

An Integrated Assessment of Regional Wastewater Treatment Options in Jamaica Using Systems Analysis

Introduction:

Small and sparsely populated communities throughout the world typically depend on on-site sanitation (OSS) facilities for the treatment of human waste. Such systems consist of an anaerobic holding tank (septic tank) that separates the solids and grease from the waste stream, followed by a leaching field or soak-away pit that further treats the resulting wastewater. Depending on site conditions, septic tanks should be emptied every one to three years and the septage should be hauled to, and treated in, a centralized plant or local treatment system, landfilled, or reused for land application. While on-site systems are, for the most part, an effective and low-cost alternative to the centralized piped sanitation systems conventional in densely populated and developed areas, there are serious environmental and human health effects associated with their mismanagement and deterioration.

In Jamaica 70% of the population depends on on-site sanitation facilities such as septic tanks with soak-away pits and pit latrines for wastewater treatment. The Pan-American Health Organization estimates that 46 million gallons of septage was produced island-wide in 2002. Of those 46 million gallons produced only 25 million gallons were accounted for at the two wastewater facilities equipped to handle septage. Failing to remove septage from tanks or pits on a regular basis can undermine the integrity of septic systems and leaching fields and, in turn, threatens the environment surrounding them. In addition to the problems associated with failing septic systems, cesspool operators in Jamaica, as in many other countries, have been known to dump untreated septage at the side of the road or into surface water bodies due to prohibitive costs and hauling distances. As a majority of Jamaica's water is obtained from groundwater sources, in addition to the immediate and localized environmental effects of mismanaged septage and wastewater, the integrity of Jamaica's future drinking water supply is also at risk.

Mismanagement of septage threatens to undermine two of Jamaica's most valuable resources; its virtually unspoiled surface and groundwater reserves (including coastal waters) and its diverse and thriving ecosystems. In addition to the varied environmental effects there is the potential for serious human health risks through drinking water contamination and the possibility of human contact with untreated septage. The lack of adequate wastewater infrastructure in Jamaica has, therefore converted raw septage into a threat to both environmental and human health.

Proposed Research:

In order to address this lack of septage management, in some parishes in Jamaica cesspool operators are building their own disposal ponds for septage treatment, with the approval of regional health authorities. These smaller-scale, localized treatment technologies provide a more economically viable option than hauling to a centralized system and also prevent operators from indiscriminately discharging septage waste. While they are a positive step forward in septage management, it is essential that these technologies be adequately studied, pilot-scale tested, and that operations and management standards be put in place to ensure their effectiveness.

The Parish Development Committee (PDC), an NGO from the southwestern parish of St. Elizabeth, is interested in developing a local cesspool operation. There are currently no local treatment systems or cesspool operators based in the parish. The goal of this research is to address this interest in septage management by developing a database of wastewater information, determining suitable areas for local treatment systems, and selecting an optimum combination of wastewater treatment options for the region. The proposed research will model various options for regional septage treatment using the Integrated Assessment approach (IA). IA considers the economic, social, and environmental constraints inherent in each option while simultaneously taking into account population growth, improved treatment technologies, and other important factors relating to the overall systems analysis. A regional decision model of septage treatment will be developed for St. Elizabeth and will incorporate treatment alternatives to hauling or pumping to the nearest existing centralized systems.

Spatial Analysis of Wastewater Treatment Options Using a GIS:

Development of a systems model will depend on a strong database of information surrounding current wastewater treatment options in the St. Elizabeth region and other spatial and temporal data. I will develop a Wastewater Information System (WWIS) that will include data relating to the following parameters: land use, population distribution, septage and wastewater production, existing septage and wastewater treatment options, soil type, groundwater elevation, topography, supply well locations, rivers, wetlands, and other surface water bodies. This information will be collected from the National Water Commission, Water Resources Authority, Ministry of Agriculture, Forestry Department and the Scientific Research Council of Jamaica. I will also collect and compile data relevant to septage production and treatment that is not currently available.

From the database of wastewater information compiled, I will then create a map of the St. Elizabeth region using a Geographic Information System (GIS). Using the map created and the data analysis capabilities of GIS, the spatial distribution of areas suitable for localized treatment systems will be determined. Unsuitable areas would include those

that are in close proximity to surface water bodies, including rivers, wetlands, and areas with high groundwater elevations, and areas that are in close proximity to schools, public buildings, or densely populated areas.

Development of a Systems Model:

While the Wastewater Information System database and map will serve to outline regions of St. Elizabeth suitable for localized treatment systems, a Systems Analysis approach will be used to select the optimal combination of treatment options and locations for the region, based on a variety of social, economic, and environmental objectives and constraints.

Environmental constraints in the analysis will include ensuring that all septage is collected and treated to the equivalent of a secondary level, that treatment technologies have been adequately tested and their performance under tropical conditions is documented, and that any wastewater resulting from septage treatment is disposed of or reused in accordance with established guidelines (such guidelines will be compiled from existing practices and recent research). Economic objectives will be incorporated by minimizing the capital and operation costs of any course of management, while maximizing the potential economic benefits from the reuse of wastewater and/or the potential creation of an industry surrounding septage management and treatment. Social objectives will be to maximize the number of citizens served by a management plan and to create job opportunities through septage management and treatment (hauling, system operators etc.).

Decision variables will include a variety of treatment technologies, locations, and systems of management. Treatment technology options such as systems with and without non-potable water reuse, small-scale treatment plants, local constructed wetlands and other options will all be considered. Land will have been parceled using the GIS map created and areas that are suitable for the construction of treatment systems will be incorporated as variables in the model. Based upon these economic, environmental, and social objectives the systems model developed will select the optimum combination of septage treatment options for the western region of Jamaica.

Results:

The Government of Jamaica is currently devoting a significant amount of time, funding, and effort toward their Water Resources Development Master Plan and to various Operations Manuals in order to address the shortcomings with wastewater management throughout the country. Toward this end, it is the goal of this research to consolidate the available data relevant to wastewater systems in the St. Elizabeth region in one central and transparent location. The resulting database of wastewater treatment systems will serve to compliment the Ground Water Information System (GWIS) already developed by University of the West Indies at Mona (UWI Mona) in collaboration with the Jamaican Water Resources Authority (WRA). The development of a Wastewater Information System, like that of the GWIS, would further promote the integrated assessment of water resources in Jamaica.

The database will be shared, in its final form, with the WRA and UWI Mona for their use in research and for further development. With the wastewater database as a foundation, a model of current on-site systems and treatment methods and future alternatives for treatment will be developed and will incorporate the social, economic, and environmental values and constraints associated with the alternatives. The aim of the model will be to outline the optimal combination of treatment options for the St. Elizabeth area of Jamaica, and to facilitate decisions with regards to regional septage management which are socially, economically, and environmentally sustainable.

The project will also take into account the opinions and experiences of both cesspool operators as well as the communities being served by these operators, in order to get a balanced view of the problems and potential solutions. The goal of this research is to provide a working tool that will outline and qualify septage management option to be used by those who have already expressed an interest in the development of a regional septage management plan for St. Elizabeth.

Long-Term Goals:

Working in the field of water resources and being intent on practicing sustainable decision-making, in my mind, requires experience and study throughout the world. The challenge of sustainable extraction, use, and management of water resources demands an understanding of the varied ecological, social, and economic values and constraints that should be considered in any decision-making process. The goal of this research, in keeping with my career objectives, is to work with the various stake holders, in this case people in Jamaica, the local NGO, the Water Resources Authority, UWI Mona, and the Ministry of Health in addressing the many challenges inherent in providing adequate sanitation in an ecologically, economically, and socially sustainable manner. I am particularly interested in the fields of Integrated Assessment, Environmental Quality Indicators, and Systems Analysis as tools used to address the challenges inherent in the sustainable development of water resources.

As a candidate for a Master's Degree in Water Resources Engineering I have taken and will continue to take classes in engineering and international environmental policy at the Engineering School and the Fletcher School of Law and Diplomacy. During this spring semester of 2004, I am taking courses in Geographic Information Systems (GIS) and Integrated Assessment of Water Resources. My research in both classes will be focused on developing a Wastewater Information System for Jamaica and conducting an integrated water resources assessment of regional wastewater treatment options.

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