Public health risk assessment tool: strategy to improve public policy framework for onsite wastewater treatment systems (OWTS)

Peter Emmanuel Cookey, Thammarat Koottatep, Peter van der Steen and Piet N. L. Lens

ABSTRACT

Public health risk assessment of onsite wastewater treatment systems (OWTS) in the city of Port Harcourt, Nigeria and its environs was carried out between the period of August 2012 and April 2013. The objective of the study was to show how the public health risk assessment tool can be used to improve public policies on OWTS. The study involved desk study reviews of the related literature on OWTS, an audit survey of 245 OWTS in the residential area of the city, a public policy survey of OWTS in Port Harcourt city, a public health risk assessment, field observations and investigations. The results revealed that there were no specific policies, legislative and regulatory standards for sustainability of OWTS practice and no risk assessment considerations in the current policy instruments. In general terms, the public policy instruments of OWTS were found to be inadequate for improved and standard system construction, installation, operations and maintenance, compliance, enforcement and inspection. The outcome of the risk map showed widespread and dispersed risk in the use of OWTS.

Key words | legislation, onsite wastewater treatment system, public health, public policy, risk assessment, standards

INTRODUCTION

Sanitation is an important indicator of development, and poor coverage, such as in Nigeria, poses serious challenges (Adelegan & Ojo 1999), especially in developing countries like Nigeria where access to adequate sanitation facilities is a serious challenge. The WHO/UNICEF (2010); WHO (2012) sanitation coverage for Nigeria records a total of 39% and 35% for urban and rural populations, respectively. According to Shako (2015), figures such as these were obtained from relaxed definitions and low standards, adopted by national governments and the international community (UN-Habitat 2003), probably because anything above, for instance those of Kvarnstrom et al. (2011), could gravely affect the sanitation statistics of many developing countries. Considering that most developing countries design public policies and intervention programmes based on such figures as those mentioned above, it is safe to assume that there will be lax standards and requirements. Public policies and standards for onsite wastewater treatment systems (OWTS) are to ensure the adequate management of domestic wastewater by introduction of cost-effective and long-term options to meet public health and water quality goals. Therefore, the difference between failed and successful OWTS practice is in the adequacy and level of implementation of the relevant and related sanitation policies and legal framework (USEPA 2005).

OWTS such as septic tank systems are the major sanitation infrastructure in Nigeria (Nigeria Demographic and Health Survey (NDHS) 2008; NISER 2010), as is the case...
in most developing countries. Onsite systems collect, treat, dispose/reuse treated wastewater at or near the source of generation (Crites & Tchobanoglous 1998) and are used by a large population globally (Strauss & Montangero 2005). For instance, 25–33% of households in the USA use OWTS (USEPA 2005); 17% in Australia (O’Keeffe 2001); 14% in Greece (Tsagarakis et al. 2001); 400,000 dwellings in Ireland (Gill et al. 2007, 2009); 28% in Turkey (Baker et al. 1998); and in Venice (Italy), more than 140 decentralized wastewater treatment systems (DEWATs) and even more septic tanks are used (Mav 2007; Tromellini et al. 2008; IWA 2011; Libralato et al. 2012). Meanwhile, OWTS are institutionally well established in Vietnam as a treatment system for domestic wastewater (Nguyen et al. 2007) as well as in Thailand (Roomratanapun 2001; Suriyachan et al. 2012).

Septic tank systems, particularly gravity fed systems, involve wastewater sources (dwelling units), tank-based treatment units (made of sandcrete block – septic tanks) and infiltration units (subsurface trench – soak-away pits) (Siegrist et al. 2000; Fidelia 2004; Burubai et al. 2007). Developed countries have consistently and progressively modernized OWTS used guided by sanitation and public health policies. Jones et al. (2004) observed that outdated and ancient OWTS may possibly provide inadequate treatment when based on the current standards/policies of rules and regulations in most developing countries. The modernized OWTS used in most developed countries ensure reliable and advanced treatment of wastewater before groundwater recharge occurs (NSFC 1996; Siegrist et al. 2000; Jones et al. 2004; Swann 2008). They are designed to exploit the physical, chemical and biological processes to achieve highly efficient hydraulic and purification performance (USEPA 1978, 1980) based on explicitly established performance goals (Otis & Anderson 1994; Hoover et al. 1998).

This is not the case in developing countries like Nigeria, where nothing has really changed in the design, operations and regulations of OWTS since the earliest days of their existence; these systems in their current state pose a high risk to public health and environmental quality, and so urgently need change and upgrade (Metcalf & Eddy 1991; Brown & Root 2001). It is, therefore, no surprise that the major public health and environmental challenges of most developing countries’ existing OWTS are in design, construction, installation, maintenance as well as regulatory and policy designs which could (and often do) lead to malfunctions. They are not likely to match up to surrounding urban modernizations. Considering that public policies are designed to guide actions, programmes and plans of government and other stakeholders, then it can be assumed that outdated public policies cannot guarantee solutions for today. Therefore, the high rate of failure and absence of technological improvement of OWTS in many developing countries can be linked to weak and outdated policy frameworks that lead to unclear and inadequate regulations and standards. We assume that it is then expedient to update related public policies to be relevant in context, technology selection and safety. Achieving strong and effective public policies for sanitation treatment systems will require improved technology design, operation and maintenance, as well as standardized risk assessment and management (Siegrist et al. 2000; Brown & Root 2001; Jones et al. 2004).

If it is agreed that adequate operations and maintenance with effective monitoring by regulators can reduce public health risks, then conversely we can assume that an absence of these factors can lead to system failures, which could be associated with inappropriate location and system setbacks, improper design and installation, overloading and physical disturbance, among others; all of these pose enormous public health risks. These are challenges which could be captured in public policies that guide regulations, and such public policies need relevant and reliable data to base directives on. The USEPA (1996) estimated that failing septic systems are the second leading cause of surface and groundwater pollution in the United States as well as the most frequently reported cause of groundwater contamination (Perkins 1984; Yates 1985; Hoxley & Dudding 1994; Nicosia et al. 2001). Many investigators in the US estimate that as many as one-half of all OWTS (septic tank-soil absorption systems) do not operate satisfactorily due to failing systems (Fehr & Pae 1977; USEPA 1977; Butler & Payne 1995; Swann 2008). The dangers of failing OWTS are usually associated with non-upgraded or old treatment systems improperly installed or poorly maintained, which represent a significant source of nutrients and enteric pathogens such as in waterborne diseases (Birkhead et al. 1989; Kramer et al. 1996; Karanis et al. 2007; Naughton & Hynds 2013). The protection of groundwater resources from such contamination is imperative for the effective management of risks posed to both human health and the
environment (Carroll & Goonetilleke 2006a; Burubai et al. 2007; Gill et al. 2009; Palmer-Felgate et al. 2010; Withers et al. 2011, 2012). The OWTS that provides no treatment at all may present the highest risks, while reliable treatment performance reduces risks (Siegrist et al. 2000). If the essence of treatment systems is to reduce human exposure to pathogens and hazardous substances from faecal matter, then risk assessment considerations are crucial (WHO 2006; Stenstrom et al. 2011), and should be factored into OWTS treatment goals to ensure public health well-being and environmental protection.

A public health risk assessment (PHRA) for OWTS was adopted and designed for this study to evaluate the potential health risks from exposure to domestic wastewater effluents and provide quantitative public health risk estimates (Paus- tenbach 1989; Lipton et al. 1993; Suter 1993; USEPA 1998, 2002; Jones et al. 2004). The primary objective was to develop a risk-based decision-making and regulatory framework for individual OWTS (Beavers 1999), to improve sanitation programming, planning and regulations (Cliver 2000), and provide verifiable data and direction for decision/policy-makers (IUCN/UNEP/WWF 1991; Geary 1992; Keeley & Scoones 2003; UNEP 2007; Stenstrom et al. 2011). This paper aims to initiate dialogue among public health, urban planning and engineering practitioners for better integration, because it is not enough to collect data on public health risk if it cannot influence policy practice. The intention of this study is to show how the information gathered from public health risk assessment of OWTS can be used for the improvement and formulation of public policies, which is important for the translation of research into policy and action.

**METHODOLOGY**

**Study site**

The study was conducted in Port Harcourt city, capital of Rivers State (Nigeria). The city is situated at the southern tip of the country, with a surface area of approximately 30,000 km², and is located along rivers and creeks, and partly on marshlands and mangrove swamps. The population of Port Harcourt city (within its municipal boundaries) was estimated to be about 800,000 in 2006, and is estimated to be 1.9 million for Greater Port Harcourt (GPHDM 2008), see Figure 1. Port Harcourt falls within the tropical rainforest belt, which is characterized by high rainfall, high temperature and high humidity all year round with an annual average rainfall of 4,000 mm. Water- and sanitation-related diseases account for approximately 80% of the illnesses reported in Rivers State (NDRDMP 2001; GPHDM 2008; PHWURSS 2009).

Water supply from the Port Harcourt Water Corporation is distributed through ancient reticulation systems installed in the 1950s that have not been maintained or upgraded in spite of the city’s rapid expansion. The bulk of the water supply is obtained from private boreholes, and sewage infrastructure is mainly provided by septic tanks, pit latrines, jetty toilets and direct flushing into the rivers. The poor state of sanitation has a direct impact on the natural environment and directly threatens groundwater quality (the city’s major source of water supply). There are several environmental and sanitation legislations and policies as well as ministries and agencies that influence the practices of OWTS in the study area at the federal level, Rivers State and the two local governments that administer the study area (Port Harcourt City and Obio Akpor LGAs). The 1999 Constitution, as amended, delegates all sanitation matters to States and Local Governments (Federal Republic of Nigeria (FGN) 1999).

The specific OWTS related and relevant public policies include: the Rivers State Water Supply & Sanitation Policy 2012, which provides a framework for sustainable water and sanitation governance, fiscal responsibility, accountability and regulation; the Rivers State Water Sector Development Law 2012, which provides for the establishment of a state water supply and sanitation (WSS) service delivery agencies, charged with the responsibility of ensuring domestic and industrial sewage management, and a state WSS coordinating mechanism; Rivers State Public Health Laws 1999; Rivers State Environmental Protection Agency Law 1986. It is interesting to note that in all these institutions and related regulations, there are no specific details on design, construction, installation, operation and maintenance, and no specific government agency/ ministry responsible for OWTS. This study reveals that available regulations relating to OWTS tend to be weak, vague and too generalized, making compliance/enforcement almost impossible (Supplementary information Figure S1, available in the online version of this paper).
Data collection

Desk study review

This involved studying various related literature with respect to OWTS. Specific literature on sanitation, sewage and wastewater management was reviewed. Relevant data on OWTS plan approval processes were also reviewed. Other documents reviewed were policy guidelines, legislation, regulations and strategies for better understanding of the policy arena.

Residential performance audit survey of OWTS in Port Harcourt city

The 246 households (consisting of a minimum of six individuals per household) were sampled using a representative

Figure 1 | Map showing study location in Port Harcourt/Obio Akpor, Rivers State, Nigeria.
The sample size calculated based upon the 1.9 million population of Greater Port Harcourt city (GPHDMP 2008). The survey was based on a 95% level of confidence by applying a simple random sample equation: \( n = N/1 + Ne^2 \) (where \( n \) = sample size, \( N \) = total population and \( e \) = the acceptance of probability of error equal to 95% or 0.05) (Tashakkori & Teddlie 2003). A standard OWTS audit questionnaire was developed to elicit information from 246 households, and 41 questionnaires were served in each of the six zones (Zone 1, Diobu/DLine Area (DD); Zone 2, Mile 4/Agip Area (MA); Zone 3, Town/Borokiri Area (TB); Zone 4, Abuloma/Woji/Elelenwo Area (AWE); Zone 5, Rumuola/Rumukota/Rumukoro Area (RR); and Zone 6, Rumumasi/Elekehia/Rumudara Area (RRE)), which the study area was divided into for ease of coordination. The heads of households (or caretakers) were interviewed and granted permission for physical inspection of OWTS and groundwater boreholes for their households as well as written consents. Data were collected via a structured questionnaire, which consisted of 74 questions. These questions were a mixture of multiple choice and open-ended (Supplementary Figure S2).

The performance audit survey of OWTS was developed to provide situational field information that would support and validate the risk assessment as well as contribute to the assessment of risks related to OWTS siting, design, construction and operations and maintenance. This audit checklist focused on screening level analysis of the engineering configuration of the systems as well as observing the ecological impact of the system on the environment. The audit system was designed to provide in-depth analysis and monitoring of the system in order to identify the gaps and shortcomings of the system.

**Public policy survey of OWTS in Port Harcourt city**

A standard questionnaire was developed to collect useful information from regulators, environmental health officers, city engineers within the municipality office, architects, urban and town planning officers, etc., working with relevant government and municipal departments, using a purposive sampling method based on the snowball technique (Tashakkori & Teddlie 2003; Teddlie & Tashakkori 2009). To ensure equal treatment, ten questionnaires were administered in each relevant state government ministry and agency, and the two municipal administrations where these cadres of officers are assigned to work. Of the 100 questionnaires given out, 85 were successfully completed and returned for analysis. Data were collected via the survey using a structured questionnaire, which consisted of 56 questions on the following issues: background information, sewage management legislation and regulation, the system plan approval process and compliance inspection and monitoring.

**Public health risk assessment (PHRA)**

The public health risk assessment aspect was used to evaluate potential health risks from exposure to wastewater effluents or environmental media exposed to these effluents. The goal was to provide quantitative estimates for constituents of concern that originate from wastewater treatment systems. The public health risk components of primary importance were nitrate and faecal coliform organisms (NAS 1983; USEPA 1989; Kolluru et al. 1996; Jones et al. 2004) because of the concerns regarding health and the environment (WHO 2003, 2006, 2008). Therefore, a total of 20 duplicate water samples were randomly collected from households with OWTS and privately owned drinking water boreholes (groundwater) in sterile glass/plastic bottles. The location of the wells was determined by the use of GPS and they were analysed according to the procedures outlined in Standard Methods (AWWA & WEF 2005). We also measured for the set-back between the source of groundwater supply (boreholes) and the OWTS in the premises.

**Data analysis**

Residential performance audit and public policy surveys of OWTS responses were analysed using descriptive statistics with the help of Excel Statistical packages (Ryan & Bernard 2003; Yin 2009; Creswell 2009). Other analyses were the determination of the mean, standard deviation, frequency and percentages’ computation. The results of the water quality analysis (nitrates and faecal coliform organisms) were subjected to further mathematical computations by inputting the value obtained from the laboratory into the public health risk assessment equations to estimate exposure concentration, routes and population at risk according to Jones et al. (2004), USEPA (1989) and Haas et al. (1999). These processes aided in the quantification and characterization of...
public health risks from OWTS, and the results were then fed into GIS software to produce the risk map of the study area. For the PHRA, correlation analysis was carried out between the risks of infection and distance of OWTS (septic tank systems) to boreholes based on three scenarios: quantification and characterization of daily ingestion of nitrates and faecal coliforms by drinking water and beverage making; accidental ingestion of nitrates and faecal coliforms while taking baths; and ingestion of nitrates and faecal coliforms through dermal contact while taking baths for adults and children in all cases. For more details on the PHRA procedures and analysis see Cookey (2013) and Cookey et al. (2014, 2015).

RESULTS

Residential performance audit on OWTS

General information on OWTS in Port Harcourt

The land-use pattern of residential areas of the city is mostly multi-family residency units, closely followed by single-family units and some business/commercial enterprises. The average age of OWTS ranged from 5–30 years and most households channelled their wastewater into open drainage systems and free-flow in the environment, especially during heavy rains; all the OWTS were left to operate at the mercy of nature. All audited systems were in different stages of poor maintenance and disrepair, with very few inspections by health officers in over five years. Results also showed that adequate and specific regulatory standards for OWTS were completely lacking, making it very difficult for the regulators to carry out quality compliance inspection/monitoring. The general public health and environmental sanitation laws are somewhat inadequate. Also, poor and inadequate OWTS regulations and design standards actually restrict the adoption of other innovative technology selections.

Site conditions and system design

The audit process revealed serious environmental nuisances resulting from free flowing wastewater. The all year-round high rainfall in the study area poses serious erosion, flooding and water-logging hazards, which threaten the normal operations of the systems and are worsened by the high water table of the area. It was revealed that these systems were not properly designed, configured and constructed, and often lacked internal structures such as baffle walls, inlet tees, and other external features such as manholes, etc., which could have significantly improved effluent quality. With no clear-cut standards in the state and country, the rule of thumb of 3 meters setback to buildings, 50 meters and above setback to drinking water sources and 150 meters setback to waterfront was not observed in most of the facilities.

Quality of tanks, distribution and absorption systems

The study revealed the poor structural condition of the septic tanks, which led to serious damage and failure of the distributing systems. Tanks were structurally unsound and unacceptable, with varying degrees of cracks, deterioration and damage, infiltration of surface water and run-off into the tanks leading to rapid filling of the tanks. It was also noticed that effluent was surfacing at the absorption area of the systems in most premises visited (Figure 2).

Public policy survey of OWTS

Background information

The majority of officers interviewed were responsible for design and construction, system plan approvals and health inspection and had 5–25 years' level of experience. The regulatory responsibilities of these officers in relation to OWTS include, among others, monitoring and evaluation, inspection and recommendation for corrective actions, disposal of sludge from systems, containment of sewage, design, installation and construction, approval of building plans and supervision of construction sites, plus prosecution of sanitation- and environmental-related cases.

Suitability of OWTS policy, legislation and regulation

The survey revealed that sewage management policies, legislation and regulations were very inadequate and inappropriate for any improvement of OWTS. There were no specific technology and design standards (a situation common in the whole country), which has led to the poor
quality of OWTS (Figure 3). The respondents revealed that there were no elements of risk assessment considerations in existing legislation on sewage management, making it difficult to improve design and construction; this is the reason why for more than 100 years there has been no form of improvement in design, technology and construction.

**OWTS plan approval and system inspection**

The respondents noted that there were few or no considerations for site evaluations and soil testing before system approval for OWTS construction. There were no permit renewals after systems had been constructed, making

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**Figure 2** | Physical structures and conditions of OWTS in Port Harcourt City as evaluated by interviewed heads of households during the residential OWTS audit survey. Zone 1, Diobu/DLine Area (DD); Zone 2, Mile 4/Agip Area (MA); Zone 3, Town/Borokiri Area (TB); Zone 4, Abuloma/Woji/Elelenwo Area (AWE); Zone 5, Rumuola/Rumukota/Rumukoro Area (RR); Zone 6, Rumumasi/Elekehia/Rumudara Area (RRE).

**Figure 3** | Suitability of OWTS public policy on environmental quality as evaluated by interviewed officers.
system owners nonchalant about operations and maintenance. The survey also revealed that there were no specific OWTS inspection mechanisms used by the Environmental Health Department of the Rivers State Ministry of Environment for approval of sanitation facilities. The common practice was the routine general health inspection, which is more reactive than preventive. The health officers noted that, on average, OWTS nuisance detection ranges from 20 to 80 cases monthly. Some recorded failure nuisances are: improperly sited systems, incomplete installation of systems, site disturbances, unmet separation distances, wastewater exposure, cracked tanks, wastewater surfacing and dampness, etc. The respondents rated the structural quality of an average OWTS in the study area to be very low. This can be linked to the lack of standards that, in turn, is responsible for poor implementation (Figure 4).

Public health risk assessment map

Coliform organisms were used as indicator bacteria to assay the level of bacteriological contamination of the water sources. A total of 20 water samples were analysed in duplicate for faecal coliform count and nitrates. These results were subjected to single factor Anova test and gave a 98% confidence level, showing that the data were normally distributed.

However, water samples from 11 sites showed no presence of faecal coliform organisms, compared to water samples from nine other sites. Therefore, only water samples from nine sites did not meet the WHO and Nigerian Drinking Water Quality Standards for microbiological quality. On the other hand, nitrates’ minimum value was 0.039 to 8.170 mg/L. In general, nitrate parameters were in compliance with the Nigerian and WHO Standards for Drinking Water Quality. The results for the microbiological quality of the water samples showed that those samples with high contamination levels were in common with boreholes that were below 8 meters’ safe distance from the septic tank systems in the study area.

These results were then fed into the public health risk assessment equations for the estimation of exposure concentration, routes and populations at risk for children and adults. This provided quantification and characterization of public health risks from OWTS in the study area, which was then used to produce the OWTS risk map (Cookey et al. 2014, 2015). The results of the risk of infection for faecal coliform organisms suggests that 45% of the sites were high risk areas and there was a correlation coefficient of 0.86, which suggests that there was a degree of relationship between the risk of infection and the distance to septic tank and borehole water. Nitrates were found not to pose any hazards in the study area (Table 1).

The main purpose of the public health risk map was to indicate areas that are at risk as a result of the use of OWTS for sewage treatment and management in the study area. The outcome of the risk map showed the widespread risk from microbial and nitrate contamination of groundwater resulting from the use of OWTS in Port Harcourt city. The zones with ‘high risk’ are the high density areas of the city. The map (Figure 5) showed that out of the six zones, only one zone is a ‘low risk’ area. This process has two implications: the identification of ‘at risk’ areas and identification of areas that should not have the density of septic systems increased or where appropriate assessment is needed to ascertain the most suitable DEWATS.

DISCUSSION

The OWTS performance audit discovered that the common system failures prevalent in the study area were discharge of raw sewage directly into the environment, poor structural conditions, water infiltration into the system, ponding of
the system, sludge surrounding the distribution system and clogging of the absorption area. Generally, most of the septic tanks surveyed in this study were situated dangerously close to the private groundwater supply source (all households depend on boreholes for their water supply), poorly designed/installed and hardly ever maintained, with cracks causing leakages and odour nuisances as well as discharging their waste into the open environment. No considerations for soil type, absorption, adequate distance, proper structure and design were taken.

This is quite worrisome, because the OWTS is the major system for sewage treatment in the city and the study covered the high density, middle class and affluent areas and found the same conditions at varying degrees. The high density areas were more grievous, probably because there are more people using a particular system. This is compounded by a weak disposal system that encourages direct discharge to the environment, even surface water. The picture painted by the public health risk assessment revealed the real time status of the city’s domestic sewage control system; this is a situation that can truly be corrected by proper and adequate regulations and standards.

The national and various state policies on sanitation are vague and ambiguous. In Rivers State, for instance, the current legal framework for the management of sanitation is grossly inadequate for sustainable OWTS in the capital city.

Table 1  | Nitrates and faecal coliform concentrations in groundwater boreholes, hazard quotients and risk of infection, respectively, in Port Harcourt city as well as the boreholes’ GPS locations, distance to septic systems

<table>
<thead>
<tr>
<th>No of groundwater boreholes</th>
<th>Distance from OWTS (m)</th>
<th>Age of borehole (years)</th>
<th>Measured mean conc (mg/L) nitrates</th>
<th>Adult</th>
<th>Child</th>
<th>Ingestion of contaminated groundwater with (mg/L) nitrates from OWTS</th>
<th>Hazard quotient (mg/kg.day)</th>
<th>Faecal coliform mean counts cfu/100 mL</th>
<th>Ingestion of contaminated groundwater with faecal coliforms from OWTS</th>
<th>Risk of infection</th>
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<td>75</td>
<td>1.24 × 10⁻¹</td>
<td>2.02 × 10⁻¹</td>
<td></td>
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<tr>
<td>18</td>
<td>11</td>
<td>25</td>
<td>5.30</td>
<td>9.1 × 10⁻²</td>
<td>2.1 × 10⁻¹</td>
<td>0</td>
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<td>0</td>
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<tr>
<td>19</td>
<td>6</td>
<td>18</td>
<td>0.39</td>
<td>6.88 × 10⁻³</td>
<td>1.6 × 10⁻²</td>
<td>23</td>
<td>9.25 × 10⁻¹</td>
<td>9.76 × 10⁻¹</td>
<td></td>
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<tr>
<td>20</td>
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<td>30</td>
<td>4.46</td>
<td>7.6 × 10⁻²</td>
<td>1.8 × 10⁻¹</td>
<td>0</td>
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</tbody>
</table>

Source: Cookey et al. (2014, 2015).
of Port Harcourt. There are several related policies that have not translated into laws and/or regulations because they are not clear, are over-generalized and open to all kinds of interpretations. When the government has no position or clear standards for OWTS, then every house builder is left to determine the standards. The local governments also have no by-laws for OWTS, but depend on the requirements adopted from the State’s Public Health laws of 1959. Since homeowners choose which standards to follow when designing OWTS for the houses they build, it is then understandable that technology uptake that ensures effective wastewater treatment can be really slow. The USEPA report of 1977 to Congress on the issue of expanding the use of OWTS concluded that adequately managed OWTS are cost-effective and long-term options for meeting public health and water quality goals. This report helped Congress to formulate laws that changed the way OWTS were operated and maintained in the US. In the study area, there was no operation and maintenance practice at all, as there used to be in the US (USEPA 2002). The US situation was based on the fact that OWTS regulatory management approaches relied on homeowners to assume full responsibility for O&M, but lacked adequate and clear public policy at that time; this has since been corrected by putting in place adequate and appropriate regulatory frameworks and standards for OWTS.

The city of Port Harcourt, however, has no specific legal framework addressing OWTS. For example, the Rivers State

![Figure 5](https://iwaponline.com/washdev/article-pdf/6/1/74/595188/washdev0060074.pdf)
Environmental Sanitation Authority, the main agency responsible for sanitation in the state, has no specific provisions for OWTS. The law only makes provisions for the Agency to control and supervise night soil services in places with pail or bucket systems and pit latrines. There is no mention of the OWTS (septic tank systems) used by more than 80% of homes and businesses; understandably so, since the law derives its provisions from the Public Health Laws of 1959 as amended in 1999. The law has not graduated to present times and so cannot make provisions for issues like technology selection, design and construction, operation and maintenance, inspection and monitoring – since it does not even recognize the OWTS. It is, therefore, safe to assume that the weak legal framework is in some ways responsible for the poor state of OWTS in the city, and the regulators are not equipped to correct the situation.

Consequently, given the threat of OWTS to public health and environmental quality, it is expedient that public policies be designed to tackle the challenge from design to maintenance. The outcome of the risk map shows the spread of risks in the use of septic tank systems, just as Carroll et al. (2006b) showed in their risk map, by identifying at risk areas to serve as a guide for improved and sound OWTS planning and programming. The findings of the public health risk assessment will go a long way to assist in the design of adequate and appropriate public policies, which can support the development of effective legislation and specific regulations and standards, as well as specific agency or ministry departments responsible for sewage management in the city and state.

Learning points

1. The public health risk assessment (PHRA) tool can improve public policy processes for OWTS.
2. The PHRA tool can determine ‘at risk areas’ as a result of poorly designed and maintained OWTS technology, thus leading to the development of appropriate intervention/remedial programmes to reduce public health risks.
3. The process of PHRA has three implications: the identification of ‘at risk’ areas; the identification of areas that should not have more OWTS introduced; and the areas that need appropriate assessment to determine the best practicable OWTS options.
4. It can also reduce the failure rate of OWTS such as septic systems, as well as addressing issues associated with design, construction, operation and maintenance.
5. PHRA encourages relevant government agencies to develop specific public policy instruments that will ensure effective management programmes, O&M, design, technology selection and better coordination among actors and institutions.

CONCLUSIONS AND RECOMMENDATIONS

The study was designed to examine the use of public health risk assessment to improve the public policy framework for OWTS in the city of Port Harcourt. The following are the main conclusions of the research: there is serious contamination and degradation of the environmental quality, especially in the case of uncontrolled free flow wastewater from dysfunctional OWTS due to varying degrees of system leakages, cracks and damages. Also, 95% of septic systems were of poor structural condition and configurations, and the suitability of sewage management and other related legislation and regulations was grossly inadequate. Furthermore, there are no specific OWTS technology system design standards. This is responsible for the lack of improvement in the quality of sewage management services. The study further revealed that there are no elements of risk assessment considerations in existing legislation on sewage management in the state (and in the country) and governance instruments are archaic, making it difficult to improve design and construction. Moving forward may require the establishment of a department for sewage control within the Rivers State Ministry of Environment responsible for developing suitable policies and a legal framework for the design, construction, installation, operation and maintenance of OWTS.

Also, state and local governments in Nigeria could develop well-thought-out strategies that consider factors such as design options, site conditions, operations and maintenance requirements, periodic inspections, monitoring and evaluation, interventions and financial support. The public health risk assessment tool can be factored into public policy as well as extensive and intensive strategy development for OWTS. This study aligns itself with the
recommendation for proper and sustainable OWTS. Conclusively, well developed public health risk assessment (PHRA) of an OWTS framework, when factored into the public policies arena, can help to provide the foundation for improvement of sanitation policy for developing countries, which can be a good driver for the achievement of universal access to adequate sanitation.

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