UNIVERSITY OF HAWAIʻI SYSTEM REPORT

REPORT TO THE 2024 LEGISLATURE

Report on New Technologies for Cesspool Replacement in Hawaiʻi

HCR 102 HD1 (2023)

December 2023

2024 LEGISLATIVE REPORT
TO HCR 102 HD1 (2023)

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New technologies for cesspool replacement in Hawaiʻi

Pursuant to House Concurrent Resolution 102 House Draft 1 (2023), the University of Hawaiʻi Water Resources Research Center (WRRC) is submitting this report on a feasibility study of new technologies for cesspool water remediation, which may include organic biodegradable water clarifiers.

Cesspools are underground pits constructed with brick or concrete walls for temporary storage of sewage. Since there is no other outlet, the liquid waste seeps into the surrounding soil. Cesspools have no designed treatment capability for wastewater, leaching untreated organics, nutrients, pathogens, and other emerging contaminants into groundwater and coastal water. Untreated wastewater poses great threats to the environment, public health, and socioeconomic well-being in Hawaiʻi. In addition to contamination of groundwater and risks to drinking water supplies, wastewater can harm marine ecosystems impacting fish and coral reefs[1,2] that have ripple effects on local tourism, aquaculture, and community resilience.

Onsite wastewater treatment (OSWT) systems are needed to replace cesspools in order to minimize such risks in Hawaiʻi. Currently approved treatment systems by Hawaiʻi State Department of Health (DOH) in Chapter 11-62, Hawaiʻi Administrative Rules (HAR) include septic tank, aerobic treatment unit (ATU), recirculating filter, and chlorine or ultraviolet (UV) disinfection[3].

Septic tank systems are the most common conventional technology to replace cesspools, consisting of two major components: a septic tank and a leach field. Septic tanks are large watertight plastic, fiberglass, or concrete underground containers. As sewage comes in, solids settle to the bottom, while oil and grease float to the top, forming a scum layer. The remaining liquid flows out of the tank into the leach field. The leach field is a network of

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[1] Gove, J.M., et al. Coral reefs benefit from reduced land–sea impacts under ocean warming. *Nature* **621**, 536–542 (2023). https://doi.org/10.1038/s41586-023-06394-w

[2] Coleman, S. (2023, September 25). Cesspools Are Killing Hawaiʻi's Coral – But It Doesn't Have to Be That Way. *Hawaii Business Magazine*. https://www.hawaiibusiness.com/cesspools-damage-killing-hawaii-coral-solutions-irrigation-landscape/

[3] Hawaiʻi State Department of Health. 2016. *Wastewater Systems*. https://health.hawaii.gov/opppd/files/2015/06/11-62-Wastewater-Systems.pdf

perforated pipes laid in trenches filled with gravel, which slowly releases liquid wastewater into the soil while removing some pathogens and nutrients before percolating into the groundwater.

Septic tank systems rely on soil conditions and natural biochemical processes for a limited treatment. Thus, ATUs or recirculating filters can be installed to treat the effluent from the septic tank when soil conditions are not suitable for leach fields. ATUs use air pumps to promote the growth of aerobic bacteria and accelerate the degradation of organic contaminants and oxidation of ammonia nitrogen. Recirculating filters use sand or other filtering media to enrich biofilm growth with attached microorganisms helping to break down organic contaminants. Chlorine addition and UV disinfection are common final treatment steps to further remove pathogens before subsurface dispersal in a leach field.

Conventional OSWT have limitations that can impact their implementations in Hawai‘i, including limited nutrient and pathogen removal, potential failure due to soil conditions, vulnerability to flooding and drought, and significant land use and space requirements. There are other technologies currently available in the market that may address these issues.

Commercially available technologies that are not yet approved by DOH, those with pending approvals, and emerging technologies with lower readiness level are referred to as “new technologies” in this report. Key factors to be evaluated for the feasibility of a new technology include site restrictions, treatment performance, and construction and maintenance costs[4]. Site restrictions as well as construction and maintenance costs vary greatly from place to place in Hawai‘i, depending on the type of technology evaluated. For example, the percolation rate for volcanic soil conditions differs from place to place affecting the minimum size of the leach field and the difficulty of underground excavation. The evapotranspiration rate varies according to climate conditions across the islands and may increase or reduce the site requirements. For a septic tank, ATU, and disposal system, estimated installation costs range from $10,000 to $38,000 with monthly maintenance costs of $33 to $109[5]. Recently, higher conversion costs have been reported, ranging from $30,000 to $50,000 per household[2].

A literature review was conducted to provide information on current knowledge of some of the emerging technologies. In addition to the approved anaerobic (septic tank) and aerobic (ATU) technologies, other available new

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[4] Carollo Engineers. 2021. *Cesspool Conversion Technologies Research Summary Report*. https://health.hawaii.gov/wastewater/files/2021/02/technicalfinalreportr.pdf

[5] Carollo Engineers. 2021. *Cesspool Conversion Finance Research Summary Report*. https://health.hawaii.gov/wastewater/files/2021/02/financefinalreportr.pdf

technologies can be classified as natural, alternative, packaged, and source-separation treatment systems.

Natural treatment systems

Natural systems can be leveraged to treat municipal wastewater on site, with major advantages including low cost, low maintenance, and usually low dependency on mechanical parts and electricity. Some examples include engineered ponds, constructed wetlands, and aquatic plant systems. These systems are suitable for treating low volumes of wastewater from a household. Multiple natural components work in collaboration with each other to remove organic and inorganic pollutants, with bacteria, algae, plants, and soil. Besides biological and chemical reactions, pollutants are also removed through concurrent physical processes including precipitation and adsorption. Removal rates of biodegradable organics range from 70-90% in natural treatment systems[6]. Raw materials are often easily sourced locally and, therefore, can quickly adapt to the local environment.

The major limitation of natural systems is its low robustness towards flow changes. Plants may die off if no flow is received for an extended period, and overflow may happen if high flow or intense precipitation occurs. Natural systems require a long retention time for effective treatment. In warm places with high evapotranspiration rates, such systems may have lower size requirements, but have potential odor problems. The choice of vegetation, design of flow, and selection of operational conditions require on site testing to accommodate various climate conditions in Hawaiʻi.

Innovative alternative systems

Septic tanks have a minimum capability to remove nutrients: Less than 5% of total nitrogen can be removed through ammonia volatilization or sedimentation of undigested solids; 20-30% of phosphorus is accumulated as sediments without other removal mechanisms.[7] Innovative alternative systems incorporate septic tanks with natural, aerobic, and anaerobic treatments to improve nutrient and pathogen removal. These systems include a wide range of technologies, such as nitrogen removing biofilters, membrane

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[6] Sharma, M. K., et al. (2022). Sustainable technologies for on-site domestic wastewater treatment: A review with technical approach. *Environment, Development and Sustainability*, *24*(3), 3039–3090. https://doi.org/10.1007/s10668-021-01599-3

[7] Lusk, M. G., et al. (2017). A review of the fate and transport of nitrogen, phosphorus, pathogens, and trace organic chemicals in septic systems. *Critical Reviews in Environmental Science and Technology*, *47*(7), 455–541. https://doi.org/10.1080/10643389.2017.1327787

bioreactors, sequencing batch reactors, and other innovative designs or modifications of septic tanks. Compared to ATUs, Innovative alternative systems often have less aeration requirements, translating into lower energy demands, less sludge production, and simpler operation. Depending on the technology that is integrated, there will be additional capital and maintenance costs besides the installation cost for septic tanks.

Additives are commercially available for septic systems; however, they are generally not recommended under normal operating conditions. The benefits of additives are still debatable, with potential negative impacts reported. There are three general types of additives (*Appendix I*): inorganics, organic solvents, and biological additives. Inorganic substances are occasionally used to open clogged drains or for odor control. Long-term use can potentially disrupt septic system by killing active bacteria and corroding tanks and pipelines. Organic solvents are used to break down scum, oil, and grease. They are banned in multiple states, with risks of destroying the microbial treatment in septic systems and contaminating groundwater. Biological additives include enzymes, active bacteria, and biodegradable surfactants or coagulants. Properly sized and designed septic tanks should have adequate retention time for suspended solids reduction and treatment, without dosing of additional bacteria or flocculants. Some biological additives may actually increase the amount of solids entering the downstream soil absorption system for disposal, causing risks of clogging and overflow[8].

No current guidelines or standards have been published in Hawaiʻi regarding additives. In addition, cesspools do not have the same treatment capacities as septic tanks. Instead of solid-liquid separation and discharge of liquid effluent to a drain field, all the waste is retained in cesspools with liquid leaching out into the surrounding soil through the walls. Thus, further testing and research are needed to clarify the impacts of additives on cesspools.

Packaged treatment systems

Packaged treatment systems use a series of mechanical, biological, and/or chemical processes to deliver treated effluent of high quality. Technologies used in these OSWT systems are similar to those used in centralized wastewater treatment facilities, but at a much smaller scale, applicable to individual households and small communities. With compartments of various treatment units, efficient removal of nitrogen and phosphorus is possible within small footprints. Packaged systems can be manufactured off site, then delivered and installed. It is best suited to places where construction and

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[8] Septic Tank Additives. Small Flows Quarterly. Winter 2002, Volume 3, Number 1. https://septicsystemsaver.net/wp-content/uploads/2022/04/Septic-Tank-Additives_sfqw02.pdf

excavation is difficult, or where space is limited.

Drawbacks include reliance on electricity, high capital and operational costs, and frequent maintenance requirements. Service by a qualified technician can be required every 2-4 months[4]. Implementation of packaged treatment systems will thus need a skilled workforce to support their continuous operation. Chapters 11-61 and 11-62, HAR requires that a packaged treatment system is operated and maintained by a certified wastewater engineer. Chapter 11-62, HAR also requires effluent testing of biochemical oxygen demand and suspended solids.

Source-separation treatment systems

Black water is mainly composed of urine, feces, kitchen sink waste, and flush water, and has high concentrations of organics, nutrients, and pathogens. In contrast, gray water comes from daily washing activities and makes up 50-80% of daily water use[9]. Gray water is much more diluted than black water and can be treated and reused on site in source-separation treatment systems. Source separation is inexpensive, sustainable, and efficient in the use of water resources[6]. It provides a platform for potential recovery of nutrients and reuse of treated water, providing resilience against the impacts of climate change and water scarcity.

Implementing source-separation systems requires modifications to the existing water infrastructure at the user end, a process that could be synchronized with cesspool replacement. Another challenge often reported for these OSWT systems is poor social acceptance, which raises the need for public education initiatives to address misconceptions, highlight benefits, and foster engagement and open discussions.

It is important that the short-term goal of improving nutrient removal in individual systems, and the long-term goal of making available packaged systems and community-based treatment in Hawaiʻi are addressed. New OSWT technologies have potential advantages over conventional septic systems in improvement of performance, enhancement of resilience, reduction of capital and maintenance costs. Nevertheless, no testing facility is currently available to conduct evaluation of these technologies that is necessary before they can be approved for implementation in Hawaiʻi.

Feasibility testing center in Hawaiʻi

Based on the survey conducted by the Cesspool Conversion Working Group

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[9] Guidelines for the reuse of gray water. Hawaiʻi State Department of Health, Wastewater Branch, June 22, 2009. https://health.hawaii.gov/wastewater/files/2016/03/14_Gray_Water_GL.pdf

in 2021, covering eight states (Delaware, Florida, Maryland, Massachusetts, New Jersey, New York, Rhode Island, and Texas), recommendations were provided for testing and approval of new technologies. Standardized applications and testing procedures, and water quality tests performed by certified laboratories are needed to collect data and evaluate the feasibility of new technologies for cesspool replacement in Hawaiʻi[4]. WRRC has been providing services to test the water quality of effluent treated by new OSWT technologies and is committed to continuing to provide those services to the State of Hawaiʻi in water-related issues.

Here we propose an OSWT Technology and Development Center to test the feasibility, standardize testing procedures, and accelerate the adaptation of new technologies, which can provide information and data including technology descritpion and system design, installation, operation and maintenance (O&M) requirements, long-term water quality monitoring, and energy and cost analysis. Commercially available technologies new to Hawaiʻi will be tested and adopted for local applications, potentially developing tailored versions for use in Hawaiʻi. In addition, novel technologies can be developed and tested at the center. The proposed center will focus on representing the interests of Hawaiʻi residents, regulators, researchers, and professionals in the OSWT industry, including designers, installers, and service providers.

<u>For designers and engineering consultants</u>, the center will provide a site for them to test the feasibility of their new technologies in Hawaiʻi. Testing will provide them with the necessary information to seek approval by DOH, customize technologies for implementations in Hawaiʻi, and seek potential collaboration with local and international professionals.

<u>For installers and service providers</u>, the center can be used for training and facilitate the exchange of knowledge, experience, and best practices. Training on site can also help prepare a workforce ready for the upcoming demand for numerous cesspool replacements and continuing maintenance. Potential certifications for industry professionals can also be carried out.

<u>For government agencies and policymakers</u>, the center can be engaged to advocate for the use of OSWT and to shape policies and regulations that promote environmentally sound and cost-effective solutions. Based on the performance data and cost information from the testing of new technologies, DOH can update review procedures and streamline approval processes (*Appendix II*).

<u>For students and researchers</u>, the University of Hawaiʻi WRRC can lead research and training programs at the center. Research initiatives can sustain technological advancements and innovative development of efficient OSWT

technologies. The center can provide educational resources for student training in engineering design, water quality monitoring, and environmental analysis and planning.

The center can also provide a great opportunity for public outreach to educate homeowners and communities about the benefits of OSWT and cesspool replacement in Hawai‘i. This may include information on system maintenance, environmental stewardship, and regulatory compliance. 501(c)3 nonprofit organization, such as Wastewater Alternatives and Innovations, and the University of Hawai‘i Sea Grant College Program can be involved to improve public engagement.

Funds required to establish the center can be partly from the State, which can be leveraged to apply for support from other funding agencies, such as U.S. Environmental Protection Agency and the National Science Foundation. Testing, application, and certification fees from the providers of new technologies can be used to cover the cost of feasibility testing and operation of the center. The center can hire full-time professionals to operate and manage various testing projects. The Department of Environmental Services from City and County of Honolulu can potentially provide an existing site and facilities for the OSWT Technology and Development Center.

Some existing testing centers nationwide with public and university engagement can be referenced as models to establish a new testing center in Hawai‘i. Such examples include the Massachusetts Alternative Septic System Test Center[10], the Center for Clean Water Technology at Stony Brook University[11], the Onsite Wastewater Resource Center at the University of Rhode Island[12], the Onsite Wastewater Treatment Systems website for the Texas A&M AgriLife Extension Service[13], and the Onsite Sewage Treatment Program at the University of Minnesota[14].

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10 Massachusetts Alternative Septic System Test Center. https://www.masstc.org/

11 Center for Clean Water Technology. https://www.stonybrook.edu/commcms/cleanwater/

12 Onsite Wastewater Resource Center. https://web.uri.edu/owt/

13 On-Site Sewage Facilities. https://ossf.tamu.edu/

14 Onsite Sewage Treatment Program. https://septic.umn.edu/

APPENDIX I

ONESITE WASTEWATER TREATMENT SYSTEMS SPECIAL ISSUES FACT SHEET 1, SEPTIC TANK ADDITIVES

Onsite Wastewater Treatment Systems
Special Issues Fact Sheet 1

Septic Tank Additives

Description

Because of the presence of significant numbers and types of bacteria, enzymes, yeasts, and other fungi and microorganisms in typical residential and commercial wastewaters, the use of septic system additives containing these or any other ingredients is not recommended. The benefits of consumer products sold as septic system cleaners, degraders, decomposers, deodorizers, organic digesters, or enhancers are not significant or have not been demonstrated conclusively, depending on the product. Some of these products can actually interfere with treatment processes, affect biological decomposition of wastes, contribute to system clogging, and contaminate ground water. The septic tank/soil absorption field system is the most commonly used onsite wastewater treatment system in the United States. It is relatively low in cost, has no moving parts, and requires little maintenance.

Septic tanks have a number of important functions, including:

- *Remove oils, grease and settleable solids.* The septic tank is designed to provide quiescent conditions over a sufficient time period to allow settleable solids to sink to the bottom of the tank and floatable solids, oils, and grease to rise to the surface. The result is a middle layer of partially clarified effluent that exits the tank to the soil absorption field.
- *Store settleable and floatable material.* Tanks are generously sized according to projected wastewater flow and composition to accumulate sludge and scum at the bottom and top of the tank, respectively. Tanks require pumping at infrequent intervals (e.g., 1 to 7 years), depending on sludge and scum accumulation rates.
- *Digest/decompose organic matter.* In an anaerobic environment, facultative and anaerobic bacteria can reduce retained organic molecules to soluble compounds and gases, including H_2, CO_2, NH_3, H_2S, and CH_4. This digestion can significantly reduce sludge volume in warm climates.

Types of additives and effects on treatment processes

There are three general types of commonly marketed septic system additives:

- *Inorganic compounds*, usually strong acids or alkalis, are promoted for their ability to open clogged drains. Product ingredients (e.g., sulfuric acid, lye) are similar to those used in popular commercial drain cleaners. These products can adversely affect biological decomposition processes in the treatment system and cause structural damage to pipes, septic tanks, and other treatment system components. Hydrogen peroxide, once promoted as an infiltration field reconditioner, has been found to actually degrade soil structure and compromise long-term viability of soil treatment potential. Its use to unclog failed infiltration fields is no longer recommended.
- *Organic solvents,* often chlorinated hydrocarbons (e.g., methylene chloride, trichloroethylene) commonly used as degreasers and marketed for their ability to break down oils and grease. Organic solvents represent significant risks to ground water and wastewater treatment processes. These products can destroy resident populations of decomposer and other helpful microorganisms in the treatment system. Use of products containing organic solvents in onsite treatment systems is banned in many states. Introduction of organic solvents into onsite systems located in states that ban the use of these products may trigger liability issues if ground water becomes contaminated.

- *Biological additives*, like bacteria and extracellular enzymes mixed with surfactants or nutrient solutions, which mirror but do not appear to significantly enhance normal biological decomposition processes in the septic tank. Some biological additives have been found to degrade or dissipate septic tank scum and sludge. However, whether this relatively minor benefit is derived without compromising long-term viability of the soil infiltration system has not been demonstrated conclusively. Some studies suggest that material degraded by additives in the tank contributes to increased loadings of BOD, TSS, and other contaminants in the otherwise clarified septic tank effluent.

Other products containing formaldehyde, paraformaldehyde, quaternary ammonia, and zinc sulfate are advertised to control septic odors by killing bacteria. This objective, however, runs counter to the purpose and function of septic tanks (promoting anaerobic bacterial growth). If odor is a problem, the source should be investigated because sewage may be surfacing, a line might have ruptured, or another system problem might be present.

Another variety of consumer products is marketed for their ability to remove phosphorus from wastewater. These products are targeted at watershed residents who are experiencing eutrophication problems in nearby lakes and streams. Phosphorus is an essential nutrient for aquatic plant growth and limiting its input to inland surface waters can help curtail nuisance algae blooms. Aluminum (as alum, sodium aluminate, aluminum chloride, and activated alumna), ferric iron (as ferric chloride and ferric sulfate), ferrous iron (as ferrous sulfate and ferrous chloride), and calcium (as lime) have been proven to be effective in stripping phosphorus from effluent and settling it to the bottom of the tank. An important side effect of this form of treatment, however, can be the destruction of the microbial population in the septic tank due to loss of buffering capacity and a subsequent drop in pH. Treatment processes can be severely compromised under this scenario.

Finally, baking soda and other flocculants are marketed as products that lower the concentration of suspended solids in septic tank effluent. Theoretically, flocculation and settling of suspended solids would result in cleaner effluent discharges to the subsurface wastewater infiltration system. However, research has not conclusively demonstrated significant success in this regard.

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APPENDIX II

SUPPORT LETTERS

JOSH GREEN, M.D.
GOVERNOR OF HAWAI'I
KE KIA'ĀINA O KA MOKU'ĀINA 'O HAWAI'I

KENNETH S. FINK, MD, MGA, MPH
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STATE OF HAWAI'I
DEPARTMENT OF HEALTH
KA 'OIHANA OLAKINO
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HONOLULU, HI 96801-3378

In reply, please refer to:
File:

December 6, 2023

Dr. Zhiyue Wang
Water Resources Research Center
Holmes Hall 346
2540 Dole Street
Honolulu, Hawaii 96822

Dear Dr. Wang:

Subject: Support for Testing Center for New Alternative Wastewater Systems

The Department of Health (Department) **strongly** supports the concept of having a center to test new technologies for cesspool replacements in Hawaii. The cost of installing a septic or aerobic system can range from $10,000 to $38,000. There is a need for alternative wastewater systems that are more affordable. The center would provide a testing site for these alternative wastewater system. The wastewater systems also would be tested in accordance with the Department's requirements needed for approval.

The center also could be used by design engineers, licensed contractors, government agencies and the students and researchers at University of Hawaii's Water Resources Research Center.

Should you have any questions, please feel free to contact me at (808) 586-4294.

Sincerely,

SINA PRUDER, P.E., CHIEF
Wastewater Branch

DEPARTMENT OF ENVIRONMENTAL SERVICES
KA ʻOIHANA LAWELAWE KAIĀPUNI
CITY AND COUNTY OF HONOLULU

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IN REPLY REFER TO:
DIR 23-79

December 21, 2023

Dr. Zhiyue Wang
Water Resources Research Center
Holmes Hall 346
2540 Dole Street
Honolulu, Hawaii 96822

Dear Dr. Wang:

SUBJECT: Support for Onsite Wastewater Treatment Technology and Development Center

The Department of Environmental Services, City and County of Honolulu (ENV) strongly supports the concept of an OSWT Technology Testing and Development Center to evaluate technologies for cesspool replacements in Hawaii. Part of the proposed Center would be a test facility with a source of wastewater. ENV can provide space for the testing at one or more of our nine wastewater treatment plant facilities on Oahu.

The center can accelerate the approval and implementation of new onsite treatment systems with lower cost and better efficiency, beneficial to households at locations that are not economical to be collected to the City's sewer system. The center also could be used by design engineers, licensed contractors, government agencies and the students and researchers at University of Hawaii's Water Resources Research Center.

Should you have any questions, please feel free to contact me at roger.babcock@honolulu.gov or (808) 768-3486.

Sincerely,

Roger Babcock, Jr., Ph.D., P.E.
Director