611	490	146	78.7	62.7	17.5
Grenada	459	284	239	36.4	21 8	19.0
Guyana	216	110	126	2.6	1.4	1.6
Jamaica	18,932	12,217	13,698	65.1	45 8	47.9
Montserrat	88	79	57	97.6	84 9	60.0
Saint Kitts and Nevis	563	305	199	119.8	66 0	45.0
Saint Lucia	709	681	275	43.8	43.1	17.0
Saint Vincent and the Grenadines	814	586	1,427	66.7	47 6	115.1
Suriname	4,450	1,518	3,504	89.0[a]	34.0[a]	76.0
Trinidad and Tobago	21,858	18,222	15,355	176.3	123 4	103 8

[a]Estimated.
Source: Caribbean Epidemiology Centre, 1995

and 150 cases and 4 deaths in September/October. There was evidence that a broken water main which became contaminated by sewage was responsible for the second wave of the outbreak.[18]

The countries have increased surveillance for waterborne diseases since 1991 when the threat of cholera re-emerged. For the first time in decades, cholera appeared in the mainland Caribbean countries in 1992, with 556 cases and 8 deaths reported in Guyana that year, 159 cases and 4 deaths in Belize, and 12 cases and 1 death in Suriname. The risk factors in Guyana were identified as drinking unboiled river water and eating smoked fish.

Overflowing household and industrial sewage disposal units (pit privies, septic tanks, and packaged wastewater systems) are common causes of localized groundwater pollution by sewage, which may contain high levels of pathogenic organisms as well as potentially harmful organic and inorganic chemical substances. As these private methods of sewage disposal continue to proliferate because of financial constraints to the extension of public sewerage systems, this problem may worsen.

The pollution of water sources with harmful substances that resist normal treatment processes, such as arsenic, soluble forms of heavy metals, numerous pesticides, insecticides, rodenticides, and organochlorines—many of which are highly carcinogenic, mutagenic, or teratogenic—can have a serious impact on health. The increased use of pesticides in agriculture and the development of many small industries threaten the safety of water sources through the runoff and underground infiltration of contaminated rainwater. Since many Caribbean countries use groundwater for their water supply, these developments need careful monitoring and call for the application of strict zoning regulations similar to those in Barbados.[3]

Pollution of coastal waters by untreated sewage from both land sources and boats is an area of concern, but information is scant on any adverse health effects associated with recreational use of Caribbean waters.

Groundwater Pollution

Groundwater is an important natural resource used for municipal water supplies, for irrigation, and for industrial purposes. Improper disposal of sewage and industrial wastes, including hazardous materials, poses a high potential for contamination of aquifers Contamination may also occur from the leaching of landfills and improper disposal of animal waste and used motor oil; such problems have been documented in the British Virgin Islands,[19] but they exist throughout much of the Caribbean. Contamination with industrial wastes containing organochlorine compounds is of great concern, especially since some organochlorines are known to be mutagenic and carcinogenic. In Barbados, which depends exclusively on groundwater for its drinking water supply and also is highly industrialized, the discharge of industrial wastes is closely monitored and regulated.[8]

Groundwater pollution from poorly constructed septic tanks, pit latrines, and soakaways (an arrange-

ment for disposal of wastewater by percolation through soil) is also a major concern in the Caribbean, notably in Anguilla[20] and also in the British Virgin Islands, where 95.4% of households are served by septic tanks or pit latrines.[19]

In agricultural areas, generalized and indiscriminate use of agricultural chemicals, especially nitrates in fertilizers, has been identified as a potential source of groundwater pollution.[7] Since it is almost impossible to clean polluted groundwater in a cost-efficient manner, and since over the long term contaminated aquifers will have to be condemned, prevention of contamination through appropriate control measures and monitoring is a matter of high priority.[7]

Surface Water Pollution

The intensive use of surface water has reduced its quality considerably in much of the Caribbean. The most serious problem is the deterioration of drinking water quality due to contamination with various chemicals, wastes, pesticides, solvents, and other products. In Grenada, for example, surface water has been affected by pesticides contained in runoff from agricultural lands.[21] Drinking water has reportedly been polluted from agricultural practices and disposal of biocides in Antigua[22] and Guyana,[6] while Saint Lucia has reported episodic fish kills from pesticide contamination of rivers and streams. In Trinidad between 1980 and 1990 six fresh-water fish kills were due to industrial waste and five to chemical poisoning.[23]

Urbanization has also affected drinking water quality in some parts of the Caribbean. Squatter communities, which typically have poor sewage disposal facilities, have been established close to surface water supplies. For example, the Lamaha Canal in Guyana (the water source for Georgetown) is at risk of contamination from nearby unregulated septic tanks and pit latrines.

Eutrophication, caused by the nutrients in sewage discharge and surface runoff from fertilized fields, can lead to biological pollution of reservoirs (i.e., algal blooms), which can cause problems for water supply intakes. It also produces objectionable tastes and odours

Marine and Coastal Pollution

Very few cities in the Caribbean treat municipal sewage adequately before discharging it to the ocean Very often, untreated or poorly treated sewage is discharged into rivers, streams, and drains which empty into the ocean, or it is discharged directly into the ocean through a short outlet. Given the importance of tourism in many countries of the region, as well as the use of beaches and coastal waters by local inhabitants, this pollution is a matter of great concern.

The discharge and infiltration of nutrients from untreated wastewater have damaged coral reefs and fisheries off the coasts of several Caribbean countries (for example, near Barbados, Grenada, and the island of Tobago). In Trinidad and Tobago coastal pollution with chemical agents caused eight fish kills between 1976 and 1990, while another seven kills were due to "natural" causes, such as algal bloom and red tide [23] Grenada has reported pollution of the marine environment from leachate emanating from a solid waste disposal site.[21]

The Caribbean is home to a growing nautical tourism trade. Many small countries receive thousands of yachts annually. The inability of these countries to receive, treat, and dispose of sewage waste in environmentally adequate treatment systems and the possible ecological damage from illegal sewage discharge in coastal areas are two issues which pose problems for the region. Currently, many areas in the Caribbean have no requirements for holding tanks in yachts. As a result, these boats discharge sewage directly into marinas and other anchorages. This common problem could be addressed by the development of a regional Code of Conduct for the operation of marinas/nautical tourism.

Control of Marine Pollution. CEHI has been active in developing a regional laboratory network to monitor the quality of marine and coastal waters [24] Other work specifically to address this problem is being conducted by the Institute of Marine Affairs (IMA) in Trinidad and Tobago.

At the national level, the installation of appropriate infrastructure to prevent sewage and other liquid effluents from polluting the marine environment in the Caribbean is hindered by lack of capital investment funds, political will, and the administrative and legal structures to regulate human development activities.[25] Nevertheless, at the international level, this problem has received attention. Some Caribbean countries, as signatories to the UN Convention on the Law of the Sea (1982), have agreed to take measures to ensure effective protection for the marine environment by preventing, reducing, and controlling pollution and other hazards, including hazardous and toxic substances. The International Convention for the Prevention of Pollution from Ships (1973), modified in 1978 and

known as MARPOL 73/78, has also been ratified by some Caribbean countries. This Convention categorizes pollutants in five annexes and refers to, *inter alia*, oil, noxious liquid substances in bulk, and harmful substances carried by sea in packaged form. By ratifying this Convention, countries have agreed to provide port reception facilities for these wastes.

In October 1990, the Regional Workshop for the Wider Caribbean on Oil Spill Preparedness and Response and "Special Area" Status under Annex V of MARPOL 73/78 was held in Caracas, Venezuela. After much discussion, the Workshop determined that the threat to the Caribbean Sea from garbage was significant enough to seek protection under the "Special Area" provisions of Annex V of MARPOL 73/78 An appropriate resolution was drafted and submitted to the International Maritime Organization's Marine Environment Protection Committee in July 1991. As a result, the Wider Caribbean region was designated as a "Special Area" under Annex V, effective 4 April 1993. Under the terms of Annex V relating to "special areas," ships of all sizes are prohibited from discharging all waste materials except food waste, which may be discharged 12 nautical miles (3 nautical miles in the Wider Caribbean) from land.

Industrial Water Pollution

A project entitled Regional Sewage Disposal Studies was designed to contribute to the protection of public health and the coastal and marine environment and to improve the economic potential of Caribbean countries in tourism, fishing, industry, and other areas of national development. The project was implemented by CEHI, on behalf of CARICOM, with support from the United Nations Development Programme (UNDP) and in collaboration with PAHO.

One component of the project involved a study of industrial (nonpetroleum) wastewaters for the purpose of developing technology-based effluent standards and guidelines for sewage effluent disposed of in Caribbean waters. Because of the diverse types of industries in the region, it was decided that the study would concentrate on those that (a) were known to produce wastewater in large quantities, or of high potency, or both, and thus represented a significant pollution concern; and (b) were either widely distributed or economically significant in particular countries. The industries selected were sugar and associated industries (sugar factories, breweries, distilleries); paint, adhesive, and soap manufacturing; food processing, including citrus fruit, meat, and milk-based industries; metal finishing and surface treatment, and quarrying and mineral extraction (sand and gravel washing plants, bauxite and alumina plants).

A total of 125 industrial plants in eight Caribbean countries were visited and were surveyed by means of a questionnaire to determine quantity, composition, and mode of disposal of wastewaters.[26–33] Because of the limited nature of the study, the information presented below provides examples and should not be considered complete for any country.

In Trinidad, industrial wastes are discharged into a number of rivers, including the Caroni River.[27] Large amounts of pollutants, including heavy metals, phosphates, nitrates, solvents, inks, and lees,[28] enter these water courses daily from most of the industry groups mentioned above. Fortunately, most of these industries are located downstream of tributaries to the Caroni River, the largest source of potable water in Trinidad. These pollutants also have an impact on the Laventille and Caroni swamps. This latter mangrove swamp has both ecological and economic importance. In terms of primary productivity, the estuary produces 20 times as much as the deep sea and about 10 times as much as near-shore waters, and thus it plays a major role in nourishing commercially important marine species. It is also a breeding/nursery ground for many organisms, invertebrate and vertebrate, including the scarlet ibis. Caroni Swamp used to be the major area for oyster harvesting in Trinidad. In recent times, however, oystering was prohibited and has been allowed to resume only under strict control.[29]

Kingston Harbour in Jamaica receives large waste discharges of industrial and urban origin from the Kingston metropolitan area. Pollutants similar to those found in Trinidad are also found in Jamaica, a notable addition being red mud from the bauxite industry.[30] The harbour is semi-enclosed. Thus, contaminants in wastewater from residential and industrial runoff remain there a long time. Primary treated sewage, natural runoff, and domestic and industrial wastes contribute to the high organic levels—some 40 times the natural nutrient level—which have led to phytoplankton blooms, oxygen depletion, and fish kills. The studies also revealed that rivers in Jamaica, including the Rio Cobre and Black River, which serve as public water supply sources, have been exposed to pollution from upstream industries such as sugar factories, citrus processors, and distilleries.

The situation in Barbados and the Bahamas is somewhat different. Although industries do discharge effluent, the receiving environment is usually groundwater. In Belize, some industries discharge effluent to the ground (e.g., soap and detergent manufacturers),[31]

while others discharge to surface bodies such as the Belize River.[27,32] More important, some of these surface bodies (e.g., Stann Creek) act as village water supplies.

The same is true in Saint Kitts and Nevis and Guyana. In Saint Kitts, effluent from a paint/ink plant discharges to Wingfields River, a source of public water supply.[27] In Guyana, effluent from the bauxite industry overflows into Kara Creek, a source of water for a nearby village,[30] and the Demerara River receives pollutants from a number of industries: adhesive manufacturers,[26] paint and ink plants,[27] distilleries,[28] and breweries [33]

In Saint Lucia, rivers receive discharges from various industries. Fortunately, from a public health standpoint, none of these rivers are used to supply potable water. Other industries in many Caribbean countries also discharge effluent directly into the sea.

Air Pollution

The pattern of rapid urban population growth in parts of the Caribbean is the primary cause of air pollution.[34] Urban air pollution, caused by industrial activities, motor vehicle emissions, and electricity generation from biomass and fossil fuel sources, is a mixture of carbon monoxide, sulphur dioxide, dust and smoke, nitrogen oxides, and a number of volatile organic compounds In most Caribbean countries where tetraethyl lead is added to gasoline, the air also contains fine particles of lead.[7] Moreover, photochemical reactions produce ozone, a highly reactive and toxic substance.

The health effects of air pollution are substantial in high-risk groups, namely, small children, the elderly, and persons with heart conditions or respiratory diseases such as asthma and emphysema. Children are very sensitive to lead in the air, and it is believed that ingestion of lead affects learning ability.[7] Ozone and nitrogen dioxide are also known to damage pulmonary tissue.

Despite these potential health effects, air pollution has not generated much concern in the Caribbean. In fact, it has specifically been mentioned as not being a problem in Guyana,[6] Grenada,[21] Saint Lucia,[35] and the British Virgin Islands.[19]

Air quality data are not readily available for most metropolitan areas in the Caribbean. In Jamaica, for example, an air pollution monitoring programme was in effect during 1978, but because of economic constraints and lack of an effective environmental programme, it was discontinued. However, a recent increase in upper respiratory problems, such as sinusitis and allergy, has prompted the Environmental Control Division in Jamaica to restart the monitoring programme. The monitoring has been limited to total suspended particulates (TSP). Results have confirmed what the complaints from the public suggested: that TSP concentrations in the areas sampled are high enough to cause children to experience an increased incidence of respiratory disease and to place persons over 50 at risk Efforts are currently ongoing to evaluate the general air quality conditions in the Kingston metropolitan area. The same is true in other metropolitan areas, such as Port of Spain, Trinidad and Tobago, where the Caribbean Industrial Research Institute (CARIRI) is preparing to carry out such evaluations.

A recent study of air pollution was conducted in Trinidad and Tobago[36] using the rapid assessment methodology outlined by WHO.[37] This study concluded that activities such as manufacturing (including petroleum refining) and transportation (especially land transport) were the major air pollution sources. Together, these sources contributed 71% of the total air pollution found in the study for the year 1993. Carbon monoxide and nitrous oxides were the main pollutants. Forest fires and the burning of sugarcane contributed significantly to TSP, carbon monoxide, and volatile organic compounds found in the environment.

Sources of air pollution that have been identified in Barbados are fumes from exhaust pipes and activities such as quarrying, automobile body work and spray painting, furniture manufacturing, and oil refining.[38] Guyana reports site-specific pollution from the bauxite industry,[39] which is also a source of some air pollution in Jamaica

Solid Waste

Health Risks

On the order of 5,000 tons of solid waste are generated daily in the Caribbean. Trash, which in the past was mostly organic and easily biodegradable, is now composed of many different materials and increasingly includes inorganic substances and even toxic contaminants.[7] Both direct and indirect risks are associated with this waste, which is usually a combination of domestic and industrial. For example, in Guyana, since the persons who collect and haul waste do not usually wear protective clothing, they are exposed to intestinal parasites and the agents of skin and respiratory diseases [39] Scavengers or salvagers likewise run the risk of disease and injury at the many uncon-

trolled disposal sites in the Caribbean. One type of unofficial recycling—the meltdown of used car batteries for remanufacture in "backyard" shops—has been linked to cases of lead poisoning in Jamaica. In Trinidad, cases of lead poisoning in children have resulted in squatter settlements developed on landfill sites containing lead.[40]

Because of poor management practices, disposal sites may also pose an indirect health risk for the general population. Smoke from uncontrolled fires is a common nuisance near many disposal sites and can lead to respiratory diseases in nearby residents, although the extent of this threat is not known. Poor management has also resulted in fly infestations in some communities, such as Ciceron, Saint Lucia. The flies not only can transmit diseases but also pose such a nuisance that they have caused school closures. Dengue transmission can also be associated with poor solid waste management practices, as the vector (*Aedes aegypti*) may breed in any containers which collect water. Rodents, which also find excellent breeding grounds at poorly managed disposal sites, are a potential threat to public health and pose a problem for farmers in countries such as Barbados[38] and Montserrat. [41]

Present Situation

Refuse collection coverage is relatively high in urban areas in the Caribbean but significantly less so in rural areas, where road conditions tend to be poor and the communities are widely scattered. Management of the solid waste that is collected remains a problem for most rural communities and all urban areas in the Commonwealth Caribbean. In most territories solid waste management receives low priority in the competition with other national needs, and there is often no clear set of central policies to guide operating agencies.[42]

Lack of planning manifests itself throughout the Caribbean in poor disposal site selection; poor equipment selection; lack of adequate short-, medium-, and long-range financing; and shortfalls in equipment and/or management techniques.[42] Generally speaking, many of the agencies involved in solid waste collection and disposal are not well prepared to perform the operating functions connected with these activities, in that they do not own heavy equipment and are often short on technically trained personnel.

In contrast to the water supply and sanitation sector during the IDWSSD, the solid waste sector has not articulated specific goals in the Caribbean. The CCH established a goal that "by 1995, each country should have developed a solid waste management plan to ensure that, without posing an environmental health hazard, solid waste produced by any source in the country is safely disposed of and should have adopted suitable measures for solid waste disposal in urban, rural and isolated communities. . . ."[10] Although this goal has not been achieved, the countries are moving towards it.

OECS Countries. Solid waste management is generally the responsibility of the Ministry of Health in the countries of the Organization of Eastern Caribbean States, where emphasis is currently being placed on how waste can be more effectively and efficiently collected, transported, and managed at waste disposal facilities.[43]

Each OECS country is served by a number of waste disposal sites, both official and unofficial. Typically, the waste disposal system is comprised of one large site serving the major urban centre and a number of smaller sites serving the towns and villages. These sites are often inappropriately situated, particularly with regard to local environmental conditions, and staffing and operations are poor. Environmental controls have generally not been incorporated into the design of existing waste disposal facilities, resulting in the occurrence of leachate and landfill gas.

Odour, dust, flies, and litter are problems at these waste disposal sites, and burning of waste on-site is a common practice. Smoke from this activity has a significant impact on adjacent areas, which may include land used for a variety of activities. Entry to most sites is unrestricted and scavenging is common.[43]

Municipalities play a central role in waste collection in the OECS countries. Urban residential wastes are usually collected by the municipality directly and sometimes by private contractors. Arrangements vary in rural areas; municipalities may handle waste collection, but in most cases waste is disposed of by individual residents ("self-haul"). Curbside collection is favoured in many countries, although communal or neighbourhood depots are also common. Industrial, commercial, and institutional waste is also handled either by municipalities or by private contractors. Agricultural wastes are believed to be either disposed of on-site or self-hauled to a waste disposal site.[43]

Larger Caribbean Countries. In Jamaica and Guyana, urban solid waste management is primarily a local government responsibility. However, in Barbados, this responsibility has been given to the Sanitation Services Authority (SSA), a statutory board oper-

ating under the aegis of the Ministry of Health. The Trinidad and Tobago Solid Waste Management Company, Limited, established in 1980, has specific responsibility for managing the collection, handling, treatment, and disposal of solid waste in Trinidad and Tobago.[44] Collection of waste is generally included as one of the responsibilities of the national boards, companies, or local government organizations responsible for solid waste management.

The waste disposal sites vary in size and quality. For example, the location of the site for Georgetown, Guyana, changes regularly because of limited available space in the Greater Georgetown area.[45] The landfill sites are generally small and located in lowland areas. Since the options are so limited and resources scarce, little attention is paid to environmental conditions. By comparison, in September 1992 Barbados opened a new landfill with a total area of 8.4 hectares. This landfill, located at Mangrove in the Pond, St. Thomas, is one of the first in the Caribbean to be fitted with a leacheate collection system, designed to limit or prevent contamination of subterranean aquifers.

The choice of sites and the poor operation of many of the landfills create potential sources of pollution for groundwater and coastal environments. Of the 25 actively utilized official disposal sites in Jamaica, 13 are near water bodies.[46] The largest landfill in Trinidad (Beetham) is located on the edge of the Caroni Swamp. The two landfill sites in Kingston are suspected of contributing to the pollution of both groundwater and Kingston Harbour.[46]

As in the OECS countries, waste disposal sites in the larger countries are plagued by odour, smoke, flies, and litter. However, the larger facilities for urban centres are generally better operated and access to the sites is usually more controlled than in the OECS.

Solid Waste Programmes

There is consensus that existing systems for the collection and disposal of waste in the OECS countries require significant upgrading, which has important financial, technical, and social implications.[43] On the other hand, some other Caribbean countries (e.g., Barbados, Trinidad and Tobago) are better off than most developing countries in terms of solid waste management.

The management of solid waste is being addressed in several countries with the assistance of international agencies such as the Inter-American Development Bank.[15] IDB projects have looked at education and the reduction, collection, recycling, reuse, and disposal of waste in the Bahamas, Barbados, and Jamaica,[12] and an urban rehabilitation programme in Guyana included solid waste management.

A number of specific initiatives are being undertaken to address solid waste management problems in the Caribbean. Among them are the Caribbean Environmental Health Institute/German Agency for Technical Cooperation (CEHI/GTZ) Environmental Health Improvement Project and the OECS Waste Management Project. The CEHI/GTZ Project, being executed under a CARICOM-GTZ grant, includes the entire Caribbean Community. Under this project, activities geared towards implementing high-impact measures, including solid waste management studies, have been undertaken in the British Virgin Islands, Dominica, Guyana, Saint Kitts and Nevis, and Saint Lucia.

The OECS Waste Management Project will tackle the problems of land- and ship-generated waste, will address major deficiencies in solid waste collection, treatment, and disposal, and will support institutional strengthening and rationalization measures in agencies concerned with environmental management. It will also seek to enhance the ability of regional and national organizations to monitor performance in the waste sector.[42]

Proposals have been made in many countries to upgrade waste disposal sites. In some cases plans call for reconfiguring and upgrading existing sites; in other instances one or more existing facilities are scheduled to be closed and another facility opened at a new location.[43]

In some countries (notably Dominica and Saint Lucia), regionalized waste management has been proposed as new sites become operational. Operations plans have been developed for new waste disposal capacity in Antigua and Barbuda, Dominica, Grenada, and Saint Lucia.

Although recycling is well established in many developing countries and is a proven strategy for reducing the problems associated with lack of infrastructure for collection and disposal of refuse, it still has not been adopted in most Caribbean countries. The Solid Waste Management Company in Trinidad and Tobago has managed to organize salvagers at the Beetham landfill site into a "co-op"; salvagers are given their own work areas on the compound of the landfill, and a brisk business in glass and plastic recycling takes place. However, this is not typical of other sites in the Caribbean.

The deficiencies in waste collection and management underscore the importance of basic sanitation programmes and projects that use simple technology,

encourage community involvement, and increase health education and awareness. Community education and health promotion activities can greatly improve sanitary solid waste disposal at the household level and also promote the appropriate storage of other waste prior to collection. However, the final disposal of solid waste is the responsibility of a private contractor or government agency with the engineering and management skills to ensure that the method of disposal is not itself a hazard to the health of the workers or people who live near the site.

Management and Handling of Hazardous/Toxic Wastes

Many industrial establishments and other facilities in the Caribbean, such as power plants, petroleum refineries, rum distilleries, and hospitals, produce toxic wastes, including sludge, oily residues, chemical solutions that contain many hazardous substances, and a wide range of solid materials.[47] Although it is estimated that between 1% and 4% of all industrial wastes are toxic, few facilities in the Caribbean recycle or safely eliminate hazardous wastes.

Final disposal practices for industrial hazardous wastes are generally rated as inadequate in the Caribbean,[47] increasing the risk of environmental degradation as well as potentially endangering the public's health. In some cases hospital and industrial wastes have reportedly been disposed of haphazardly in open dumps or in nearby drainage canals.[6] Disposal of chemicals such as pesticides is also creating problems in countries such as Guyana[39] and Barbados.[38] The current practice of disposing of these wastes along with safe wastes can no longer be tolerated, and the necessary measures to deal with this situation must be taken at national and regional levels.

A 1993 survey provided summaries of the hazardous waste produced by health care facilities from seven Caribbean countries: Anguilla, Barbados, Dominica, Guyana, Jamaica, Saint Lucia, and Trinidad and Tobago. It found that most countries were incinerating some of the waste. However, it was known that in the majority of the countries the incinerators were not functioning adequately, as they rarely reached the temperatures required for complete combustion.[47]

Substances such as lead, toluene, benzene, trichloroethylene, chloroform, phenol, PCBs, arsenic, cadmium, and chromium—all of which harm health after prolonged low-level exposure—can occur in toxic wastes.[8] Some of these substances can cause cancer, birth defects, and genetic damage. There is concern in the Caribbean about hidden exposures in circumstances where people are not aware of their contact with toxic substances.[47] However, few cases of chronic effects of exposure to hazardous wastes have been documented in the Caribbean, aside from the cases of lead poisoning previously mentioned.

An important aspect of the problem is the international transport of hazardous wastes from developed to developing countries, mainly handled by private enterprises. There have been attempts and proposals to unload and process hazardous wastes in such Caribbean countries as Antigua and Barbuda, Guyana, Haiti, and Montserrat. The international transport of hazardous and toxic wastes is covered under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. The convention provides a consensual regime for the trade of waste, requiring that the waste exporters receive written consent from an importing nation before any waste is shipped. In addition, many Caribbean states are also contracting parties to other international conventions that deal with this subject. Caribbean countries who are parties to the Lome IV Convention have committed to "ensure that international movements of hazardous wastes and radioactive wastes are generally controlled . . . ." Contracting parties are also required to expedite the adoption of the necessary national legislation and administrative regulations to implement this undertaking. Some Caribbean countries, as signatories to the Cartagena Convention (1983), have also agreed to take all necessary measures to prevent, reduce, and control pollution of the Wider Caribbean region. In addition, in August 1988, parties to that convention were urged to prohibit the importation and transfer of hazardous wastes in the region

The first CARICOM Ministerial Conference on the Environment, a meeting of 13 English-speaking Caribbean countries held in Port of Spain, Trinidad and Tobago, in 1989, resulted in the adoption of the Port of Spain Accord. Among the priority issues it highlighted were the management of toxic and hazardous substances, including the control of agrochemical residues and the dumping of extra-regional hazardous and toxic wastes in the region. The need to address these issues at both the national and regional levels was recognized.

As mentioned earlier, the CCH initiative, adopted by the CARICOM Ministers Responsible for Health in 1986, identifies environmental protection as one of its priority areas and includes the goal of "reducing health risks associated with environmental conditions through the promotion of environmental health pro-