THIRD INTERNATIONAL SYMPOSIUM ON TROPICAL HYDROLOGY

Fifth Caribbean Islands Water Resources Congress

AWRA

PROCEEDINGS

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TROPICAL HYDROLOGY AND CARIBBEAN WATER RESOURCES

THIRD INTERNATIONAL SYMPOSIUM ON TROPICAL HYDROLOGY
AND
FIFTH CARIBBEAN ISLANDS WATER RESOURCES CONGRESS

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FOREWORD

The tropics are the most hydrologically active regions of the world – the regions where the great rain forests are located. The moisture and heat circulation cycles of the tropics affect weather patterns on a global scale. Research in tropical hydrology is making evident the tremendous importance of this field to understanding the role of the hydrologic cycle in weather systems, ecosystem dynamics, and ecological effects of human activity.

The wide range of topics presented in the symposium is representative of the breadth of disciplines that have found application in the field of tropical hydrology. The fields of water supply and distribution, climatic change, water resources planning, water quality, ecosystem studies, and water resources education are aptly represented by several symposium papers reflecting the diversity of current research efforts in the field of tropical hydrology.

The papers are grouped into specific sessions according to the topics requested in a call for abstracts. First drafts of papers were peer-reviewed and returned to authors for preparation of final manuscripts. These are the papers presented in this Proceedings. The Proceedings will be useful to students, practitioners, and researchers alike due to the diverse number of contributors to the publication. Contributions from universities, research institutes, government agencies, and consulting firms are indicative of the widespread involvement of a gamut of organizations in the field of tropical hydrology.

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The Organizing Committee is also grateful to the many individuals who contributed their time and effort to the accomplishing of the symposium. We greatly thank the authors for their cooperation during the revision process.

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ALTERNATIVE ON-SITE SEWAGE DISPOSAL SYSTEMS IN THE UNITED STATES VIRGIN ISLANDS

Janice D. Hodge,[1] William F. McComb,[2] and Henry H. Smith[3]

ABSTRACT: Disposal of residential sanitary waste is a challenge in many areas of the U. S. Virgin Islands not served by the public sewer system. Conventional septic tank/ seepage pit systems are proving to be inadequate due to the shallow soils, steep slopes and also the increasing numbers of these systems. Proper disposal of sewage is critical in the tourism based Virgin Islands economy not only because of public health concerns but also due to the adverse effects of untreated sewage on the pristine marine waters which are a source of both recreation and food. The Water Resources Research Institute at the University of the Virgin Islands and the Virgin Islands Department of Planning and Natural Resources have investigated alternative methods of treating sanitary waste for individual residences. Pilot systems installed have proven to be effective and have the potential for widespread application in areas where environmental constraints are similar to those in the U. S. Virgin Islands.
KEY TERMS: onsite sewage disposal; nonpoint source; constructed wetlands; wastewater treatment; alternative OSDS.

INTRODUCTION

Increasing volumes of sanitary waste being produced and discharged from individual residences in the U. S. Virgin Islands, where public waste collection and treatment facilities are confined to limited areas, are a growing concern. Not only is improperly treated sewage unsightly and unsanitary, but much of it makes its way to the shorelines fostering conditions that are unsafe for swimmers, injurious to marine life and aesthetically unappealing in the tourism based economy.

Septic tank/soil absorption systems as used in the USVI consist of a buried tank that discharges into a leach field or seepage pit. The tank is sized to allow for detention of the wastewater for a period of two to three days. Effluent from the septic tank discharges to the seepage area. This area often consists of a network of perforated pipes discharging in to soils but more commonly because of the steep slopes and limited soil is a rock-filled hole in the ground.

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One study has found that septic tank/soil absorption systems are the predominant means by which domestic waste from individual household is discharged in the USVI and that most of these systems frequently fail. Failure of a septic system refers to the system failing to adequately accept wastewater prior to discharge to the environment. System failure is usually recognized when there is a presence of odors and/or visible discharge of effluent on the ground surface. In the USVI failure generally occurs due to inadequate sizing of the seepage its due to limited space, unsuitable soil characteristics and/or insufficient soil volume.

It was found that the widely used septic tank/soil absorption systems are unsuitable for use in the Virgin Islands because few areas have the two to three feet of pervious soil through which effluent from these systems should be treated prior to discharge to the environment. Because of unsuitable soils and terrain, these systems very often fail resulting in harmful discharges that very often also make it to the nearshore marine environment. It is critical that effective and practical procedures are developed for onsite treatment of sanitary wastes in the Virgin Islands.

THE STUDY SITES

The U. S. Virgin Islands Government's Department of Planning and Natural Resources Management (DPNR) is responsible for controlling, regulating and monitoring water pollution. Under its Nonpoint Pollution Control Program, DPNR received a grant through Section 308 of the Coastal Zone Management Act to investigate the use of alternative means of onsite disposal of domestic wastewater in the USVI.

The Virgin Islands Water Resources Research Institute of the University of the Virgin Islands (WRRI) was contracted by DPNR to conduct the monitoring program.

Four systems were monitored as part of this investigation. Two were new systems designed and installed for this study and two were systems that were already in operation and from which it was felt that useful information could be gained. The systems are described below with the two main study sites, Estate Harmony and Cabrita Point, presented first and followed by descriptions of the two systems already in full operation prior to this study, Red Hook and Nazareth.

Estate Harmony Site

At the Estate Harmony site the residence served by the OSDS consists of a house that includes three bedrooms, two full baths, a fully equipped kitchen and laundry facilities. A two-bedroom caretaker's house is also located on the property. A water meter is installed to monitor water withdrawn from the cistern and used as an estimate of water treated by the OSDS. The system's design capacity is 1,200 gallons per day.

A two stage secondary tank receives effluent from a traditional septic tank with a capacity of 2,000 gallons. The 600-gallon secondary tank serves to enhance the breakdown of solids which could clog trenches further on in the system. This secondary tank is split in to two sections with the first two-thirds of the volume partitioned off to store solids and provide anaerobic activity additional to that present in the septic tank. The remaining one-third of the tank isolates the solids and floating material from entering the remainder of the treatment system.

The secondary septic tank discharges its effluent into an 18-foot long primary filter with an 18-inch high central divider running the length of it. This divider serves to slow the passage of the effluent through the trench for the flow distance between the trench's inlet and outlet is almost twice the length of the trench, 32 feet. The effluent's residence time in the primary filter is increased.

The primary filter consists of a twelve inch deep trench, for free flowing liquid, that is overlaid with a twelve inch bed of washed gravel. A metal grating covered with a durable permeable fabric serves as the separator. The gravel is covered with twelve inches of soil. The design results in the gravel bed also being saturated with effluent. The roots of the vegetation growing in the soil then extend into the gravel bed and through to the free flowing liquid at the base of the primary filter.

Discharge from the primary filter enters the two secondary filter trenches which also consist of concrete troughs and a central divider. In the troughs are lower layers of gravel 16 inches thick. This gravel is covered with eight inches of soil. The troughs are 12 feet, 6 inches long. The troughs' outlets are placed so that the gravel remains saturated at all times and allows only free flowing effluent to leave the secondary filter troughs and enter the next troughs, the hydroponics section. The hydroponics trough consists of a tank 17 feet long and four feet wide. It is filled with two feet of topsoil in which vegetables such as lettuce, tomatoes, egg plants and basil and other herbs are grown. Ornamental plants are grown in the primary and secondary filter troughs at this site.

Provision has been made for excess water to be discharged from the hydroponics trough in to a gray water cistern. From the gray water cistern the effluent may be used in a drip irrigation system, recirculated to the first stage of the septic tank (primary separator) or to a fish pond where fish such as tilapia may be cultured.

Seven monitoring ports were placed in the system and provisions were made for cleaning the system without disturbing the overlying soil beds and vegetation by using drains placed in the bottom of each trough.

Cabrita Point Site

At the Cabrita Point site the residence served by the OSDS consists of two two-bedroom condominiums having a total area of 2,621 square feet. Water meters are installed at each condominium to obtain estimates of wastewater entering the OSDS. The design capacity of the OSDS is 600 gallons per day.

Twenty four 150 gallon stock tanks, each approximately 3' x 5' x 2' deep, are connected in series following the existing septic tank. These tanks are placed on a downhill slope of 1/8" per foot from the septic tank and filled with a foot and a half of gravel topped with six inches of pea gravel. The final tank is fitted with a 30 foot length of 3/4 inch perforated PVC pipe for discharge of excess effluent which is expected to occur only under very unusual conditions for the system was designed for all effluent to undergo evapotranspiration. Any discharge from the final tank is diffused by the perforated pipe into the surrounding earth. Provision for overflow is important due to the possibility of the tanks being filled by rain or surface runoff during high rainfall events.

Effluent entering each tank fills the voids in each tank until it reaches a level where it is high enough to discharge through a port in to the next tank. The gentle slope downward through the system insures that there is a gravity flow on to the next tank downstream as each tank is filled. Reeds and ornamental plants such as canna lilies with high water uptake are planted in each tank.

Sampling ports are placed in the 1st, 8th, 16th and 24th tanks for monitoring of the effluent's quality.

Red Hook Site

At the Red Hook site a packaged wastewater treatment plant was monitored. The installed system has a design capacity of 600 gallons and serves a two bedroom residence lived in by three working adults on a year round basis.

An aerator in the bottom of the unit's single tank keeps the wastewater completely mixed and aerated at all times. The system is fitted with a pump to supply pressurized gray water for landscape purposes. Samples in this study were taken from a faucet that was part of this gray water supply system.

Nazareth Site

The system at the Nazareth site has been in operation for about two years and serves a residence and small architect's office that is in use year round. The system is planted with reeds, ginger lilies, canna lilies and elephant ears.

Like those at the Harmony and Cabrita Point sites, this system uses a conventional septic tank for primary removal of solids. This site is particularly similar to the Cabrita Point site except that two long trenches rather than stock tanks are used for treatment of effluent after it leaves the septic tank. These trenches are each about 30 feet long, four feet wide and three feet deep. They are lined with polyethylene (plastic) to keep the effluent contained in the system, filled with pea gravel, and are installed parallel to each other on the natural contour of the slope where they are located. The system is gravity fed with excess water from the second trench being pumped by a solar powered pump to a lily pond.

Three sampling ports are located in the system and samples could also be taken at the lily pond.

THE MONITORING PROGRAM

Effluent samples, water meter readings and rainfall levels were taken on a monthly basis and observations made by residents at the site noted. Occasionally, the sites were visited on a weekly basis to assess their progress. Samples were analyzed at the University of Virgin Islands by qualified personnel using approved methods for the examination of wastewater detailed in Standard Methods for the Examination of Water and Wastewater(APHA,1992). Parameters monitored were coliform, dissolved oxygen, total suspended solids, BOD, phosphorous, nitrogen as ammonia and Kjeldahl nitrogen.

During the study period, Hurricanes Luis and Marilyn hit St. Thomas in September 1995. Though the systems were all installed prior to the hurricanes and some preliminary monitoring done, monitoring was done on a continuous basis for six months beginning in January 1996. Electrical power interruptions and general disruptions at the study sites had stabilized by January 1996. Occupancy, though, was never at the level for which the systems were designed.

FINDINGS

None of the systems experienced any problems that prevented their operation during the study period or required extensive maintenance. Occasionally, there was insufficient effluent at some sampling ports and samples could not be taken. This could be reflective of high uptake by the plants but more probably related to low effluent inflow to the OSDS. Water usage rates at the monitored sites were not as high as anticipated. This undoubtedly was due to the unusual circumstances caused by the hurricanes. A summary of the findings for parameters monitored at the two principal site appears in Table 1.

Table 1: Summary of Observed Parameters

Parameter	Cabrita	Harmony	Parameter	Cabrita	Harmony
Coliform			Dissolved O_2		
	100	170	(mg/L)	10.3	9.9
col/100ml)	99	88	% change	66	56
% change					
TSS			BOD		
(mg/L)	60.1	19.5	(mg/L)	6.3	4.0
% change	51	83	% change	23	14
Phosphorus			N as ammonia		
(mg/L)	0.8	4.5	(mg/L)	4.8	44.5
% change	89	40	% change	92	18
Kjeldahl-N					
(mg/L)	7.8	30.0			
% change	89	44			

CONCLUSION

The biological systems investigated in this study eliminated all the effluent that they were provided with which is particularly significant for then there is no need to be concerned with the quality of the effluent they were discharging to the environment. The mechanical system operated with no maintenance problems and produced an effluent that was within existing standards but nevertheless needed to be disposed.

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