DEMYSTIFYING USE OF SEPTIC TANKS FOR WASTE WATER TREATMENT IN DEVELOPING COUNTRIES.

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DOI:10.53974/unza.jonas.5.1. Article No. 711

ABSTRACT

The narrative that septic tanks are agents of ground water pollution, has contributed to the false negative responses that are experienced any time an installation of these tanks is undertaken. To demystify this narrative, it was imperative to explore different perspectives from social-cultural environment to technological one. The study used qualitative multiple case study approach, to review available published literature, surveys and experimental studies on septic tanks. To resolve the challenge of low sanitation coverage that may risk achievement of SDG 6.2, focus should shift from conventional centralised systems to onsite in this case septic tanks. Within the context of septic tanks, dome shaped digesters should be preferred because of structural integrity when tested for deformations, bending moments and shear forces under different combinations of loads. The social perspectives of pollution, caused by septic tanks, should not stand if baseline data on variables such as space, soil formation and strength of material are conducted. To avoid environmental contamination, areas designated for septic tanks should be delineated as such. An inventory of all septic tanks should be kept. Consultants and developers involved in selection of waste water treatment options, should avoid false negative response and focus on empirical results, after delineation. The research findings have indicated that dome shaped digesters as opposed to traditional rectangular septic tanks, should be adopted if developing countries are to improve sanitation coverage.

Keywords: Demystify, Septic Tanks, Sanitation, Waste Water

INTRODUCTION

Developing countries are now facing a serious challenge to provide sanitation services in urban areas, due to unprecedented urbanisation. The massive urbanisation is stressing the existing sanitation infrastructure which is mostly dilapidated and poorly constructed. The need to expand these facilities is impeded by lack of financial resources, for such capital-intensive projects. Governments are emphasising on expensive centralised systems as the sole method to provide sewerage services. This narrative is changing, because the appetite to develop systems away from conventional ones has grown. The

normal practice(business as usual) in the management of sanitation in urban areas, should not emphasise on conventional sewerage, and waste water treatment as the only approach to treat waste water, if developing countries have to achieve universal safely managed sanitation (Gambrill *et al.,* 2020). These alternative systems should include septic tanks and decentralised systems. Depending on the approach, a transition from single household septic tank to clustered or decentralised system is non-negotiable.

Sanitation Coverage in Developing Countries

In many low-income and developing countries, less than 50 per cent of the population use safely managed sanitation (Jeannette and Sebastien, 2017). Unless effort to adopt alternative systems to improve coverage, 90 per cent of developing countries may not achieve Sustainable Development, target 6.2 of the Sustainable Development Goals(SDGs) "By the year 2030, achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations" (United Nations, 2015).

To increase the coverage in developing countries, researchers and consultants should encourage low-cost household technologies, as a preference to centralised systems. Low-cost systems offer alternative means of addressing sanitation in a sustainable and integrated manner (Montgomery and Elimelech, 2007). To achieve basic sanitation in developing countries, the rate of coverage has to increase from an estimated 0.7 percentage points per year to 5 percentage points per year (United Nations, 2015).

Historical Role of Septic Tanks

The antique definition of a septic tank, illustrates a horizontal continuous flow one-story sedimentation tank, which technically allows flow slowly in order to permit suspended matter to considerably settle at the bottom. The organic matter is retained to allow anaerobic decomposition and the resultant is organic matter changing to liquid and gaseous state. This reduces the quantity of sludge that require disposal (Baumainn and Babbitt, 2007). However, other researchers argue from the perspective of maintenance. A case study conducted in Hanoi-Vietnam and Bangkok –Thailand found that septic tanks' performance was questionable. Results indicated that pollutants were just converted to dissolved form with presence of BOD, TKN, NH4 and PO4. This poor performance was attributed to training of operators (Nam *et al.,* 2009).

Conversely, another early scholar, McDonnel maintained that a septic tank is very efficient, economical and satisfactory for dwellings which are unserved by public sewerage system as a method for waste disposal (Baumainn and Babbitt, 2007). Additional investigations have indicated that treatment by conventional septic tanks can be more inefficient, unless modifications are carried out on additional baffles and disinfection (Anil and Neera, 2016). Placing vertical baffles and inclusion of Zeolite

filter, resulted in a removal rate of 99.9 percent total coliforms, 99.57 per cent total suspended solids, 46.8 per cent Ammonia Nitrogen, 31.08 per cent of Nitrate and BOD 94.4 per cent (Anil and Neera, 2016).

Other modifications include the development of Up-flow Thermophilic Septic Tank (UTST) which is more of an innovative onsite treatment technology. It promotes the growth of thermophilic microorganisms and Blackwater. Microorganisms are introduced in black water feed, and laboratory results, at different temperatures and on average, a removal rate of 75 per cent of BOD was achieved (Koottatep *et al.,* 2020).

Solar septic tanks, have more recently been developed as a technology to improve performance. Further, the effluent from the septic tank is channelled into a multi-soil layer based constructed wetland (MSL-CW). The removal rate of total BOD ranged between 78 per cent to 82 per cent. The drive to improve performance has now extended to demystify the whole utilisation of septic tanks. It is clear that divergent theories have existed before, and in the recent past. More negative views are hinged on contamination caused by these tanks. These investigations include the more recent methodology to test the discharge for the presence of products such as prescription drugs, over the counter drugs and personal care products. These investigations have substantiated the claim by the presence of these products in insignificant amounts of less than a milligram per litre (Ramage *et al.,* 2019).

DEMYSTIFICATION OF SEPTIC TANKS

The situation analysis, of the role of septic tanks in sanitation improvement, illustrated that several perspectives of researchers focused on social-cultural, environmental and natural resources, technological and operational perspectives. Variables on each perspective have been outlined. However, the knowledge gap existed on how these should be related to sanitation coverage improvement. An analysis on whether these variables were material enough to guarantee abandonment septic tanks at the expense of basic sanitation was paramount. The questions thereof were; to what extent can this perspective be material? Can a transitional approach be adopted? Can space, soil conditions and strength of construction material be parameters to trigger transition (Transition theory) from single septic tank to decentralised (clustered septic tanks) and finally a decentralised system be applied?

Therefore, to create a baseline, these parameters were analysed in Table 1 using the United States Environmental Protection Agency–source water protection program (EPA, 2021).

Table 1: Analysis of Influencing Variables

Parameter	Variables			
	Delineation	**Inventory of sources of contamination.**	**Susceptibility of threats**	**Mitigation**
Space	*Average space*	*Within septic tank catchment*	*Record magnitude*	*prevent reduce and eradicate threats*
Soil conditions	*A base line required*	*Compare onsite conditions to historical data*	*Record magnitude*	*prevent reduce and eradicate threats*
Strength of material	*Prescribe material*	*Relate to standard materials.*	*Record magnitude of weakness*	*Additional reinforcement*

In the event that a choice has to be made, after pre assessment using the three variables, limitations should be prescribed so that a single septic tank should be transitioned to clustered septic tanks to reduce multiple sources of contamination to a single point, depending on how many tanks within a catchment can be interconnected. The final puzzle in the transition theory is to finally connect a cluster of isolated septic tanks into a decentralised system, that can feed into a water body and a natural or built wetland

Social-Cultural Perspective

Social-cultural perspectives do and do not influence inferential decisions. The evaluation of septic tank utilisation has leaned towards the negative due to the wrong narrative that has been presented by society. The mention of a design, that incorporates installation of septic tanks as a sanitation improvement measure, has normally received a false negative response.

The phenomenon of false negative response, was propagated during an experiment conducted to examine decision to shoot in a weapon identification task in which the influence of culture stereotype, and perceived threat on false positive error was investigated (Kelvin *et al.,* 2010).

Without a false negative response, septic tanks can be viewed as a solution to massively improve sanitation coverage, and all developing countries should be on the way to achieve SDG 6.2. To further illustrate the social bias, a study conducted in Ashanti Region, Ghana found that 25 per cent of boreholes for portable water located between 0-39 meter of the septic tank catchment, showed contamination with Escherichia Coli, Salmonella and faecal coliforms (Takal and Quaye-Ballard, 2018). However, the missing analysis in the study was the results on structural integrity and soil formation within and around the septic tanks investigated. This false negative narrative was made with one sided empirical data.

It was the researcher's strong view that social-cultural perspectives should include a holistic set of variables like Soil analysis and structural integrity of septic tanks. If Social –Cultural perspective are to be included in assessment for utilisation, it should be in the context of Community Participatory Approach (CPA), during system design and selection, with all possible options presented to beneficiaries. This approach is highly encouraged for peri-urban and rural areas that are a fertile ground for poor sanitation options.

Environmental and Natural Resources Perspective

To understand the environmental and natural resource perspective of septic tanks, it is crucial to assess the life cycle based on three permutations and categories namely; urban, peri-urban (semi-urban) and rural areas.

A study conducted in Poland, illustrated the assertion though focused on pre-constructed units by material such as fibres. It was indicated that life cycle comparison is initiated by septic tank registers showing the capacity, number of users and frequency of disposal. These factors are key to understanding the environmental interaction of septic tank effluent (Burchart-Korol and Zawartka, 2019). This approach relates well with variables outlined in Table 1. The narrative that all septic tanks pollute is not correct, empirical evidence is required by conducting an extensive soil hydraulic conductivity test.

In order to advance the use of septic tanks to improve the low sanitation coverage in developing nations, environmental baseline for all areas earmarked for development through septic tanks should be established through delineation (Table 1). Key tests to be considered should include but not limited to; soil porosity, soil resistivity, soil water content, bulk density, organic carbon, saturated hydraulic conductivity and soil PH.

In some areas, there is already Seasonal high ground water and In-situ ground water investigations are non-negotiable to conduct. Other areas show good Subsurface Soil absorption characteristics and, in such cases, septic tanks will perform well.

Technological and Operational Perspective

There should be a good justification why despite the advancement in technology, the septic tank remains in use. The main reason is low cost associated with treatment, and that a single septic tank unit can reduce the organic matter up to 45 per cent. Other designs can achieve a removal rate of up to 78 per cent when the modification includes an MSL-CW (Koottatep *et al.,* 2021).

On the other hand, over forty million residents in the United States have utilised onsite waste water treatment or decentralised sewerage collection. All these systems purely depend on septic tanks for primary treatment.

In discussing septic tank designs, the belief and theory has skewed towards retention required for the effluent as in the case of stabilisation ponds. However, the

theory should not apply to small septic tanks. The main focus should be structural integrity of the septic tank. In this case, the inclination should be to dome shaped digesters as compared to rectangular designs. Dome shaped digester performs better in deformations, bending moments and shear forces under different combinations of loads (Ashim & Chinmoy. 2012). The shear forces that may occur, in weak soil formation, can be sustained when a dome shaped digester with a conical base is installed.

TRANSITION FROM SEPTIC TANK TO DOME BIO DIGESTER

To achieve sufficient structural stability, a waste water structure requires to be stable in both horizontal and vertical movement. Sudden loads are a source of concern for buried structures. The impractical loading concept, on most rectangular septic tanks remains, questionable as lack of structural analysis by the contractors engaged contribute to septage leakage.

For structural integrity to be guaranteed as the appetite for septic tanks increase, dome shaped digesters (Fig 2) should be considered as compared to traditional rectangular ones (Fig 1). The desire for dome shaped structures is as ancient as the septic tank theory. In the Mughal era, the concept was used with a purpose of lending symmetrical and enhancement of structural aesthetics (Ashim & Chinmoy. 2012).

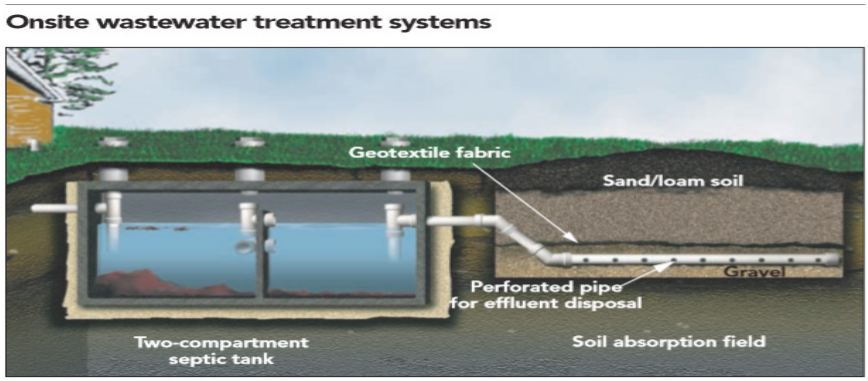

Figure 1: A Septic Tanks and Soil Aborption Filed *[Texas A & M AgriLife extension, 2021*]

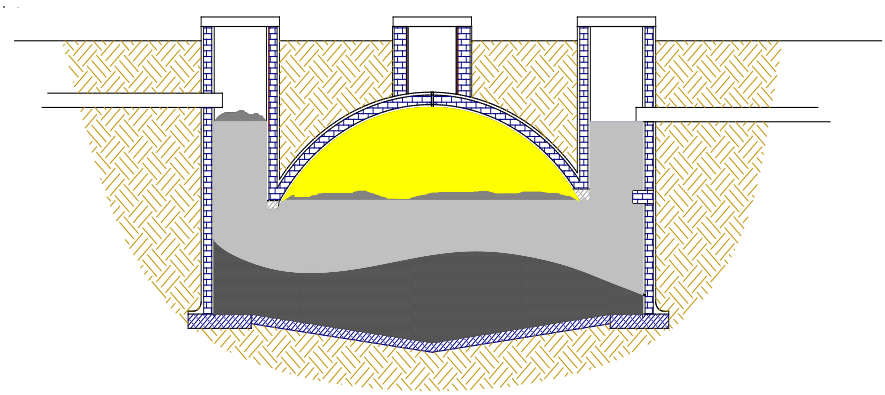

Figure 2: Dome Shaped Digester-courtesy Author

Figure 3: Construction of dome Shaped Digesters *Source: Chris, 2008*

CONCLUSION

To fully utilise septic tanks in developing countries, and subsequently increase sanitation coverage, all perspectives from cultural, environmental and technological variables have to be assessed. Consultants and developers involved in the selection of waste water treatment option, should avoid the false negative response and focus on empirical results after the process of delineation. The research findings lean towards dome shaped digesters as opposed to traditional rectangular septic tanks.

Hydraulically, dome shaped digesters easily match land availability and have a high structural stability (Bounds, 1997). A comparison made between a flat roof structure and a dome roof structure on deformations imposed under lateral loading. Dome structures, performed better in deformations, bending moments and shear forces under different combinations of loads (Bounds, 1997). Therefore, as developing countries desire to improve waste water treatment, the most economic design is a dome shaped digester.

The social benefit to utilisation of dome shaped digester is in the by-product of methane gas produced that can be utilised for cooking depending on gas consistency. In terms of quality of solid treatment, performance regarding organic load reduction in dome shaped digesters is more preferred.

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