Considering A Viable Solution For Sewage and Solid Waste
Why We Should Do So?

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The population of Quintana Roo increased by 43 percent between 1990 and 1995 and is expected to increase by an additional 20 to 40 percent by the end of the year 2000 resulting in over 844,130 people living permanently on the coast. The tourists will bring an additional four million people. By the year 2004 the number of hotel rooms from south of Cancun to Tulum, now named the Maya Riviera, will double from 12,000 to 24,000, the same number as is currently in Cancun.

The waste generated by this population threatens to overwhelm facilities for disposal and portends a grave risk to human health. Already health specialists report that infectious diseases are spreading around the globe due to inadequate sewage disposal. Sewage dumping in the oceans, for example, has been implicated in outbreaks of cholera in Bangladesh.

Criteria for an adequate sewage treatment system must include the following capabilities: 1) Remove pathogens; 2) Remove toxic materials; 3) Remove nutrients; 4) Be financially feasible to design, build and maintain; and 5) Have a long life. When designed and operated properly, constructed wetlands are one system that can meet all the criteria, including removal of toxic substances and heavy metals. Wetlands, lagoons or sand filters, often used in conjunction with properly constructed and maintained septic tanks, can offer viable, low-cost alternatives to high-tech treatment plants for small, medium and large communities.

The parallel problem of solid waste disposal can be reduced in volume by up to 85 percent through an integrated system of materials recovery. This can help to protect the quality of the ground water and help to protect public health from the risks of ground water contamination. In addition, this may help to protect the health of the offshore coral reefs, that are exhibiting evidence of degradation in quality and quantity.

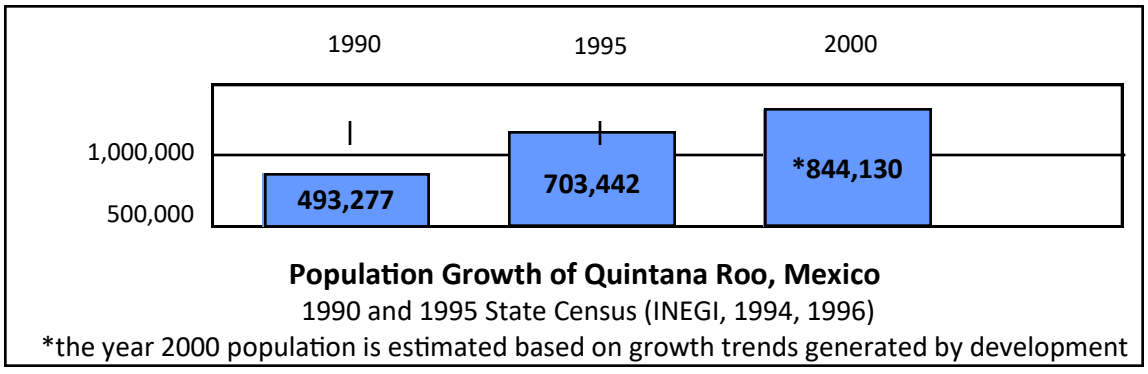

Figure 1

Introduction

The need to effectively manage the sewage and the garbage generated by the increasing human population becomes more immediate as development continues along the Quintana Roo coast. The population of Quintana Roo increased 43 percent between 1990 and 1995 from 493,277 to 703,442 (INEGI). With the development currently under construction, the population can be expected to increase another 20 to 40 percent by the end of the year 2000.

Increasing populations, with no effective method for containing or disposing of their sewage and garbage, bring a growing risk to human health (MMWR, 1994). This increased risk to human health is due largely to pollution of the ground water.

Water pollution is defined as contamination of water by foreign matter such as microorganisms,

chemicals, industrial or other wastes, or sewage. Such matter deteriorates the quality of the water and renders it unsafe for human consumption.

Special attention must be directed to "emerging infectious diseases." The term "emerging infectious diseases" refers to diseases of infectious origin whose incidence in humans has either increased in the last two decades or threatens to increase in the near future worldwide. These emerging diseases illustrate that no nation can be complacent regarding human vulnerability to microorganisms in the environment. As a consequence of changes in society, technology and the environment; pathogens such as viruses and bacteria evolve or spread, and the spectrum of infectious diseases expands. Emerging infections transmitted by contaminated public water supplies place entire communities at risk (MMWR, 1994).

Cholera, smallpox, and plague are infectious diseases that historically have spread globally with devastating impact, often during periods of rapid economic change or population growth. Both economic change and population growth are happening in Quintana Roo. Today, travel and commerce have fostered worldwide spread of pathogens such as influenza, as well as the reemergence of cholera as a global health threat (MMWR, 1994). These examples underscore the fact that emerging infections can affect persons in geographically widespread areas, regardless of factors such as lifestyle, cultural or ethnic background, or socioeconomic status.

Recent studies in the Florida Keys indicate that contamination from septic tanks is reaching the marine environment within 24 hours after the flush of a toilet (Paul, et al., 1995). Some of this offshore contaminated water has been found to contain viruses and bacteria which, in the past, were thought to be eliminated in sea water. However, it is now known that some of these viruses and bacteria become more resistant and more virulent once having entered the marine environment. Unsurprisingly, individuals swimming offshore in Florida have reported a variety of bacterial and viral infections ranging from ear and lung to intestinal. These infections are thought to be a result of sea water contaminated from onshore sources (Rose, 1999).

The number one source of foreign exchange in Quintana Roo is tourism. Every day, thousands of travelers from all over the world arrive at the Cancun airport. There is no way to control or screen the health of these travelers. Pathogens from infected individuals have a very good possibility of reaching the ground water when sewage is not treated. A recent study has implicated the dumping of sewage offshore as the source of a cholera outbreak in Bangladesh (*Scientific American*, 1999).

In the next five years it is planned that resort development will add 15,000 more hotel rooms between Cancun and Tulum; this will bring the total to 24,000 rooms (J. Friedland, Wall Street Journal, 1999). These resorts will require an average of three employees for each room. (In Cancun, the range is four to five.) A conservative estimate would be 72,000 new workers and their families moving into the coastal area. Family size averages four (found at Nuevo Akumal) to eight people elsewhere (INEGI, 1998). An increase in the local population of between 288,000 to 576,000 people may be expected.

Using a year-round double occupancy rate of fifty percent (the average cited in INEGI is 61.7 percent statewide), the number of people-days can be estimated to be 8,760,000 annually. This is more than double the current tourist figures.

Without adequate sewage and garbage disposal, this increase in the local and tourist populations could be a potential source of infectious diseases in areas where the ground water is being contaminated. While many of the resorts are building sewage treatment plants for their hotel com-

Sources of Pollution

Poorly constructed and badly located septic tanks, deep deposit wells and leaky garbage dumps are known to contaminate the groundwater with a variety of pollutants (Paul, et al., 1993). At Akumal, the contamination of the ground water has been well documented over a five-year period (Shaw, 1997). It is believed that the contamination comes from the deep deposit wells and septic tanks into which all the effluent is put. The septic tanks and the deposit wells are often not water tight and have no leach-

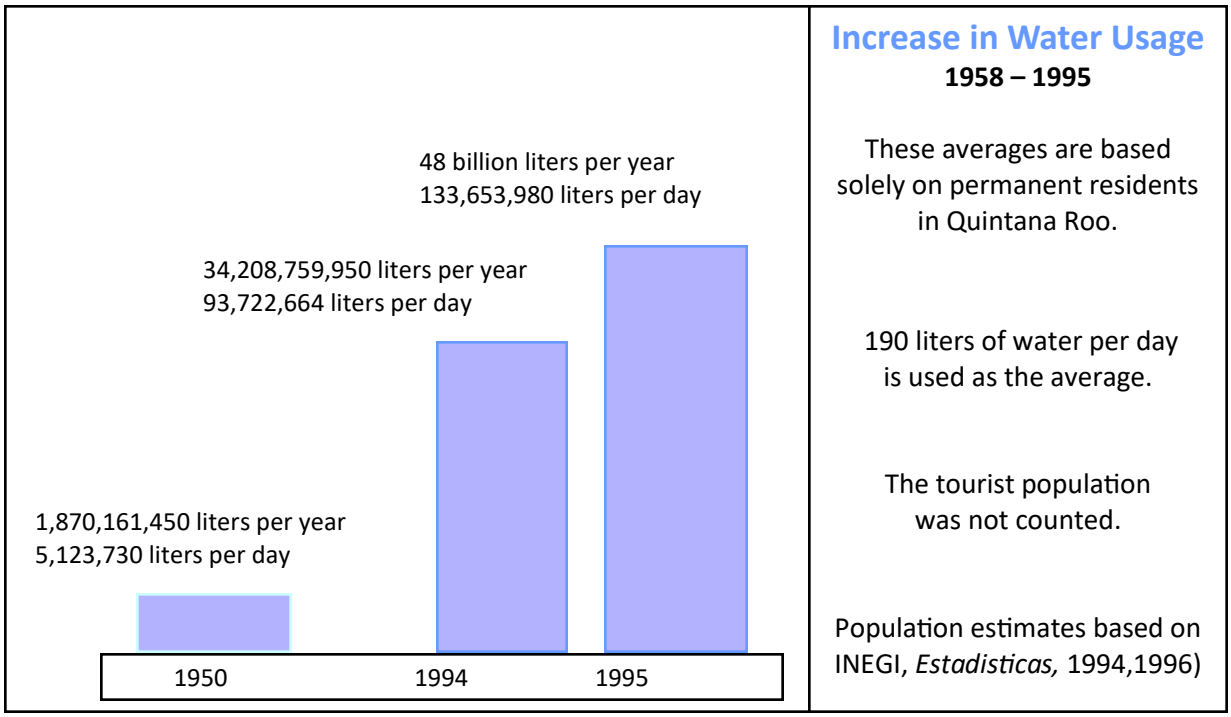

Figure 2

field.

In the United States today, the average daily water consumption rate in populated areas ranges from 380 to 950 liters (100 to 250 gallons) per person per day (Encarta, 1997). In 1995 there were 703,000 permanent inhabitants in Quintana Roo (INEGI, 1996). If each person uses half the low average, 190 liters (50 gallons) of water per day, there are approximately 133,653,980 liters of water being contaminated every day. The population has grown since 1995, so the consumption and contamination of the water have certainly risen.

In 1950 the population of Quintana Roo was 26,967 inhabitants. Again, using an average of 190 liters per day, 9,500,000 liters of water per day were being contaminated by personal use. The amount of ground water being contaminated per day in 1950 was insignificant compared to the amount being contaminated in the mid-90s, when the population of the state was 703,442 and the daily use was 93,722,664 liters. The increase in water usage from 1958 to 1994 is at least fourteen fold. This in itself is a significant increase and may be low, as the tourists may be using a significantly higher quantity of water.

The tourists would use an additional 5,700,000 liters per day, for a daily total of 99,422,664 liters of

This is a large quantity of contaminated water which must go somewhere. The most likely place it is going is into the ground water and the ground water is going to the sea. For the marine environment, effluent that is low in nutrients, particularly nitrogen and phosphorous is essential. An excess of these nutrients in seawater nearshore is associated with phytoplankton blooms or a proliferation of fleshy seaweed at the expense of naturally occurring marine populations, especially the economically important coral reefs (J. Lang, personal communication, 1999).

Toxic substances are implicated in a continuing concern for the public health. There are 1,047 toxic substances in common use which may end up in the water. Since there are relatively few heavily polluting industries located in Quintana Roo, toxins may not be a major source of pollution. However, film processing, automobile repair, and others which need to be identified, are industries that are problematic and need to be addressed. Recycling solutions such as those being used in California need to be explored. Toolkits for materials recovery and toxic chemical recycling are available.

How can we be assured of having water safe from pathogens to protect human health and water that is low in nutrients for the health of the reef system? The only way is to use those technologies that effectively contain, treat and dispose of the sewage and solid waste.

When deciding on which wastewater treatment system should be chosen, the following essential criteria must be met for a system that will be effective:

- Ability to remove pathogens.
- Ability to remove toxic substances
- Ability to remove nutrients
- Low cost to design, construct and maintain
- Long life expectancy of the design.

Possible Solutions

What sewage treatment technologies are available today and do they meet the above criteria?

- **Septic tanks** have been found to be ineffective in Quintana Roo because of the limestone karst terrain. A septic tank, if lined, can be an effective 1st step in sewage treatment, however, without adequate soil in the leachfield, they are not a solution. There is not adequate soil in this area. More importantly, after time, there is sewage sludge which accumulates in the septic tank that must be removed and disposed. A septic tank is not a system which meets the criteria of pathogen, toxicant and nutrient removal.

- **Deep deposit wells** do not meet the criteria. The theory behind the deep deposit well is that the sea water deep in the well kills the contaminants. This has been found to be an untrue and dangerous supposition (Paul, et al., 1997). It is now known that the sewage does not remain deep in the well as thought, but because fresher water floats on sea water, the effluent returns to the top of the well and floats off toward the shore. From there it flows out to sea with the ground water, which is now contaminated with feces and other toxicants (Shaw, 1997).

- **Sewage treatment plants** can be effective if properly built and maintained. They are, however, highly mechanical and costly to maintain. A highly efficient and well-trained staff is required. The machinery in a system such as this will wear out and need to be replaced, increasing costs over time.

Relatively speaking, the residents of Quintana Roo are at the beginning of this decision making process. However, we are running out of time, because it is unlikely that once money has been invested in a system, that the system will be changed. Since July 1993, Centro Ecológico Akumal has been seeking viable solutions to the environmental problems at Akumal and in Quintana Roo. Research sponsored by CEA has highlighted a primary problem: the health, or lack thereof, of the ground water. CEA has acquired other research data from around the world, especially from those areas which are geologically similar to Akumal and Quintana Roo, i.e., limestone karst terrain with caves, cenotes and ground water flow through porous and permeable rock to a tropical ocean environment with economically valuable coral reefs.

The results of the CEA research provide the community of Quintana Roo and the decision-makers valuable information which can be utilized to make well-informed decisions for the future. Many decisions in the past, have been based on limited information about the geology, movement of ground water, coral reef ecology and the realistic ecological sustainability of the fragile coastal region.

The coral reefs, the bays and the cave systems, are exhibiting changes that are an indication that many of the development decisions have not been based on good information. Valuable new information is now available.

Constructed Wetlands

A system that can meet all of the criteria set forth at the beginning of this proposal is the constructed wetland. This type of system has been built at Akumal for the CEA dorm rooms, several of the condominium buildings and individual homes, as well as larger projects, such as Xpu Ha EcoPark.

The constructed wetland has been found to be effective in reducing the fecal coliform, phosphorous, nitrogen and volume of effluent released back into the environment. Studies indicate a 90% removal of nutrients, and a 50% reduction in volume of effluent due to plant evapo-transpiration (Nelson, 1998). This is a significant reduction.

The constructed wetland system requires little energy, if any, is not very mechanical, is inexpensive to build and maintain and will last far into the future. This is not a new system; there has been increasing interest in using wetlands as interface ecosystems for wastewater treatment since early studies demonstrated their effectiveness in the removal of nutrients and suspended solids. These include use of cypress swamps in Florida (Odum et al., 1977; Ewel and Odum, 1984) and northern Michigan peatlands (Kadlec, 1979).

According to the National Small Flows Clearinghouse, the constructed wetlands are ideal for small communities now building or replacing aging infrastructure. (USEPA & Office of Municipal Pollution Control, 1987) In fact, the United States Environmental Protection Agency will provide (to small communities) 75 percent of the funding to build wetlands. They also will provide 10 percent of the cost of land acquisition.

The use of constructed wetlands has proven to be effective in eliminating the problems created by other systems. This is now being recognized in communities all over the world. Other systems such as lagoons and sand filters can be equally as effective at relatively low cost, however, Centro Ecológico Akumal has not had the opportunity to test the effectiveness of these types of systems.

The rapid growth of the population of Quintana Roo demands a comprehensive, large-scale solution for the sewage. Constructed wetlands or another system using nature, are needed to solve this im-

mense and very pressing problem.

Solid Waste Disposal Program

Garbage disposal is the other pressing issue of our time. Again, as the population of the state continues to grow, the mountains of garbage will continue to mount, leaking contaminated liquids into the ground water below.

Changes in the hydra community have been observed at Carwash Cenote (S. Smith, personal communication, 1999). This is not surprising since the town of Tulum relocated its garbage dump to the west of Carwash Cenote and the Tulum water supply. This was an uninformed relocation which is potentially very dangerous for the inhabitants of Tulum.

What are some of the options for garbage disposal?

Sanitary landfills used in the United States and in other countries around the world have been shown to have many inherent problems which make them not very useful, especially in a leaky environment such as this one.

A landfill is a carefully engineered depression in the ground or is built on top of the ground, resembling a football stadium into which solid wastes are put. The aim is to avoid any water-related connection between the wastes and the surrounding environment, particularly the ground water.

There are four critical elements in a secure landfill: a bottom liner, a leachate collection system, a cover and the natural hydrogeologic setting. The natural setting can be selected to minimize the possibility of wastes escaping into the ground water beneath the landfill. In this limestone karst terrain, a location where there is no connection to the ground water is unlikely. The ground water is a meter or less below the surface and unless the other three elements were engineered perfectly, it is highly unlikely that the landfill will not leak.

Even the very best liners for landfills, made from a tough plastic film called high density polyethylene (HDPE) are degraded by a number of common household chemicals that make it lose its strength, causing it to soften or become brittle and crack. Not only household chemicals, such as moth balls, degrade HDPE, but much more benign things such as margarine, vinegar, ethyl alcohol, shoe polish and peppermint oil, to name a few, can cause the liner to develop stress cracks (Rachel, 1999).

Each of the other elements of a landfill have their problems too. The leachate collection systems can clog within as short a time as a year and the cover can come under attack from at least six different sources:

- Erosion by natural weathering such as rain, hail, snow, freeze-thaw cycles and wind.
- Vegetation which sends down roots and penetrates the cover.
- Burrowing or soil dwelling mammals, reptiles, insects, and worms present a constant threat to the integrity of the cover.
- Sunlight will dry out clay or destroy membrane liners through the action of ultraviolet radiation.
- Subsidence will cause cracks in the cover.
- Rubber tires which float upward in a landfill.

These are just a few of the problems with landfills as a solution for the disposal of the garbage.

However, if an effective materials recovery program is implemented, many of the products that cause failure of the landfill liner, such as margarine and rubber tires, will be removed from the trash. In this

case, a landfill might be a solution for the disposal of the final 10 - 15 % trash left after recovery.

Incinerators are another method used to rid ourselves of the garbage. There is a body of information available which tells the story of incinerators and the pollution problems that they create. Simply the problem of the creation of dioxin should indicate that we do not need to trade one contamination problem for another.
Grass roots movements in the United States and in Europe have sprung up where concerned citizens have taken on the incinerator industry and have killed incineration proposals one by one at the local level. More importantly, these communities developed waste reduction, recycling and composting programs that starved incinerators by diverting the trash. Up to eighty-five percent of solid waste can be recycled or composted.

There are many aspects to consider in solid waste incineration: dollar cost, hazardous air pollution, toxic ash, foolish destruction of material resources, enormous waste of energy, and the political corruption that accompanies multi-billion-dollar public works projects.

An Alternative Solution to Consider

In the United States and in Europe alternative technologies which together go by the name of "materials recovery" are expanding rapidly. Small towns like Berlin Township, United States (population 5,629) have achieved 57% composting and recycling and large cities like Seattle, Washington (population: 497,000) had already achieved 36% in 1995 toward their goal of 65%. It can be expected that in time rural, suburban and urban communities will recover more than 75% of their trash. Incinerators are simply never needed.

Key Elements of A Successful Materials Recovery Program:

- Comprehensive composting programs
- Mandatory participation
- Materials must be recovered not only from single and multi-family homes, but also from commercial and institutional establishments.
- A wide variety of materials must be targeted for recovery.

There are many contact groups and information available to help begin a comprehensive program of materials recovery. When considering garbage collection and disposal it may be in our best interests as citizens of the state to contact these groups and find out for ourselves which methods will truly achieve the primary goal: **terrestrial containment of all contaminants from entering into the ground water system and reaching the marine environment.**

Any system that does not achieve this goal must be considered inadequate.

References

Alcocer, J., Lugo, A. Marin, L. E., & Escobar, E. (in press). Geo-chemical evaluation of water from five cenotes for use as potential drinking-water supplies, northeastern Yucatán, México.

Anon., (1997*),* Sewage Sludge: A New U. S. Waste Policy Emerges, Pt 2. *Rachel's Environment and Health Weekly*

Ewel, K. C. and H. T. Odum, eds., (1984). Cypress Swamps, University of Florida Press, Gainesville, Fla.

Friedland, Jonathan (1999). Fast Tourism Growth, Hotel Boom Threaten Balance in the Yucatan. *Wall Street Journal*, Aug. 20, 1999.

Goodland, Robert and Rockefeller, Abby (1996). What is Environmental Sustainability in Sanitation? UNEP-IETC Newsletter 5 – 8.

INEGI, (1994). Poblacion total por sexo segun grupo quincenal de edad, Anuario *Estadístico del Estado de Quintana Roo,* p. 63.

INEGI, (1996). Poblacion total por sexo segun municipio, Anuario *Estadístico del Estado de Quintana Roo,* p. 71.

Kadlec, R. H., (1979). Wetlands for tertiary treatment, pp. 490-504, In: Wetland Functions and Values: The State of Our Understanding, P. Greeson, J.R. Clark and J. E. Clark (eds.), American Water Resources Assoc., Minneapolis, Minn.

MMWR (1994). Executive Summary Addressing Emerging Infectious Disease Threats: A Prevention Strategy for the United States, *Morbidity and Mortality Weekly Report* 1–16.

Microsoft (R) 97 Encyclopedia. © 1993-1996 Sewage Disposal, *Encarta Encyclopedia (*1997).

Nelson, Mark (1998). Limestone Wetland Mesocosm For Recycling Saline Wastewater In Coastal Yucatán, México *Ph.D. Dissertation, University of Florida*, p 298 .

Odum, H. T., Ewel, K. C., Mitsch, W. J. and J. W. Ordway (1977). Recycling treated sewage through cypress wetlands in Florida, Wastewater Renovation and Reuse, F. D'Itri (ed.), Marcel Dekker, New York, pp. 35-068.

Paul, John H., Rose, Joan B., Brown, Jordan, Shinn, Eugene A., Miller, Steven and Farrah, Samuel R (1995). Viral Tracer Studies Indicate Contamination of Marine Waters by Sewage Disposal Practices in Key Largo, Florida, *Applied and Environmental Microbiology*, Vol. 61, No. 6, 2230 – 2234.

Paul, John H., Rose, Joan B., Jiang, Sunny C., Zhou, Xingting, Griffin, Dale, Farrah, Samuel and Lukasik, Jerzy (1997). Evidence For Groundwater and Surface Marine Water Contamination By Waste Disposal Wells In The Florida Keys*, Water Resources* Volume 31 No. 6 1448-1454.

Paul, John H., Rose, Joan B., Jiang, Sunny C., Kellogg, Christina A., and Dickson, Linda (1993). Distribution of Viral Abundance in the Reef Environment of Key Largo, Florida. *Applied Environmental Microbiology* Vol. 59, No. 3