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APPROPRIATE SANITATION AND INTEGRATED COASTAL MANAGEMENT: AN ECOLOGICALLY-BASED HUMAN WASTE TREATMENT SYSTEM FOR COASTAL SETTLEMENTS ON THE BAHIA DE NAVIDAD, JALISCO STATE, MEXICO

*Eugene C. Bricklemyer, Jr., Alfredo Tomas Ortega Ojeda, Cuauhtemoc Leon, Boris Graizbord, Richard Kyle Paisley**

The human body does not produce sewage.
– Uno Winblad, architect, town planner and international pioneer of the ecological sanitation movement.

EXECUTIVE SUMMARY

In this paper we present an overview of the global sanitation crisis and how it increasingly affects the planet's heavily populated coastal zone. We note that the scarcity of water in many nations that do not have adequate sanitation infrastructure will forever preclude their adoption of the Western standard. We investigate alternatives to, in our view, a vastly wasteful conventional flush-and-discharge system, and how better engineered solutions can save water, enrich soil and contribute to the mitigation of global warming. Finally, we describe how this technology is being used in an integrated coastal zone management project on Mexico's Pacific Coast in an effort to protect the richness of the area's ocean bay and adjacent estuary, restore its freshwater lagoon and provide a model for other coastal areas likely to experience explosive tourism-generated growth in the future.

* This is the sixth in a series of six related papers appearing in this volume. For biographies of the individual authors of this paper, please see 9 Ocean & Coastal L.J. 174 (2004).

I. INTRODUCTION

Inadequate management of human excreta is the cause of severe and widespread public health and environmental problems throughout the world. Globally, discharges of raw or partially treated sewage constitute one of the major sources of pollution of coastal ecosystems and freshwater resources, leading to disease and adversely affecting local, regional and national economies.[1] The problem is particularly acute in the urban and peri-urban areas along the coasts of developing countries, which hold a dramatically increasing share of the world's population. In 2002, it was estimated that, of the world's 6.25 billion people, 2.6 billion – including fifty percent of the developing world's population – had no access to a toilet or even a decent pit latrine in an outhouse.[2] Even more striking, according to the executive director of the United Nations Children's Fund

1. UNITED NATIONS ENVIRONMENTAL PROGRAMME, GUIDELINES ON MUNICIPAL WASTEWATER MANAGEMENT V (2004), *available at* http://www.gpa.unep.org/documents/wastewater/Guidelines_Municipal_Wastewater_Mgnt%20version3.pdf (last visited Mar. 7, 2005). *See also* Albert M. Wright, *Toward a Strategic Sanitation Approach: Improving the Sustainability of Urban Sanitation in Developing Counties* at 2–4, *available at* http://www.wsp.org/publications/global_ssa.pdf (last visited Feb. 26, 2005). For U.S. perspectives, *see* PEW OCEANS COMMISSION, AMERICA'S LIVING OCEANS: CHARTING A COURSE FOR SEA CHANGE (2003), *available at* http://www.pewoceans.org (last visited Feb. 26, 2005); and U.S. COMMISSION ON OCEAN POLICY, AN OCEAN BLUEPRINT FOR THE 21ST CENTURY 22 (2004), *available at* http://www.oceancommission.gov/documents/welcome.html (last visited Feb. 26, 2005).

2. WORLD HEALTH ORGANIZATION (WHO) – UNITED NATIONS CHILDREN'S FUND (UNICEF), MEETING THE MDG DRINKING WATER AND SANITATION TARGET: A MID-TERM ASSESSMENT OF PROGRESS 12 (2004), *available at* www.who.int/water_sanitation_health/monitoring/en/jmp04.pdf (last visited September 28, 2004) [hereinafter WHO, MEETING THE MDG]. *See also* WORLD HEALTH ORGANIZATION, GLOBAL WATER SUPPLY AND SANITATION ASSESSMENT 2000 REPORT 1 (2000), *available at* www.who.int/docstore/water_sanitation_health/globassessment/Global1.htm (last visited Mar. 23, 2004). "At the beginning of 2000 one-sixth (1.1 billion people) of the world's population was without access to improved water supply and two-fifths (2.4 billion people) lacked access to improved sanitation." *Id. See also* WATER AND SANITATION PROGRAM, WORLD BANK, COMMUNITY WATER SUPPLY AND SANITATION CONFERENCE 3 (Sept. 1998), *available at* http://www.wsp.org/publications/global_proceedings.pdf (last visited Apr. 16, 2004). WORLD HEALTH ORGANIZATION, ENVIRONMENTAL SANITATION, WATER AND SANITATION, *available at* www.who.int/docstore/water_sanitationhealth/Environmental_sanit/ environmental_sanitation_2.htm (last visited Mar. 23, 2004). Eight years ago, the WHO had estimated that three billion people lacked even the most basic sanitation. WORLD HEALTH ORGANIZATION, CREATING HEALTHY CITIES IN THE 21ST CENTURY, BACKGROUND PAPER, UNITED NATIONS CONFERENCE ON HUMAN SETTLEMENTS, (1996), *available at* http://whqlibdoc.who.int/hq/1996/WHO_EOS_96.9.pdf (last visited Apr. 14, 2004) [hereinafter WHO, CREATING HEALTHY CITIES].

(UNICEF), "[m]ore than 5,000 children die every day from diarrhoeal diseases."[3]

The best way to solve these problems is for governments to invest more in the abundance and security of clean water and sanitation systems, and to do it in a way that empowers local communities to respect their drinking water and sanitation systems. In September 2000, in light of a number of pressing worldwide development problems like those associated with clean water and appropriate sanitation, 189 countries came together at the United Nations and dedicated themselves to accomplishing eight Millennium Development Goals (MDGs) within a given time frame. Goal seven, to ensure environmental sustainability, had as one of its targets to halve by 2015 the number of people without sustainable access to safe drinking water and basic sanitation. In a recently published mid-term assessment of progress, the Joint Monitoring Programme on Water Supply and Sanitation notes that in 1990 (the baseline year for MDGs), 2.7 billion people lived without improved sanitation. Although more than a billion people gained coverage by 2002 (the midpoint in reaching the target), due to population growth, the total number of people without sanitation only declined by 100 million to 2.6 billion. The task is immense.[4]

With the exception of relatively few rich countries fortunate enough to have abundant water resources, conventional sanitation approaches have not adequately addressed the problem for much of the world's population. The magnitude of the numbers of unserved, the lack of financial and technical resources, and the current or impending scarcity of water in many regions converge to necessitate that effective alternatives must be developed and implemented.

A radically new approach to excreta management is needed if we are to solve this most fundamental challenge. Rather than aspiring to follow the "Western" model by creating sewage through the addition of water for transport and then attempting to treat or dispose of it, appropriate, ecologically-based sanitation presents a technology whose time has come. It would safeguard public health and prevent pollution by using affordable, low-technology means to destroy pathogens and reuse excreta as a resource without mixing human waste and fresh water. To be appropriate, such sanitation systems must:

· Not waste fresh water resources;

3. United Nations News Service, *Poor Sanitation a Huge Killer of Children, UNICEF Says on World Water Day* (Mar. 22, 2004), *available at* http://www.un.org/apps/news/storyAr.asp?NewsID=10157&Cr=water&Cr1= (last visited June 23, 2004).

4. United Nations, *Millennium Indicators Database: Goals, Targets, and Indicators, available at* http://millenniumindicators.un.org/unsd/mi/mi_goals.asp (last visited June 23, 2004); WHO, MEETING THE MDG, *supra* note 2 at 15, 17.

- Prevent the transmission of disease;
- Be non-polluting;
- Recover excreta as a resource;
- Be simple;
- Be affordable;
- Be culturally acceptable; and
- Be aesthetically pleasing.

Michael Rouse, the current President of the International Water Association and former head of Great Britain's drinking water inspectorate, goes further in advocating for reforming sanitation practices. In March 2003, prior to presentations at the Third World Water Summit in Kyoto, Japan, Mr. Rouse stated that "'[i]f we started sanitation again from scratch in Britain, we would not do it the way we do now. . . . Instead of flushing and piping all the waste away, we would collect the solids once a week like household rubbish, take it to a central depot and compost it. Eventually it would be used as fertilizer.'"[5] Those like Mr. Rouse believe that if a fundamental shift away from expensive water and pipe schemes to simpler methods is not adopted in many regions, the Millennium Goal of halving the number of people without access to safe drinking water by 2015 cannot be achieved.[6]

Beyond addressing the wasteful use of water, pollution, and health problems directly associated with inadequate excreta management, we first note that the vision of appropriate sanitation includes harnessing the benefits that result from the restoration of nutrient cycles through the reuse of human excreta as fertilizer. Current agricultural and sanitation practices are linear. They transport nutrients from rural soils, where the food is grown, to urban areas where it is consumed and where the resulting waste products are discharged as pollutants into fresh and coastal waters. In contrast, by avoiding the mixing of human wastes with water for out-of-sight, out-of-mind transport, an ecologically appropriate sanitation system is cyclical, reclaiming excreta as fertilizer and, thus, ultimately returning

5. Paul Brown, *World Sewage Plans "Should Be Abandoned,"* THE GUARDIAN, Mar. 10, 2003, *available at* http://www.guardian.co.uk/international/story/0,3604,910998,00.html (last visited June 24, 2004).

6. According to Mr. Rouse, the target of providing 140,000 new people every day with appropriate sanitation services is impossible to meet through traditional approaches. *Id.* Note that while between the years 1990 and 2002 there were only 100 million fewer people who did not have improved sanitation, WHO/UNICEF found that to meet the MDGs, "[t]he population without [sanitation] coverage will need to decrease from 2.6 billion people in 2002 to 1.9 billion in 2015, a total decline of 760 million people." WHO, MEETING THE MDG, *supra* note 2, at 17. Because of population growth, this means that by 2015 a billion new urban dwellers and almost 900 million people in rural areas will need to be served. *Id.*

significant resources to the soil. Furthermore, if practiced on a large scale, appropriate sanitation can help to restore degraded lands that are often the cause of migration to urban areas in the first place, thereby having the indirect effect of decreasing many other urban problems. Finally, there is even the potential prospect that, if implemented as part of a broader program of science-based soil management, the reuse of excretal nutrients could potentially play a significant role in mitigating the greenhouse effect by enhancing the soil's ability to store carbon.

The concept of integrated coastal management (ICM) programs is discussed in several papers contained in this collection of works.[7] For that reason, only a brief summary of the theory is given here. To accomplish sustainable management, the general conclusion appears to be that all levels of societal governance must be engaged fully in the development, implementation, monitoring and enforcement of any program that tries to conserve and manage coastal activities. Most important in this regard is local citizen involvement. In this paper, we will explore the development of just such a model that involves a bay – Bahia de Navidad, an estuary – Albufera Barra de Navidad, a freshwater lagoon – Laguna de Tule, and the towns of San Patricio-Melaque, Barra de Navidad, Jaluco and Villa Obregon, all located midway down the Pacific coast of Mexico in Jalisco State.

II. SANITATION

A. A Failed Technology

The conventional Western flush-and-discharge system for treating and disposing of human waste is fatally flawed. Consider that an average person produces 105.6 to 132 gallons of urine and 13.2 gallons of feces annually and that the waste is flushed away with 3,960 to 6,072 gallons of clean water. In the United States, which has the highest estimated use, it was estimated that 1,615,590 gallons of drinking water were flushed in

7. See Eugene C. Bricklemyer, Jr., et al., *Preservation of Coastal Spaces: A Dialogue - The Oregon Experience with Integrated Land Use Management*, 9 OCEAN & COASTAL L.J. 137 (2004) [hereinafter Bricklemyer]; Cuauhtemoc Leon, et al., *Challenges for Managing the North American Coastal Zone*, 9 OCEAN & COASTAL L.J. 279 (2004).

2000.[8] This process produces what is known as blackwater. In addition to blackwater, which composes approximately forty percent of in-home water use, the conventional model must also process grey water generated from kitchen and bathroom sinks, tubs, showers and laundry. Grey water composes approximately sixty percent of in-home water use.[9] Grey water may add up to another 3,960 to 7,920 gallons per person annually.[10] In the United States, the average in-home water use averages between 100 and 175 gallons per person, per day,[11] and almost all of that goes down the drain and into the sewage system. In the best case, at the end of this sewage pipeline system is a waste treatment plant.

The other widely relied upon option is the septic tank system, also used in the United States and other industrialized nations. Here, combined blackwater and grey water from a residence is piped to a below-ground holding tank (usually concrete) located near the residence. The liquid is drained off into the adjacent soil using perforated pipes laid in a pattern in the "drain field." The sludge accumulates in the anaerobic environment in the tank and must be periodically pumped out and manually carried away. For numerous reasons, this is not a desirable environmental solution. Two immediately apparent reasons are problems associated with the improper placement of such systems, whereby drain field liquid pollutes wells, and improper disposal of the resultant sludge.

Such profligate waste management makes even less sense in the face of severe droughts all over the world. For example, during the spring of 2002,

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8. DAVID DEL PORTO & CAROL STEINFELD, THE COMPOSTING TOILET SYSTEM BOOK: A PRACTICAL GUIDE TO CHOOSING, PLANNING AND MAINTAINING COMPOSTING TOILET SYSTEMS 1 (The Center for Ecological Pollution Prevention 2000); STEVEN A. ESREY ET AL., ECOLOGICAL SANITATION 2 (Uno Winblad ed., Swedish International Development Agency 1998). This latter useful primer has been revised. *See* UNO WINBLAD ET AL., ECOLOGICAL SANITATION (2004), *available at* http://www.ecosanres.org/PDF%20files/Ecological%20Sanitation%202004.pdf (last visited Feb. 28, 2005).

9. PAT COSTNER ET AL., WE ALL LIVE DOWNSTREAM: A GUIDE TO WASTE WATER TREATMENT THAT STOPS WATER POLLUTION 47 (The National Water Center 1987).

10. ESREY ET. AL., *supra* note 8. Adding to ultimate treatment and disposal problems is the fact that this domestic waste stream is usually joined by rainwater from streets (via storm sewers) and liquid discharges from industry.

11. ROBERT ENGELMAN & PAMELA LEROY, SUSTAINING WATER: POPULATION AND THE FUTURE OF RENEWABLE WATER SUPPLIES 15 (1993). For a frame of reference, the United States Geological Survey reports that in 2000 the U.S. withdrew 408 billion gallons of water per day for all users, over 3/4 of which was supplied to thermoelectric plants (both fresh water and salt water) and irrigation (the largest fresh water users at 137 billion gallons per day). U.S. GEOLOGICAL SURVEY, ESTIMATED USE OF WATER IN THE UNITED STATES IN 2000 (2004), *available at* http://water.usgs.gov/pubs/circ/2004/circ1268/ (last visited Sept. 21, 2004). Public water supplies used forty-three billion gallons per day and provided eighty-five percent of Americans with drinking water. *Id.* Domestic private wells withdrew 3,590 million gallons per day, supplying 43.5 million people with water. *Id.* The use has remained virtually the same since 1985. *Id.*

the entire East Coast of the United States from Maine to Georgia suffered from a "severe" drought, with some Northeastern states classified as being in a "drought emergency."[12] In Mexico City, which uses groundwater for approximately eighty percent of its freshwater supply, a combination of less rainfall, more people to supply and increased levels of waste attributable to dilapidated infrastructure has meant that pumping exceeds recharge rates by between fifty and eighty percent.[13]

While this paper's objective is to focus on the opportunity to foster a new paradigm in Mexico, the reality is that there has been a failure to appropriately manage human wastes in all of North America. Vermont, for example, has experienced significant problems with sewage management, including failing and failed septic systems, outdated or poorly operated public treatment plants and water pollution.[14]

It is estimated by the Vermont Agency of Natural Resources that fully one-half of Vermont's population uses septic systems, and seventy-five percent of the population gets its drinking supply from groundwater. A significant portion of those citizens get their water from the 70,000 to 80,000 private wells in the state, as many as four-fifths of which have never been tested for potability. In addition to the problems that these statistics bring to mind, it is estimated that at least a dozen small villages and parts of towns in Vermont still dump raw sewage into rivers and lakes. In Vermont's most rural areas, fixing the problem in the traditional way – building or connecting to publicly-owned treatment works – can be exorbitantly expensive.

Unfortunately, even when there is a waste treatment plant, problems with technology continue. For example, Shoreham, Vermont, has a new plant, but it will not be able to remove phosphorous, a questionable short-term cost-savings decision that could lead to oxygen depletion in receiving waters through the promotion of aquatic plant growth. Other examples abound. Fairhaven contaminates the Castleton River because its treatment plant's pump station often overflows; Poultney contaminates the Poultney River because of periodic plant overflows; and Vergennes contaminates lower Otter Creek because of periodic overflows at treatment plant lagoons.

Thus, Vermont's difficulties demonstrate not only that waste treatment plants are expensive, but also that constant, costly maintenance is required if the facilities are to perform properly. Then there is the question of what

12. Drought emergency classifications indicate serious water shortages. They often result in stringent controls on water usage.

13. SANDRA POSTEL, LAST OASIS: FACING WATER SCARCITY 150 (Linda Starke ed., W.W. Norton & Co. 1992).

14. *See generally* Nancy Bazilchuk, *Vermont Struggles With Sewage*, BURLINGTON FREE PRESS, Dec. 17, 2000, at 1A.

to do with sludge. Because waste treatment plants are usually domestic/urban/industrial systems, the mixture of effluents found within them are often highly toxic and laden with heavy metals and other undesirable elements.

Faced with these difficulties, much of the world has taken the seemingly easier approach: no end-of-pipe treatment at all. Over ninety percent of all the sewage in the developing world is discharged completely untreated. In Latin America the figure is ninety-eight percent.[15] In Costa Rica, with its "green" image, less than five percent is effectively treated.[16] Even in the United States, treatment plants too often fail. As noted above in the case of Vermont, as well as elsewhere, commercially and recreationally important water bodies are polluted by faulty septic systems.[17] And in at least one affluent, northern North American city, the waste is inadequately treated as a matter of course. In Victoria, British Columbia's capital city, a steady stream of between 30,250,000 to 45,000,000 gallons of primary-treated wastewater (only solids are removed) is discharged daily into the Strait of Juan de Fuca.[18]

B. Coastal Zone Pollution

The coast, an environmentally complex, diverse and always striking land and water interface, is suffering from a growing burden from humans. Figures vary, but it is generally accepted that between sixty and seventy-five percent of the world's population lives within approximately thirty-five

15. John Briscoe & Andrew Steer, *New Approaches to Sanitation – A Process of Structural Learning*, 22 AMBIO 456, 456–57 (1993).

16. Interview by Eugene C. Bricklemyer, Jr. with Arce Guillermo, Director, Division Obras por Administracion, Aqua y Acueducto, Costa Rica, in San Jose, Costa Rica (Oct. 25, 1996) [hereinafter Interview with Arce Guillermo].

17. Hood Canal, part of Washington State's renowned Puget Sound, is suffering from slow suffocation due to severe oxygen depletion. This year alone, hundreds of thousands of fish, shellfish and other marine life have washed ashore dead, forcing state agencies to curtail fishing on several occasions. It is estimated that human activities discharge between 100 and 300 tons of nitrogen into the canal each year. Nitrogen and other polluting nutrients feed algae blooms then leave insufficient oxygen for the fish. A main culprit of this phenomenon is the leaking and fully failed septic systems of the canal's many inhabitants. More troubling is the fact that the state does not even know how many systems need replacing or how much alternatives to septic systems would cost. *See* Puget Sound Action Team, *Hood Canal is Slowly Suffocating*, SOUND WAVES, Summer 2004, at 1, *available at* http://www.psat.wa.gov/Publications/soundwaves/archive_sw/sw_summer_04_rev.pdf; Janet Huck, *Bottom Fishing Closure Hits Hood Canal Again*, PORT TOWNSEND & JEFFERSON COUNTY LEADER (WA), Feb. 18, 2004, at A2; *Hood Canal Needs Oxygen*, PORT TOWNSEND & JEFFERSON COUNTY LEADER (WA), Feb. 11, 2004, at A9.

18. CAPITAL REGIONAL DISTRICT, CORE AREA LIQUID WASTE MANAGEMENT PLAN, ch. 5 (2000), *available at* http://www.crd.bc.ca/es/lwmp/index.htm (last visited Feb. 28, 2005).

miles of the coast, and eighteen of the world's twenty-five largest cities are in close proximity to the coast.[19]

In the United States, where forty-three percent of the population lives in coastal counties on only sixteen percent of the nation's land, coastal densities are seven times greater than in the rest of the country.[20] In Mexico, 1995 figures indicate that twenty-nine percent of the population lives in the country's seventeen coastal states.[21] Everywhere, the growth of coastal communities continues.

In the developing world, the universal lure of the coast is heightened by the actual and perceived urban employment opportunities and increasing agricultural failures in rural areas. Coastal cities in these countries have been unable to handle the task of dealing with basic infrastructure needs. The resulting failures, especially with respect to sanitation, further jeopardize valuable coastal ecosystems that provide jobs and food through fisheries, transportation and tourism.

The situation of growing coastal populations and the problems associated with sewage pollution is not relegated to the developing world. The U.S. Department of Commerce's National Ocean Service (NOS) recently released a national eutrophication report, detailing the effects of nutrient enrichment in U.S. estuaries. Eutrophication is the process whereby nutrients – primarily nitrogen and phosphorus – stimulate algal growth when added to a water body. The NOS study took five years to complete and surveyed 138 estuaries representing over ninety percent of the estuarine surface of the contiguous United States in addition to the Mississippi River Plume.[22]

The work, concluded in 1999, indicated that almost all U.S. estuaries are now receiving inputs at many times the rate that occurred before the surveyed landforms were modified and developed. Over sixty-five percent of the estuarine surface exhibited moderate to high expressions of eutrophic conditions; and sixty-seven percent exhibited moderate or high levels of at least one of the following symptoms: depleted dissolved oxygen, loss of submerged vegetation and nuisance/toxic algal blooms.[23] Half of the estuaries were identified as being less available to a multitude of human

19. Sanitation Connection, *Coastal Settlements*, *available at* www.sanicon.net/themes/intro.php3?theme=20 (last visited Apr. 5, 2004).

20. *See* National Oceanic and Atmospheric Administration, U.S. Department of Commerce, TURNING THE TIDE: AMERICA'S COASTS AT A CROSSROADS, CD-ROM (1997).

21. Leon, et al., *supra* note 7.

22. *See* S. B. BRICKER ET AL., U.S. DEPARTMENT OF COMMERCE, NATIONAL ESTUARINE EUTROPHICATION ASSESSMENT: EFFECTS OF NUTRIENT ENRICHMENT IN THE NATION'S ESTUARIES (1999), *available at* http://spo.nos.noaa.gov/projects/cads/nees/Eutro_Report.pdf (last visited Sept. 23, 2004).

23. *Id.* at iv.

uses due to eutrophication.[24] Such uses included impaired opportunities for recreation and commercial fishing; shellfish and fish consumption; and swimming, boating, aesthetic appreciation, and tourism. The pollution also resulted in a loss of submerged aquatic vegetation, bottom habitat, and assimilative capacity. The point and non-point source discharges judged most important for nutrient management included "wastewater treatment, combined sewer outflow, and on-site waste disposal such as septic systems."[25]

A recent study of Mexico's coastal areas found similar cases of pollution and degradation from human activities.[26] Such degradation was worse near big cities and industrialized locations and often included, along with a soup of chemicals, pollution levels of fecal coliform bacteria and other indicators of human excreta in excess of legal limits.[27]

In all cases, the cost of sanitation-related pollution must be considered, and analyses must factor in lost productivity capacity due to death, lost workdays during sickness, school days missed and education foregone, and compromised long-term health. Consider that in 1996 the World Health Organization (WHO) concluded that 3.3 million people die annually from diarrhea, of which 2.5 million are infants and young children.[28] Also, 1.5 billion people are infected with intestinal worms from fecal-oral contamination.[29] Recent studies estimate that by 2020, if our attention to these matters does not improve, 135 million people will have died from preventable water-related disease.[30]

In sum, from the available data we can conclude that:

1. Two-thirds of the world's population lives on the coast;
2. Of the world's twenty-five largest cities, eighteen are on the coast;

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24. *Id.*

25. *Id.* at 61. The other activities listed include industrial discharge, large animal operation, urban runoff, agriculture, forestry practices, rangeland use, atmospheric inputs, and aquaculture.

26. *See* Instituto Nacional de Ecologia SEMARNAT, *La Calidad del Agua en los Ecosistemas Costeros de Mexico* (2000), *available at* http://www.ine.gob.mx/ueajei/publicaciones/consultaPublicacion.html?id_pub=308&id_tema=4&dir=Consultas (last visited June 12, 2004).

27. *Id.*

28. WHO, CREATING HEALTHY CITIES, *supra* note 2.

29. *Id.*

30. PETER GLEICK, PACIFIC INSTITUTE FOR STUDIES IN DEVELOPMENT, ENVIRONMENT, AND SECURITY, DIRTY WATER: ESTIMATED DEATHS FROM WATER-RELATED DISEASE 2000–2020 (August 15, 2002), *available at* http://www.pacinst.org/reports/water_related_deaths/ water_related_deaths_report.pdf (last visited Apr. 11, 2004).

3. Of the twenty-three mega-cities (over ten million inhabitants), eighteen are in the developing world and over the next twenty-five years, virtually all of the world's population growth will occur in such cities;[31]

4. In 1996, about forty-five percent of the world's population was living in cities and thirty-seven percent of those urban dwellers were without sanitation;[32]

5. Today, at least 2.6 billion people have no improved sanitation facility, including half of the developing world;[33]

6. According to the WHO, "despite all the efforts made, about 66% of the world's population has no access to safe excreta disposal;"[34]

7. What may have been marginally acceptable sanitation practices in rural inland areas in the developing world (*e.g.*, going *al aire libre*) will not work in densely populated urban coastal areas;

8. The informal settlements adjacent to, and a part of, many large coastal cities in the developing world, even if legitimized, will be highly unlikely to get conventional, expensive, first-world sanitation systems that work; and

9. Coastal ecosystems are economically important and ecologically fragile and therefore highly susceptible to degradation by pollution.

So where does this leave us? As we have seen, the flush-and-discharge system is not working effectively. It is wasting ever-more-scarce water and nutrients, and it is polluting the coastlines of the world. Coastal populations are rapidly growing at a rate that leaves hundreds of millions without safe sanitation facilities. Finally, the impoverished masses in informal settlements will never get a flush-and-discharge treatment system.

A WHO website summarizes at least part of the problem. According to the WHO, "[u]rban wastewater discharges are considered to be one of the

31. MAGGIE BLACK, WATERAID, MEGA-SLUMS: THE COMING SANITARY CRISIS 1 (1994); *See also* Press Release, United Nations, Cities Have Crucial Contribution to Make to Rural Development Says Secretary General in World Habitat Day Message (Sept. 29, 2004), *available at* http://www.un.org/news/press/docs/2004/sgsm9508.doc.htm (last visited Oct. 4, 2004).

32. WHO, CREATING HEALTHY CITIES, *supra* note 2. The United Nations Human Settlement Programme (UN-HABITAT) estimates that number will increase to sixty percent by 2015. UN-HABITAT, WORLD HABITAT DAY 11 (2004), *available at* http://www.unhabitat.org/whd/2004/documents/whd/2004brochure.doc (last visited Oct. 4, 2004).

33. *See* WHO, MEETING THE MDG, *supra* note 2, at 1.

34. WHO, ENVIRONMENTAL SANITATION, WATER AND SANITATION, *supra* note 2.

most significant threats to sustainable coastal developments worldwide."[35] What the WHO leaves unsaid, however, is how many times that threat is multiplied by the pollution that invades coastal waters when there is no wastewater, only waste, because no treatment facility has been constructed for the purpose of disposing human excreta. As we will show, the solution to these problems – appropriate, ecologically-based, culturally aware sanitation – requires an entirely new way of dealing with human waste.

C. Appropriate, Ecologically-Based Sanitation

To water that which is from water and to soil that which is from soil.
— Cesar Anorve, a leader in ecological sanitation efforts in Mexico

1. Principles

An appropriate sanitation system must be founded on three principals: (1) prevention of pollution and disease; (2) sustainability in design and operation; and (3) equity of services to all genders and socio-economic classes. After educating the public about appropriate sanitation, public officials in the developing world must devise a sanitation plan that takes into account the unique requirements of the population to be served. These public interactions must specifically include women, who are most often the water gatherers, who typically run household affairs, and who usually care for the children. If we analyze the current Western model of flush-and-discharge treatment, we find it meets none of the following requirements for a successful, ecologically-based sanitation system:

> *Prevention*: Unless well designed and operated at maximum efficiency, sewage systems take disease containing effluent away from the production site by diluting it and then ultimately dispersing it back into the environment.
>
> *Sustainability*: At the onset and for maintenance, sewage is water dependent and capital intensive, and treatment is technically complicated and thus often unlikely to be sustainable in the long term, especially in developing countries.
>
> *Equity*: Sewage systems are usually available in wealthier countries or for privileged segments of society. In water-scarce regions, inefficient sewage systems allow the wealthy minority to waste fresh water badly needed by the poor.[36]

35. Sanitation Connection, *Coastal Settlements*, *supra* note 19.
36. M. SIMPSON-HEBERT, SANITATION MYTHS: OBSTACLES TO PROGRESS? *in* Appendix

In the discussion that follows, a range of solutions, past, present and future, are explored. The discussion here is intended to be a summary as opposed to an exhaustive analysis.[37] For billions of people, past and present sanitation methods have involved defecation on the ground and in streams or in shallow holes ("unimproved privies"). It is, however, also important to note that our necessary evacuations have been viewed as a resource in some societies for thousands of years. For instance, inhabitants of Asian countries have long collected human and animal excreta and deposited it directly onto their fields, thus the poignant image of the "honey bucket" in traditional China.

The next step up, the most primitive of improved sanitation facilities, is an unlined, hand-dug covered pit or latrine, our "outhouse." This drop-and-store method has no ventilation and mixes urine and feces. It is anaerobic, meaning that it breaks down slowly in the absence of oxygen; it smells; it is toxic and prone to pollute groundwater and wells; and when it rains and overflows, it can pollute the earth's surface and surface waters.[38] When such facilities are full, they are covered and others dug. A third alternative when there is no water piped to a toilet is the pour-flush system. Such systems often discharge sewage via pipe to streams or other water bodies or onto the surface of the ground.

Lastly, septic tanks, which are often used in developed and developing countries, may be better than the 19th Century open cesspools, but they waste water and resources and usually perform well below their design characteristics. Both pour-flush and conventional flush toilets can be drained into a septic tank. The septic tank is often no more than a glorified pit, although its sludge is contained, because its drain field assures that contaminated waters from the anaerobic mix will flow into the adjacent soil

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A. Water Supply and Sanitation Collaborative Council Working Group on Sanitation 52 (WHO ed., 1996). As to sustainability, the sheer cost of continuing on as in the past seems unsustainable. The new WHO/UNICEF mid-term report estimates that it will cost $11.3 billion U.S. dollars annually to meet the MDGs for safe water and improved sanitation (which still leaves billions without either). WHO, MEETING THE MDG, *supra* note 2, at 20. Finally, to the concepts noted here as well as our initial, introductory ones, the leading authority in the field of ecological sanitation adds that a first principle is "Don't mix." Do not mix human urine and feces; human excreta and water; blackwater and grey water; household wastes and industrial wastes; or wastewater and rainwater. UNO WINBLAD, TOWARDS AN ECOLOGICAL APPROACH TO SANITATION 13 (Sida Publications on Water Resources: No.5, 1997) [hereinafter Towards An Ecological Approach].

37. The last several years have seen publication of three well thought out and readily available books on the subject. *See* ESREY ET AL. *supra* note 8; WINBLAD ET AL., *supra* note 8; and DEL PORTO & STEINFELD, *supra* note 8.

38. Dave Rapaport, *Aerobic Composting Toilets for Tropical Environments*, BIOCYCLE, 77-78, July 1996. For a study of groundwater pollution from pit toilets *see* T. A. Stenstrom, *Water Microbiology for the 21st Century*, as reported in ESREY ET AL., *supra* note 8, at 3, 82 n.6.

and any adjacent water body. Performance failure of such systems is especially likely if, as is often the case, they are not pumped when full. And in developing countries, when septic tanks are evacuated, pump trucks may easily, and often do, empty their loads into the nearest stream.[39]

If human excreta is to be most effectively and efficiently managed, it must be safely stored and relieved of its pathogens through either decomposition or dehydration. When properly carried out, these processes pollute no water and return resources to the soil.

2. Composition of Excreta

What exactly are the constituent components resulting from this most basic of human processes? Humans produce urine, normally 100 to 130 gallons a year for an adult. Urine is generally considered pathogen-free and sterile and contains about seventy percent of the plant nutrients available in excreta. These nutrients are mainly nitrogen, potassium and phosphorus, and are in forms that are ideal for plant assimilation as fertilizers. Furthermore, urine normally contains lower levels of heavy metals than commercial products. For purposes of resource conservation, urine should be diverted from – as opposed to mixed with and thus polluted by – feces.[40]

On average, humans also produce about thirteen gallons of feces annually. Feces contains undigested organic matter such as carbon fibrous material, small amounts of nitrogen, potassium and phosphorous, and pathogens. The latter include bacteria (for example, fecal coliform), viruses, protozoa and eggs of parasitic worms that live in the gastrointestinal tract. Numerous scientific studies have shown that these pathogens can all be effectively killed in the systems described below. The major conditions that are necessary, to varying degrees depending on the destruction process chosen, include time, temperature, moisture, nutrients, other organisms, sunlight and pH. Once the proper destruction processes are completed, it is then safe to use the resultant product for fertilizer (humus, if composted) or soil conditioner (mulch, if dehydrated). Both composting and dehydration result in products that can be used to increase the soil's organic matter content, its ability to retain water and store nutrients, and its receptivity to beneficial soil organisms.[41]

39. This is the case in Costa Rica. Interview with Arce Guillermo, *supra* note 16.

40. ESREY ET AL., *supra* note 8, at 17–18. Some authors state that urine contains up to ninety percent of the nutrients available in excreta. *See* DEL PORTO & STEINFELD, *supra* note 8, at 61. The effect of pharmaceuticals and personal care products on the usefulness of urine and feces has not yet been generally discussed in the literature.

41. ESREY ET AL., *supra* note 8, at 11–13, 18–19.

3. Composting: The Decomposition of Excreta

The composting toilet alternative – where organic material is converted to humus – requires more management. Urine is usually not diverted, but may be separated later with other excess liquids. Optimal conditions are achieved when sufficient oxygen is present to allow the excretal heap to remain aerobic; the moisture content is fifty and sixty percent; the carbon:nitrogen (C:N) balance is between 15:1 and 30:1; and the temperature in the composting vault is greater than 59°F. "Bulking agents," such as sawdust, chips, leaves, or grass, must be added to help achieve the C:N balance and absorb moisture. Manual or mechanical turning can add oxygen that speeds the process. Red earthworms (*e.g.*, *Lumbricus rubellus*) sometimes have been added and used effectively. Increasingly high temperatures aid in the destruction of pathogens, but such conditions are difficult to maintain in most designs.[42]

Composting designs were introduced half a century ago in Sweden, but these are expensive, costing up to several thousand U.S. dollars per unit. The model best known in North America is the "Clivus Multrum" single vault model, consisting of a large, below ground (*e.g.*, in-basement) unit. Early models were often likened to having a school bus body beneath the floor. The vault receives feces and urine from a bathroom opening equipped with a conventional-appearing riser and seat and receives kitchen wastes from a second opening. The unit's bottom is slanted, so there is a slow movement of material away from the in-house openings toward the removal door. The movement is normally so slow that by the time the pile gets to the end, it is reduced to ten percent of its original volume. The pile is then fully decomposed and the humus is safe to use.[43] Ventilation pipes assure that oxygen flows throughout the pile and any excess liquid is drained and held in a separate container. More modern versions of the composting concept include models that have a much smaller below-floor processor, one version of which has a larger, stationary outer drum and a smaller inner drum on a pivot. The inner drum has four or more compartments. One of the compartments is positioned below the bathroom drop hole and when it is full, the drum is rotated to the next compartment. By the time the last compartment is full, the first is safely composted and may be emptied. Urine is not diverted and is drained with other excess liquid

42. *Id.* at 33; DEL PORTO & STEINFELD, *supra* note 8, at 55.

43. It may be five years before an average household has to remove the first humus. ESREY ET AL., *supra* note 8, at 33. While opinions vary, it is safest to apply humus only to non-food crops or to crops that do not touch the earth, such as those from orchards (humus should always be buried at least six inches below the surface). DEL PORTO & STEINFELD, *supra* note 8, at 61.

into the lower drum. This liquid is then dealt with by evaporation or by piping it into an evapo-transpiration bed of flowers, rushes or bamboo.[44]

Greenpeace and the Centre for Clean Development (CCD) designed a much less expensive and low-tech composting device for the islands of the South Pacific.[45] The unit is stand-alone unit with superstructure. It consists of two impervious chambers built above grade. One chamber is used while the other is blocked. Feces is caught on an intermediate mat of woven palm fronds suspended in the chamber off the floor, assuring air penetration and thus keeping the pile aerobic. Bulking agents such as shredded coconut husks are added after each use. Exterior ventilation is added, bringing air out of the chamber through the roof. This ventilation aids in liquid evaporation, as urine is not diverted. Evapo-transpiration beds containing nonedible plants may also be used. When the first chamber is full, the seat riser is moved to the other chamber. By the time the second chamber is full, complete composting will have occurred in the first chamber. The humus then can be removed via a door in the rear, and the palm fronds can be replaced if necessary. A family of up to ten takes a year to fill a vault.[46] While this design is based on the double vault composting (DVC) toilets seen in many developed countries, the CCD model operates aerobically.[47] A major concern with anaerobic composting models such as the DVCs is that they may fail to fully kill all pathogens, especially if the residual time in the vault is short (*e.g.*, only several months).[48]

4. Dehydration of Excreta

A second major alternative to flush-and-discharge, and, based on research, the most effective method of pathogen destruction, is dehydration.[49] Dehydration is facilitated by urine diversion, which means the system produces not only mulch, but also generates urine for use as fertilizer.[50] Here, the idea is to reduce the level of moisture to below twenty-five percent as rapidly as possible, which deprives pathogens of their necessary humidity range of twenty-five to sixty percent. In addition

44. ESREY ET AL., *supra* note 8, at 33–36.
45. *Id.* at 39–40; Rapaport, *supra* note 38, at 77.
46. ESREY ET AL., *supra* note 8, at 40; Rapaport, *supra* note 38, at 77–82.
47. ESREY ET AL., *supra* note 8, at 40; Rapaport, *supra* note 38, at 77–82.
48. Rapaport, *supra* note 38, at 78.
49. ESREY ET AL., *supra* note 8, at 13. "Wet methods of disposal, like flush-and-discharge, are not particularly efficient at pathogen destruction. Wastewater is an ideal environment for pathogen survival because it mimics the intestine in many ways." *Id.*
50. *Id.*

to lack of moisture, alkalinity level and time are the next most important elements, followed by increased temperature.[51]

Dehydration is not new. For centuries villages in Yemen have used the method to manage waste. Several bathrooms can be found on the upper floors of some extended family homes in this hot, dry country. These houses are narrow stone and mud structures often five to nine stories tall. The toilets in each bathroom are laid out so that excreta drops down a long shaft to a ground level vault where it is dehydrated. Solids are then collected, dried further if necessary, and burned. Urine and washing water (Yemenites do not use toilet paper, but wash after defecation) are diverted and then directed out and down the often highly decorated exterior face of the building, evaporating during the journey. That which remains is diverted into a soak pit.[52]

Another example of long-established use of the dehydration comes from Ladakh, a high, dry region of India. Traditional Ladakhian houses, often consisting of several stories of mud or brick, usually have the toilet room on the second floor. The room is typically covered with soil, upon which excretions are made. The soil is then pushed through a hole and into a ground-level vault to dehydrate. Ashes from the kitchen are often added to aid in the dehydration process. Because the Ladakhian climate is so arid, there is no need to divert urine.[53]

Of the less primitive dehydration-based sanitation systems, the most ubiquitous, the Vietnamese double-vault dehydrating toilet, was developed in the 1960s by Dr. Nguyen Dan Dug. Traditionally, especially in northern Vietnam, fresh feces had been applied directly to rice fields, with the attendant spread of disease. As part of a health campaign, and furthered by the Vietnam War's effect on the supply of outside fertilizer, the Vietnamese double-vault toilet became widely used.

Because of generally low elevations, the Vietnamese double-vault toilet is built above ground on a slightly elevated base of cement or bricks in order to protect it from flooding. It has two chambers, a solid top platform covering the vaults with an opening for each vault. Footrests are provided for squatting defecation. There is a common urine diversion system that empties into a container. As only one vault is used at a time, the vault opening not being used is blocked off. A side opening at the rear of each vault allows access to dehydrated mulch. Before the initial use, sifted earth is spread over the floor to absorb feces moisture and to prevent sticking. After each use, ashes are sprinkled over the waste. When the chamber is two-thirds full (two months for a household of five to ten people), the heap

51. *Id.*
52. *Id.* at 30; Towards an Ecological Approach, *supra* note 36, at 8.
53. ESREY ET AL., *supra* note 8, at 32.

is leveled and the remaining space is filled with dirt. The vault is then sealed and the other vault is used. When the second vault is similarly full, the contents of the first vault are emptied and applied to fields. That chamber's drop hole is then unblocked and used again.[54] In the 1970s, hundreds of thousands of these rurally located toilets were producing over 600,000 tons of fertilizer annually.[55] This successful system has also been replicated and adapted for use around the world, especially in China, Mexico Central and South America.[56]

Slightly modified double-vault toilets were introduced in Guatemala in 1978, and thereafter in Mexico and El Salvadore.[57] As an added feature, these toilets have seat risers and seats. There is no tradition of using urine as fertilizer in Latin America, so these systems usually channel urine via a pipe to a soak pit under the toilet area. Sometimes these toilets are attached to the rear of the house, as is often the case in San Salvador, or placed inside the house, as is the case with some in Cuernavaca. In Cuernavaca, Cesar Anvore, an architect, entrepreneur, and advocate of dry toilets, has one in his own home. Anvore has developed and sells a moveable seat riser system that incorporates a successful urine diverter (UD).[58] In 2004, Anvore's design, made of polished cement, cost about $46 U.S.D. His more expensive fiberglass design cost about $105 U.S.D.[59]

With proper initial education and simple maintenance, these toilets are easy to use and inexpensive. The toilets continue to perform so well that, through word of mouth, more are requested and set up. Anvore has consistently encouraged other small manufacturers to replicate his product, and he sells a fiberglass mold to facilitate this. His design is so successful that it has recently been patented by a large for-profit corporation holding substantial Mexican government contracts to supply dry toilets with UDs throughout the country. However, it has been reported that these large programs generally have not been as successful as small-scale NGO projects because of a lack of initial and ongoing education and follow-up attention. Thus, while there are probably hundreds of thousands of dry toilets in Mexico alone, how many are in use and performing to acceptable standards is not known.[60]

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54. *Id.* at 21–22 (as the general residual time for effective dehydration is considered to be six months, some concern has been expressed about complete pathogen destruction in two months).

55. Rapaport, *supra* note 38, at 77.

56. WINBLAD ET AL., *supra* note 8, at 21.

57. ESREY ET AL., *supra* note 8, at 22–26.

58. *Id.*

59. WINBLAD ET AL., *supra* note 8, at 45.

60. E-mail correspondence by Eugene C. Bricklemyer, Jr., with Mahsa Hojjat, Centro de Innovacion en Technologia Alternativa, AC (CITA) (Nov. 27, 2001).

Higher-tech and higher-priced designs of dehydrating toilets are now also available. Such designs, pioneered in Scandinavia, are now also manufactured in the United States, Canada, Australia and elsewhere, and can cost as much as $1,700, a price that unfortunately puts them out of reach for many in the developing world. At least one such design made by BioLet in Sweden is marketed in the United States. The system treats waste that drops to a tray just beneath the toilet riser, the whole device sitting above the bathroom floor. A radiant heating element dries the feces and evaporates the urine, and a vent fan whisks any odor away through the roof.[61]

5. Grey Water

Notwithstanding the use of water-less excrement management systems, without sewers, grey water resulting from fresh water use in the kitchen and from the bathroom must be dealt with locally.[62] Grey water is usually free of pathogens, although there is concern over its role in the spread of Hepatitis. The easiest solutions at the individual household level for managing grey water include using it for plant irrigation and allowing it to evaporate through constructed gravel beds or more sophisticated (and expensive) infiltration systems. Depending on the locale, grey water can also be used to keep dust down on roads. One final fact about grey water should also be noted. In many of the places where there is no sanitation, there is also no running water piped inside homes or anywhere nearby. Thus, there is much less grey water to deal with in the first place. When you carry forty pounds of water in a five-gallon bucket any distance at all, you quickly respect its value and carefully conserve its use. Waste is not an option.

6. Better Carbon Cycling Benefits

One final benefit of large scale observance of appropriate sanitation practices relates to the possible use of collected urine and feces as soil enhancers. This is the point at which ecologically-based sanitation systems allow a sustainable circle to be completed, as the excreta can be reused at or near its point of origin. That appropriate sanitation can supply non-chemical fertilizer is clearly a benefit in its own right, but what is often overlooked is that, by enhancing the quality and fertility of the soil, the

61. BioLet USA, Inc., *available at* http://www.biolet.com (last visited Feb. 27, 2005).

62. When using grey water for irrigation, some reeducation may be necessary, as toxic household products (such as chlorine-containing cleansers or whiteners) washed down the drain could kill plants.

soil's ability to absorb CO_2 is increased. In so doing, the soil can decrease atmospheric amounts of a gas implicated in global warming. It is estimated that a modest doubling of the amount of carbon in non-forest soils, from the current low of one percent (brought about by global mismanagement of soils) to two percent occurring over the course of a 100-year span, would offset the concurrent increase of atmospheric carbon during that same period.[63]

III. ICM AND COMMUNITY PLANNING: A PROJECT IN MEXICO

The issues of sanitation and sustainable development of our oceans' coasts go hand-in-hand. Especially in the developing world, the need to come up with both an appropriate sanitation technology and an orderly process and program to put into place is mandatory if we are going to be successful in conserving this important land-water interface. We believe that the technology we have described in this paper is up to the task. To implement it into the field, this technology must become a critical part of a process called Integrated Coastal Management (ICM). As ICM is discussed in detail elsewhere in this series, the requirements for its successful use will be described only briefly here.

A. Summary of General Principles

In order to have a successful coastal conservation management regime at the state level, at least the following elements must be provided (with the sequencing of the first three occurring almost simultaneously):

1. A vision that formulates a plan for conservation and sustainable development.

2. A compilation of facts that assesses what natural resources exist and that determines what is occurring from a land use/demographic point of view. This will allow at least a preliminary assessment of potential short- and long-term changes and an estimate as to what significant natural and cultural environmental features could be lost if no action is taken.

3. An initial education program to provide an informed, supportive and involved electorate during the conversion of the general vision into a legislatively-mandated roadmap to guide conservation and growth.

63. ESREY ET AL., *supra* note 8, at 76. *See* Maurice Strong & Erik Arrhenius, *Closing Lineal Flows of Carbon Through a Sectoral Society: Diagnosis and Implementation*, 22 AMBIO 7, at 414–16 (1993.

4. A legal roadmap developed and passed by state legislatures mandating the use of comprehensive plans. The legislation should have statewide qualitative and quantitative standards and should require local implementation.

5. A strong, dedicated and adequately funded state management agency that is put in charge of coastal comprehensive planning and growth management and that will use its legislated power (and powers of persuasion) to assure that the law is enforced.

6. Locally drawn comprehensive plans that establish how the vision is specifically applied through land use regulations. This process must include mechanisms to encourage full community participation.

7. A review and approval process whereby the state management agency assures that initial local plans and any local amendments fit the roadmap and conducts periodic reviews.

8. A vigorous state and local government program for the acquisition of land for conservation that is supplemented by private land trusts. Such a program must provide a range of mechanisms that guarantee that sufficient and consistent funding will be available and set clear priorities for how those funds will be used.

9. A sophisticated and active NGO community composed of conservation and environmental groups that scrutinize government decisions.

10. An ongoing, innovative effort by the local authorities and the state management agency that keeps citizens interested and involved in the never-ending bureaucratic process necessary for costal conservation and sustainable development.[64]

In a report by the Pew Oceans Commission, Dana Beach, Executive Director of the South Carolina Coastal Conservation League and front-line activist, is more succinct: The way to successfully manage coastal development is to develop and implement a comprehensive, enforceable and enforced regulatory regime focused on using natural boundaries.[65]

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64. Bricklemyer *et al.*, *supra* note 7.

65. *See* DANA BEACH, PEW OCEANS COMMISSION, COASTAL SPRAWL: THE EFFECTS OF URBAN DESIGN ON AQUATIC ECOSYSTEMS IN THE UNITED STATES (2002), *available at* http://www.pewoceans. org/reports/water_pollution_sprawl.pdf (last visited Apr. 7, 2004). Dana Beach, a nationally respected leader in the quest to control inappropriate coastal development in South Carolina (a state suffering intense growth pressure on its once quite lovely Atlantic coast), is a great believer in the power of local/regional planning. He argues that the watershed should be used to delineate the area regulated by land use controls.

In Mexico, all of this is still a grand vision. The Mexican coastal zone has yet to be recognized as an area deserving of intense scrutiny and protection. Therefore, the use of multi-jurisdictional management, often required for watershed regulation, is some time away. But as to general environmental laws, Mark Spalding of the University of California at San Diego's Center for U.S.-Mexican Studies notes that "Mexico has rigorous environmental laws, which sometimes require more stringent ecological assessments than U.S. law [before development can occur]. . . . When it works, it's great. It also is frequently shelved and ignored."[66]

In addition to a strong, ecologically focused legal regime, wise local and regional decisions must be made as to where to constrain development and where to allow it to occur. All the information required to make these decisions may not be immediately available, but some initial regulation, restoration and conservation work can occur while this data is being gathered and compiled. In all cases, it must be made clear at the outset that no long term, overall success in ICM or sustainable development will result until these hard decisions are made.

To accomplish this, there must be a leader – someone who at least serves as a catalyst to get the program going. This person must challenge, involve and propel an engaged and participating citizenry as the community works through the many difficult choice-making processes upon which success depends.

B. An ICM Plan for Bahia de Navidad

1. Introduction

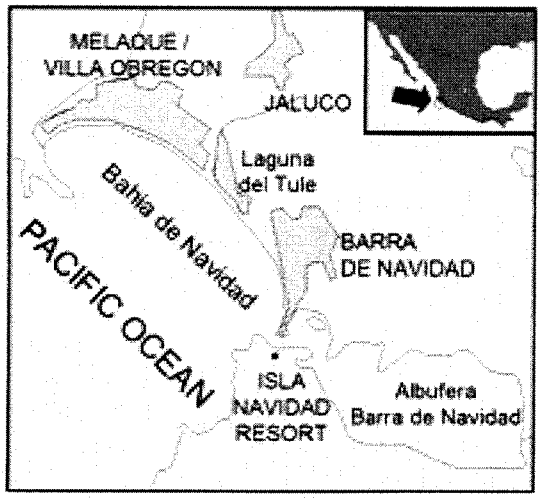
In a small group of rural villages on a Pacific bay in Jalisco State, Mexico, a visionary, local leader, an American NGO and the University of Guadalajara, in close cooperation with the regional municipality and a unique social council of key stakeholders, are partnering in an attempt to rectify a long-standing human waste problem and plan for the future. The long term goal is to create a model of sustainable development using principles of ICM that will help to create a watershed conservation ethic. The immediate goal is to stop sending untreated sewage into a fresh water lagoon, an adjacent estuary and the ocean bay.

Planning and growth decisions could then be made to appropriately conserve and sustainably develop the land within this geological unit. That would mean that local, county and state agencies would have to work in consort. Any federal involvement in the region's progress (*e.g.*, funding for transportation infrastructure) should have to recognize this plan.

66. Kenneth R. Weiss, *Baja's Great Leap*, SEATTLE TIMES, May 26, 2002, at A3.

In an Earth Day 2004 press release summarizing discussions underway within the United Nations on how to meet the Millennium Development Goals, Peter Kolsky, Senior Water and Sanitation Specialist at the World Bank, recommended that governments with scarce resources not create large sanitation facilities that they cannot afford. Instead, he recommended that they "should use funds as a lever to stimulate household demand and create conditions for local industry to meet that demand."[67] It is no happenstance that just such an approach has been adopted for all efforts in the Bahia de Navidad community described below. More importantly, however, in this case Bahia de Navidad residents are also invited to describe the problem and come up with preferred solutions, and this input will be fully incorporated into the final solution.

2. Geography



The Bahia de Navidad is a protected ocean bay located on the central Pacific coast of Mexico nearly midway between Mazatlan and Acapulco in Jalisco and Colima states. Its coastline measures approximately 2.5 miles between two rocky headlands. Its waters are rich in diverse marine wildlife that in turn supports large numbers of various species of birds. The weather is warm, on average 77°F, and the region gets sufficient rainfall to

67. Press Release, United Nations News Service, Water, Sanitation-Related Diseases Among Most Significant Global Health Problems, Sustainable Development Commission Told (Apr. 22, 2004), *available at* http://www.un.org/news/press/docs/2004/envdev768.doc.htm (last visited Sept. 22, 2004). Instead of situations of people using newly donated latrines as tool sheds and store rooms when sanitation solutions are provided from on high, Kolsky wants sustainable sanitation and suggested: "[C]ould somebody earn all or part of their livelihood out of it. If they could, then sanitation would happen, and would be sustained. If they could not, no efforts in sanitation could be sustainable by any sense of the word." *Id.*

grow agricultural crops on the nearby inland lowlands. Four watersheds flow into the bay. The physical space that it occupies, and that which it directly and indirectly influences, can be delineated in different ways according to many criteria, including oceanic, hydrological, ecological, and biological, but all such delineations must be considered in light of the social, demographic, political and cultural aspects of the four communities inhabiting the bay's watersheds. Bahia de Navidad is a complex system of human-natural environment interactions.

3. The Communities and the Natural Environment

The area has a number of small, connected towns unified as a municipality. It is subject to all the normal pressures of a community of 13,000 living on a tropical ocean coast in a rapidly developing part of the world. In the last thirty years, the main economic activity has shifted from agriculture and fishing to tourist services and commerce, which currently account for a little less than half of the economically active population. Recent growth combined with the urbanization process have had important social and environmental consequences.

The Laguna del Tule is a biologically rich fresh-water lagoon about one-half of a square mile in size immediately adjacent to the Pacific Ocean beaches of the sheltered Bahia de Navidad. It is also near a vital 2.3 square mile saltwater estuary, the Albufera Barra de Navidad, which enters the southern end of the bay. For the past twenty years, the coastal towns surrounding El Tule (mainly San Patricio-Melaque, Jaluco, Villa Obregon and Barra de Navidad, all part of the greater municipality of Cihuatlan) have used the lagoon for sewage disposal and have pumped in untreated human waste. This unnatural nutrient-rich effluent mix combined with the introduction of water hyacinth, water lettuce and lotus has resulted in areas of the lagoon so thickly covered with vegetation that dogs can cavort on its surface with abandon. The result has been degraded water quality that now poses a persistent threat to the community's health. In fact, tests have shown that levels of pollution in the lagoon exceed recommended limits for any human use of its waters.

Laguna del Tule gets its water from an aquifer that is fed from the nearby mountains. The same aquifer supplies all the potable water for the communities of Bahia de Navidad, including that coming from both private and municipal wells. The polluted lagoon poses serious risks of contamination to local drinking water. It also affects the ocean beaches in at least two important ways: First, the lagoon, via the subsurface aquifer, continuously supplies the ocean with polluted waters. Second, during the rainy season, which begins in June, the lagoon begins to reach its holding capacity so that

from September through November, it opens its mouth to the ocean and sends polluted waters and associated detritus onto the beach and into the bay. Both phenomenons have health implications (swimmers have reported rashes) as well as economic impacts (tourists are reluctant to visit if they cannot safely swim or walk on clean beaches).

The frequency of direct discharge has been somewhat abated recently through the creation of large holding ponds distant from the towns, but when the pumps fail, as they often do, sewage is again redirected to the lagoon. While a new treatment plant was completed in 2002, it has not been put into use because of lack of operational funds. Moreover, when it eventually goes on line, it will only serve the fifty percent of the area's residences that are hooked up to sewage lines. In the interim, wastes will continue to flow into Laguna del Tule and valuable resources will continue to be degraded.

The Albufera Barra de Navidad is a 2.3 square mile estuary. Its mouth is at the southern end of the bay adjacent to the Barra de Navidad. Its main environmental problem is the accumulation of silt from upstream activities and pollution and reduction of basin area due to infill for urban and tourist development. All of these activities threaten endemic species and wildlife diversity. While Laguna del Tule is wholly within the state of Jalisco, the estuary, like the bay, is shared by both Jalisco and Colima states, thus increasing the challenges involved in planning and conservation efforts.

Bahia de Navidad, though probably somewhat diminished in productivity from its undisturbed state, still appears healthy judging from the prolific and diverse bird life that feeds there. It also supports active artisanal, recreational and commercial fisheries.

Although there are numerous issues present, all are a subset of the biggest threat to the bay and its communities: the potential for massive development. There is already an internationally acclaimed "super resort" at the southern end of the bay. It will take a constituency of the communities as a whole working together and united around the concept of sustainable development and watershed conservation to properly manage further development. A plan to accomplish that has been drafted.

4. The Community Project: Bringing Habitat Protection and Appropriate Sanitation to the Bahia de Navidad

Developed by the University of Guadalajara and in observance of basic concepts of sustainable development, the Project for Integrated Management of the Coastal Zone of the Bahía de Navidad (Proyecto Piloto de Manejo) establishes a dynamic, ongoing planning and decision-making process. The project will guide the economic and social development of

the Bahia de Navidad region, ever mindful of the conservation of both terrestrial and aquatic ecosystems. The cornerstone of the project is the fully inclusive Bahia community planning program. The program's goal is to harmonize urban growth and development of tourism with traditional activities such as fisheries and agriculture for the benefit of the population. Its mandate is to do this while maintaining the ecological integrity of the valuable natural wealth of the region, specifically including the beauty of its landscape.

In order to initiate the community planning program, the first step was to include representatives of all disparate users of the coastal zone at all socio-economic groups. It would then be possible to analyze, understand and plan to meet their needs and expectations. Next, regulations would be instituted to solve real and perceived conflicts among these users. Ultimately this would mitigate the impact of human activities on the environment. In 2000, the Consultative Council of the Bahia de Navidad (Consejo Consultivo de Bahia de Navidad) was formed.[68] The council consists of an alliance of community members, including over sixty key stakeholders, including the mayor of the municipality of Cihuatlan, elected representatives from the towns, academics, professionals, business and community leaders, representatives from government agencies and members of the general citizenry.

The legal infrastructure of the project was provided by the Political Constitution of the United States of Mexico (Constitucion Politica de los Estados Unidos Mexicanos) and the General Law of Ecological Balance and Environmental Protection (Ley General del Equilibrio Ecologico y la Proteccion al Ambiente).[69] Passed in 1998 and since amended, this "Ecology Law" is administered by the Secretariat of the Environment of Natural Resources (Secretaria de Medio Ambiente y Recursos Naturales or SEMARNAT). SEMARNAT, under the Ecology Law and other legislation and regulations that add flesh to the general law, has, among other duties, authority to promote the protection, restoration and conservation of ecosystems and natural resources for sustainable use and development; propose new and manage existing protected natural areas; develop a national ecological zoning plan; and encourage states and municipalities to

68. The project, its community planning process and its Consultative Council exist in large part because of the vision and leadership of Dr. Alfredo T. Ortega, Head of the Department of Sustainable Development of the Coastal zone at the Melaque Campus of the University of Guadalajara. Dr. Ortega is one of the authors.

69. For additional information on the Constitucion Politica de los Estados Unidos Mexicanos, *see* http://www.cddhcu.gob.mx/leyinfo/refcns/index.htm (Spanish). For information on Ley General del Equilibrio Ecologico y la Proteccion al Ambiente, *see* http://www.semarnat.gob.mx/dgeia/web_ingles/indice.shtml (English) or http://www.cddhcu.gob.mx/leyinfo/pdf/148.pdf (Spanish).

do the same. SEMARNAT is also charged with managing the protection and development of the coastal zone and marine uses therein. States as well as municipalities have authority to pass environmental legislation that does not conflict with federal laws and authority, and have done so. In fact, all thirty-one have included ecological zoning plans in their statutes.[70]

The legal structure for this project is provided by the Ecologica Ordinance of the State of Jalisco (Ordenamiento Ecologico Territorial del Estado de Jalisco), passed in 1995, and subsequently adopted and implemented by the municipality of Cihuatlán.[71] The ordinance provides permissible outlines for the use of the land, the fresh water lagoon, and the estuary and will guide the future rural, urban, and tourism development of the region.[72]

The project is grounded in principles of ICM and integrated watershed resources management. The overall strategy is one of gradual study and conservation of the three major aquatic ecosystems, by means of a series of specific efforts that undertake smaller projects initially, and, building on the successes of the past, work up to subsequently larger and more complex projects. Expected to take fifteen years to complete, this work should culminate in a successful and replicable sustainable development example for coastal regions worldwide.

a. Project Components: Sanitation First

Now organized, the first task that the project faces is stopping the pollution of the lagoon, bay and drinking water caused by the current sewage situation. As a first step, the newly-constructed treatment plant needs to be put into operation. This has yet to occur because, while the state government paid for the plant to be built, no provision was made for the costs necessary to run it. Discussions are underway among the recently-elected president of the municipality, local representatives and the Community Council concerning how to pay for these costs.

70. A good summary of Mexican environmental law is provided by the North American Commission for Environmental Cooperation and its publications section, *available at* http://www.cec.org/pubs_info_resources/law_treat_agree/summary_enviro_law/publication/index.cfm?varlan=english (last visited Sept. 27, 2004). Another useful site describing Mexican law in English is the electronic summary of a text: JORGE A. VARGOS, MEXICAN LAW (1998), *available at* http://www.mexlaw.com/guide.html (last visited Oct. 3, 2004). For general federal laws in Spanish, see the site of the Camara de Diputados del Hon. Congreso de la Union (Chamber of Deputies of Mexico's Federal Congress), *available at* http://www.cddhcu.gob.mx/leyinfo/ (last visited Sept. 30, 2004).

71. Ordenamiento Ecologico Territorial del Estado de Jalisco, *published in* Periodico Oficial, El Estado de Jalisco, sec. IV, *available at* http://periodicooficial.jalisco.gob.mx/index.html (last visited Feb. 28, 2005).

72. *Id.*

Even when the plant is finally up and running, it will only serve fifty percent of the area's homes and businesses because the requisite infrastructure does not exist for the other half of the area's population to hook-up to the system. Thus there is an opportunity and need to establish an ecological sanitation utility, an *AproSanidad*. As discussed earlier, alternative methods to Western flush-and-discharge sanitation systems have long proven successful. However, there are very few examples of such technology being used as a part of a full service utility.[73]

In a unique collaboration between the municipality of Cihuatlan, the University of Guadalajara and Aquatic Resources Conservation Group, an American NGO, a new sanitation utility, *Aprosanidad Melaque*, is currently being developed. The utility will not use water for the transport of wastes, and it will not create sewage. Instead, it will pick up preliminarily composted or dehydrated feces, and in some cases diverted urine, from residential ecological sanitation devices (RESDs) in homes. Using specially designed, environmentally friendly vehicles for delivery to a secondary treatment and re-integration facility, an "ecostation," end products will be sold as fertilizers and soil conditioners, and the resulting income will provide funds for the utility's operation. Additionally, grey water systems will be designed to assist each household in dealing with other wastewater.

So far, the project is moving forward successfully. In February 2004, *Aprosanidad Melaque* was designated a "Model Project" by the United Nations Environmental Program's (UNEP's) Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA), the only such award in the GPA's Latin American and Caribbean region in 2004. A formal cooperative agreement for the effort has been signed between the UNEP and the municipality of Cihuatlan. Also, the Swedish International Development Cooperation Agency (SIDA) has indicated its interest in providing funding for a one-year pilot initiative. Discussions are also underway with the United Nations Development Program, the World Bank and its Global Environment Facility, and a

73. One recent exception can be found in the funding for such a system that was agreed upon in the fall of 2003 as part of the creation of a new suburb in northern China. The project involves the construction of new one-, two- and three-story units incorporating dehydrating, urine separating ecological sanitation devices to serve 7,000 people. The project will also provide collection services and further treatment of wastes, as necessary, at a central location, and will use end-products as soil amendments. The effort was spearheaded by Uno Winblad, funded by the Swedish International Development Cooperation Agency (SIDA) and managed by the Stockholm Environment Institute as an initiative of the Swedish EcoSanRes Program. The new ecosan tower, Hei Zao Kui, will serve as a suburb of Dong Sheng in Inner Mongolia. Initial houses were to be ready for occupancy by the end of 2004. *See* Stockholm Environment Institute, *available at* http://www.ecosanres.org (last visited Mar. 1, 2005).

Mexican federal development agency, FIDERCO, for additional funding.

A critical component in the AproSanidad concept is for the community to own and operate the utility. The potential for serving up to 6,000 citizens, charging service fees and selling end products justifies expectations that the utility will eventually become self-supporting. Further income could also be generated by the local manufacture and sales of RESDs and the licensing of unique infrastructure components and system designs to other communities.

b. Project Education Campaigns and Planning for Cleanup of the Lagoon

At the same time the above efforts are being coordinated through the Consultative Council, the Council is working to develop a recognition of the importance of water in the community. As a key component of this watershed awareness campaign, a Laguna del Tule environmental education program, entitled "El Tule – un Tesoro que Debemos Rescatar,"[74] has begun in earnest. The lagoon will be the poster child for the watershed campaign and the ecologically-based sanitation and sustainable work. As part of this effort, a local community organizer is working to develop a water conservation ethic, specifically focused on showing how simple daily decisions (*e.g.*, whether to use chlorine bleach or other caustic cleaners) can affect the water of the community.

Also, money is being raised for a comprehensive environmental assessment of the lagoon. Once the assessment is completed and widely distributed, a series of community meetings will be held to decide how and on what schedule the lagoon's restoration can be initiated. As the restoration occurs, the community organizer will work with key stakeholders and citizens at all levels to propose an ordinance that would designate the lagoon as a Jalisco natural protected area reserve, an area solely dedicated to the conservation of flora and fauna. This ecological reserve status will control the type and extent of development that can occur in any area that might affect the lagoon. Thus, the practical result of the plan will be to convert, through community action and cooperation, what is now a human health, natural ecosystem, and aesthetic liability into a sustainable asset for the entire region.

c. Future Efforts

During its lifespan, the community initiative envisions undertaking two other major projects. The first is the protection and restoration of the

74. Translated, "un tesoro que debemos rescatar" means "a treasure we must rescue."

Albufera de Barra de Navidad, the region's salt water estuary. It is a larger and more complex body of water with wider-ranging social and environmental problems than El Tule. Further ecological and socioeconomic studies are needed in order to seek the best alternatives for its environmental management. Again, the goal is to guarantee that the community agrees on both the economic uses as well as the methods for its conservation. This will ensure that its valuable natural system services can be sustained for the long term. The second project is the creation of a plan to permanently conserve the Bahia de Navidad. In this phase, the community initiative will undertake to completely understand and resolve the specific marine problems facing the bay. For instance, it will continue to allow managed fishing, but will institute careful development and stringent pollution regulations.

These two projects will compose the final elements to be incorporated into the overall sustainable development plan for the community and will also complete the fifteen year master plan. Together, the projects will help to assure that the economic, social, and cultural development of the Bahia community occurs in a manner that includes rational use of the area's natural resources while retaining a healthy environment for all.

d. Strategy Benefits

To develop an integrated long-term sustainable development plan for any coast, it does not suffice to have solid scientific information on the environment and natural resources or profound sociological and economic studies. Fundamental tools necessary for effective ICM, including social coordination of the civil society and community-based resolution of disparate views over the use of natural resources, must also be brought to bear. The Mexican project discussed here combines all of these things with a strategy that evolves into a fully implemented plan by beginning at a smaller scale and taking on progressively larger tasks as the project and skills of the community mature. Employing appropriate sanitation to clean waters is important, as are the environmental benefits accruing from assuring that this beautiful spot is developed in a sane and sustainable manner. But arguably the most important contribution of the Bahia project for its citizens is the creation of a cooperative community possessing an esprit de corps. Through the Consultative Council, all socio-economic groups and sectors will have the opportunity to participate, and all planning will be based on local citizen determinations, achieving mutually beneficial agreements where, historically, confrontations have existed.

Beyond Bahia, Mexican federal authorities are closely watching the effort in Jalisco as a possible model for replication elsewhere in the

country. Local success, replicable because of the careful documentation of the work, will thus have the potential to benefit other coastal communities in Mexico and beyond.

IV. CONCLUSION

Coastal zones and their ecosystems are valuable and fragile places. They are subject to increasing pressures due to ever-greater influxes in human populations. One of the most serious problems accompanying this growth and attempts to manage it is the question of how to effectively treat and dispose of human excreta. The current flush-and-discharge system is not working to prevent pollution, even in the most affluent nations like the United States. For fifty percent of the developing world that currently has no improved sanitation facilities, a substantial portion of whom reside on the coasts, it will be a long time before such populations see the kind of infrastructure that is required to make the flush-and-discharge system work even as well as it does here in the United States. While we wait, six-thousand children die each day due to lack of access to safe drinking water and improved sanitation facilities.[75]

Thus, for much of the world, it is clear that we must replace a method of dealing with sanitation that results in linear nutrient cycle flow with a sustainable one that is cyclical and natural, one in which only that which is from water is returned to water and that which is from soil is returned to the soil. AproSanidads – utilities based on alternative, ecologically attuned dry toilets and service systems that accompany the devices, combined with effective community-devised and enlightened education programs – can prevent disease, protect coastal environments from pollution, conserve water, and enrich the earth. This experiment is currently being attempted in a small coastal community in Mexico. If the effort is successful, Aprosanidad Melaque could illustrate how ICM can resolve a critical coastal issue and, by extension, how it might be used to truly conserve the coast.

75. *See* Water Supply & Sanitation Collaborative Council, *Listening*, *available at* http://www.wsscc.org/dataweb.cfm?code=489 (last visited Feb. 28, 2005). This is the same as twenty jumbo jets crashing every day.