Journal of Civil Engineering Forum, January 20XX, 8(2): 147-156
DOI 10.22146/jcef.3812
Available Online at http: https://jurnal.ugm.ac.id/jcef/issue/archive

The Mandatory 4 Years Desludging Frequency of Underground Septic Tanks in Residential Areas: A Case Study in Sibu Sarawak, East Malaysia

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SUBMITTED 27 August 2021 **REVISED** 15 October 2021 **ACCEPTED** 12 November 2021

ABSTRACT Underground septic tanks are the most common and conventional primary black water treatment adopted by local households in Sarawak. To ensure its usefulness, periodic mandatory desludging or emptying of the various types of rateable holdings was enforced from 1998. The current mandatory desludging frequency is 4 years for residential households, although its effectiveness is still not clear, substantial annual finance and subsidies are being allocated by the Sarawak State Government. In this study, the underground septic tanks in Sibu located in residential areas in Sarawak, East Malaysia, were evaluated quantitatively based on the measured faecal sludge with a known retention time in respect to the regulated desludging frequency. Furthermore, various problems were encountered during the initial measurement carried out by sludge judge which typically used by the wastewater treatment and chemical plants. A modified PVC pipe was proposed to overcome these observed problems. This has greatly improved the measurement time and substantially reduced unwanted impediments for the contractor during desludging. The back analysis results showed that the recommended desludging frequency based on the ratio of total sludge and scum to the effective working volume in 30% and 50% thresholds for residential areas were 3.82 and 6.36 years, respectively. Furthermore, it was discovered that there was a potential to adjust the existing mandatory 4 years desludging frequency to a longer period for cost-effective consideration. This study is strictly on the physical quantity measurement of sludge and scum volumes for the known retention times. The complex influences of microbiological activities, micro-environmental factors and sizes or geometries of septic tanks for faecal sludge production were not considered.

KEYWORDS Underground Septic Tank; Desludging Frequency; Faecal Sludge; Sludge Judge; Modified PVC Pipe.

1 INTRODUCTION

Conventional onsite sanitation treatment such as typical pit latrines and underground septic tanks are the most common primary black water treatment adopted to fulfill the local sanitation needs in Sarawak. There are approximately 1.35 million individual septic tanks and 1.4 million primitive septic tanks in Malaysia but less than 10% of them are desludged (IEM, 2021). Furthermore, approximately 2.7 billion people worldwide are served by onsite sanitation technologies with a predicted increase of 5 billion by 2030 (Linda S. et al., 2014). Therefore, an effectively executed faecal sludge management is essential to safeguard the environment.

Onsite or decentralized technologies for faecal sludge management are not the only viable long-term option for sewage system management. Although it is possibly the more sustainable alternative in many ways compared to the sewer-based systems which are prohibitively expensive and resource-intensive (Linda S. et al., 2014). In Dakar, capital of Senegal, West Africa, the cost of well-planned faecal sludge management technologies with onsite septic tanks, collection and transport truck and drying bed are five times less expensive than a combined annualized capital plus the annual operating cost for a typical sewer-based solution (Pierre-Henri D. et al., 2012).

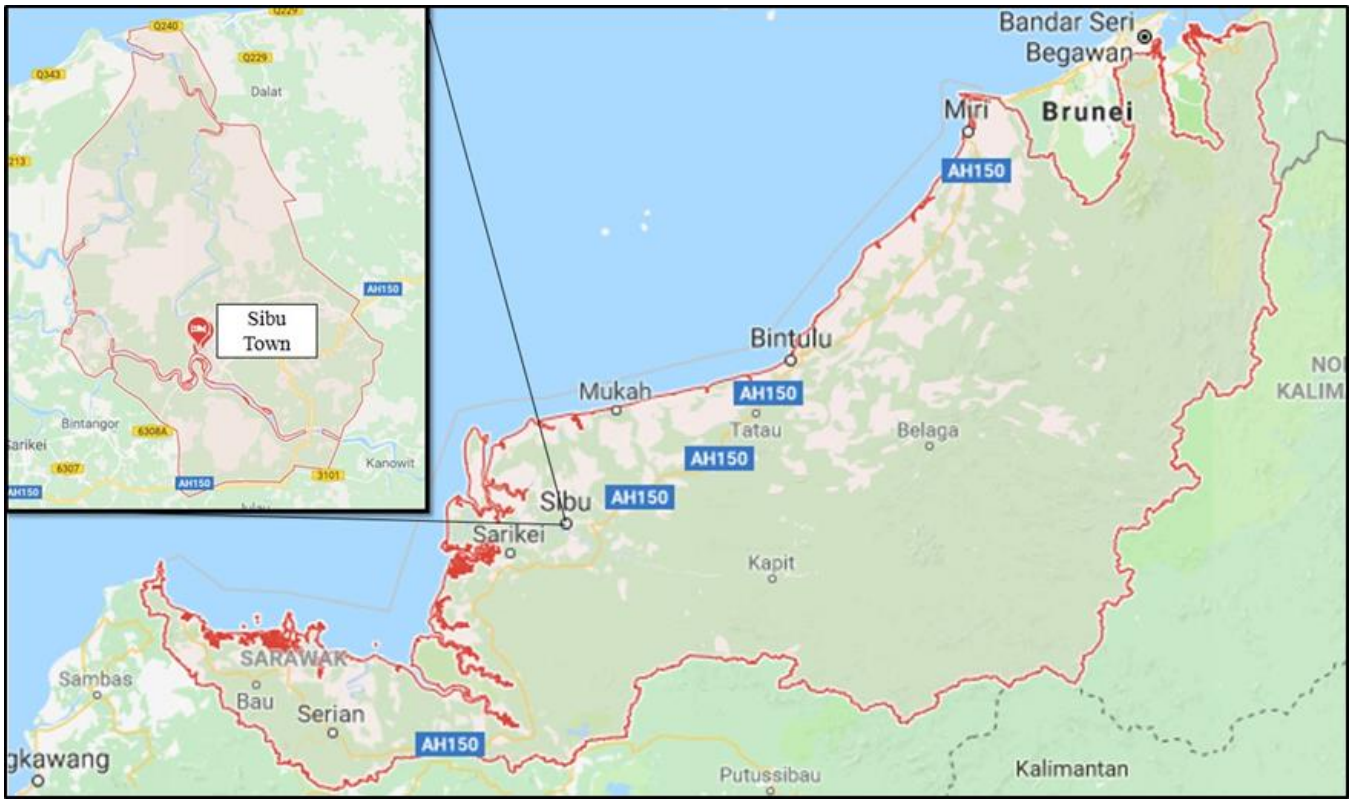


Figure 1. Location of Sibu town in Sarawak, East Malaysia (Source: Google Map)

In Sarawak, emptying or desludging works on septic tanks were legalized by law from 1998 based on the rateable holdings category (Local Authorities, 2002). The ordinance clearly stated that desludging works should be carried out once in 6 months for industrial areas, a year for public buildings such as schools, hospitals, government administrative buildings, etc, 2 years for commercial areas, and 4 years for residential areas. However, from the observations of various stakeholders, the mandatory desludging works required further studies and understanding particularly for the septic tanks in residential and commercial areas. In this study, a physical quantification of sludge and scum produced in the septic tanks for the known retention time was carried out for residential area in Sibu Sarawak, East Malaysia (Figure 1), and compared to the implemented mandatory desludging frequency. However, the complex influences by the microbiological activities, micro-environmental factors and the septic tank sizes or geometries of faecal sludge production were not considered in this study. Figure 2 shows the typical cross-section of an underground concrete septic tank commonly adopted by the major residential households in Sibu Sarawak.

2 LITERATURE REVIEW

In general, the required desludging frequency for accumulated septic tank faecal sludge is influenced by the factors below.

a) Service years: The sludge was generally non-biodegraded for the first 12 months to a large degree and desludging within this period retarded the development of the required biological processes for optimum digestion on the organic solids (EPA, 2018). Before desludging, about 2 to 5 years is recommended to ensure the satisfactory development of microbiological processes inside the septic tank (Philip H. et al., 1993; Terry R.B. 1994; CWAS 2020). Furthermore, the Water Services Industry (Desludging Services) Regulations (2021) by Suruhanjaya Perkhidmatan Air Negara (SPAN) mandated desludging at least once every 24 months and 36 months for septic tanks situated within and outside the boundary of local authorities

respectively. However, scientific evidence to justify this enforcement is still vague.

b) Volumetric accumulation rate: The pumping interval or desludging frequency should work on a respectable degree of reliability. This is achievable by monitoring the existing volumetric accumulation rate rather than yearly desludging guidelines without scientific approaches (Karen M., 1984, Terry R.B., 1994). Furthermore, desludged septic tanks or newer systems were found to be higher in terms of volumetric accumulation rate, however, it declined steadily over time (EPA, 2018). It could be due to (i) Longer detention time leading to the improvement of biodegradation of organic matter; (ii) The increased compaction and densification of settled solids; and (iii) The loss of solids due to carry over (MOE, 1977; Philip H. et al. 1993; Gary N.F., 1995; Tarek E., 2013).

c) Effective working volume: The total volume of the sludge and scum should not exceed 50% of the total tank content. The limiting volume ranging from 30% to 50% of the system's total working volume used was reported in studies (EPA, 2018). The desludging work should be carried out once the thickness of scum and sludge reached one-third of the total working depth (USAID, 2008). Furthermore, the allowable volume of the accumulated sludge and scum for a septic tank ranged from one-third to two-thirds of the total working volume which is satisfactory for preliminary treatment (USEPA, 2002). Desludging guidelines published by Thurston County Washington's Public Health and Social Services (2021) stated that the addition of sludge and scum depth is greater than one-third of the working depth, therefore, desludging work should be carried out.

Based on the reviewed studies as summarized above, it can be concluded that to warrant the optimum performance of the septic tank system, the total accumulated scum and sludge should be kept well below 30% to 50% for the effective working depth, hence, desludging should be carried out.

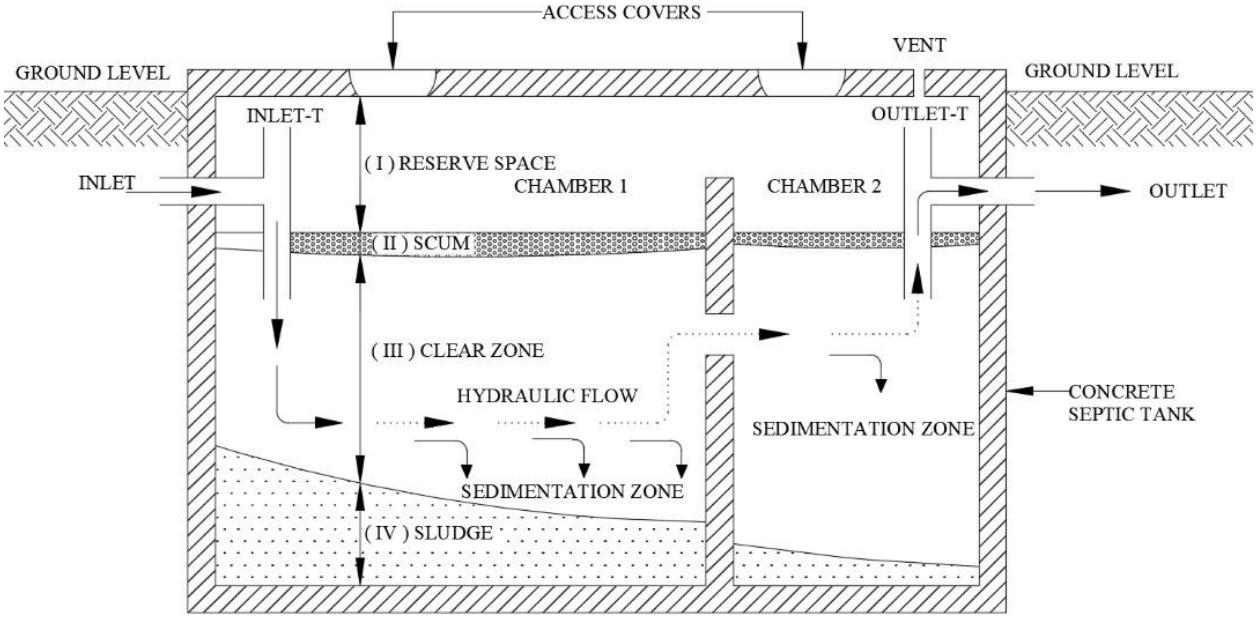


Figure 2. Typical underground concrete septic tank adopted in a residential household in Sibu Sarawak, East Malaysia

3 METHODS & ANALYSIS

The onsite measurement was carried out between March 2018 and May 2019. Two different types of equipment were used for this physical quantitative measurement with details shown below. Also, the comparison between these two methods is summarized in Table 1.

3.1 Sludge Judge

A sludge judge or sampler is a transparent hollow tube used to measure the non-caustic settled solids of food processing facilities, typical wastewater treatment and chemical plants. The float ball valve at its tip allows the fluid material to flow in while sinking into the water bodies. Furthermore, the thicknesses of its three distinct zones can be observed and read off from marked scales (Figure 3).

Figure 3. The thicknesses of sludge, clear zone and scum as captured and observed by a sludge judge

The advantages of using sludge judge are:

a) The boundary and the thicknesses of three distinct zones can be seen and recorded based on the demarcated scale.
b) It can measure up to 15 ft (≈ 4.572m) depth.

However, several shortcomings were observed at the initial stage of the measurement, including:

a) A significant amount of time (at least 10 minutes or even more depending on the sediment's characteristics such as particle sizes, fluid viscosity, density and concentration) was required for the suspended materials inside sludge judge to settle before the required thicknesses could be obtained. This seriously impeded desludging by the contractor.
b) Disturbances were created by the lifting and thrusting action of the hardened and stabilized sludge layer which penetrate through and reached the septic tank bottom. This layer was mainly caused by the consolidation or densification of prolonged overburden retention period.
c) The float ball valve at the tip was not completely watertight while sludge judge was being lifted. Therefore, the leakage from the hollow tube disturbed the stabilized layers and affected the second trial measurement, leading to the first trial being unsatisfactory.
d) The float ball valve was also always clogged by sludges and the sludge layer exhibited very soft to a soft consistency.
e) Time was consumed for the assembling of an extended sludge judge for deeper septic tanks using screw joints.

3.2 Modified PVC Pipe

This equipment was specifically modified to overcome the problems observed by sludge judge. The two important working principles for this measurement is as follows:

a) The buoyancy force is imposed by the clear zone.
b) The base resistance and skin friction are generated by scum and sludge layers while seating and penetrating on it.

The buoyancy force leads to the modified PVC pipe moving freely during thrusting in the clear zone. This movement stops once the pipe rests on the sludge layer surface. Furthermore, for the case of the pipe penetrating slightly more into the sludge layer, it is overcome by pulling out

slightly and shaking gently until the swaying motion is re-

observed. At this stage, the thickness of the clear zone can be determined from the scale. Figure 4(a) shows the modified PVC pipe, while Figures 4(b) and (c) shows the fabricated "plug and play" joint. In general, the usage of a modified PVC pipe requires practice particularly for the estimation of the scum and sludge layers.

The major advantages of a modified PVC pipe compared to sludge judge are:

a) It has low disturbance compared to the sludge layer.
b) It has completely sealed tip which is easier to clean due to the absence of clogging (Figure 4(d)).
c) Disturbance due to water tightness and leaking is nonexistent, therefore, a few trial measurements are carried out for more representative data.
d) Its joints used the "plug and play" idea for extensions in depth measurement (Figures 4(b) and (c)).
e) More rapidly measurements are carried out. The flow for desludging carried out by the contractor was greatly improved.

Figures 5(a), (b) and (c) depict the typical measurement procedures using a modified PVC pipe. These procedures are summarised as follows:

a) A small steel rod or steel ruler acting as a lever was placed at the top of the septic tank.
b) The pipe was inserted until it reached the top scum and the reading was recorded.
c) Insertion of the pipe continued to penetrate the scum layer until it reached the clear zone. A reading was recorded at this state.
d) The modified PVC pipe was further inserted until it rested on top of the bottom sludge layer and reading was recorded.
e) The pipe was further inserted until it touched the bottom of the septic tank.

The user can only roughly estimate the thickness by inspection provided that a thin scum is encountered.

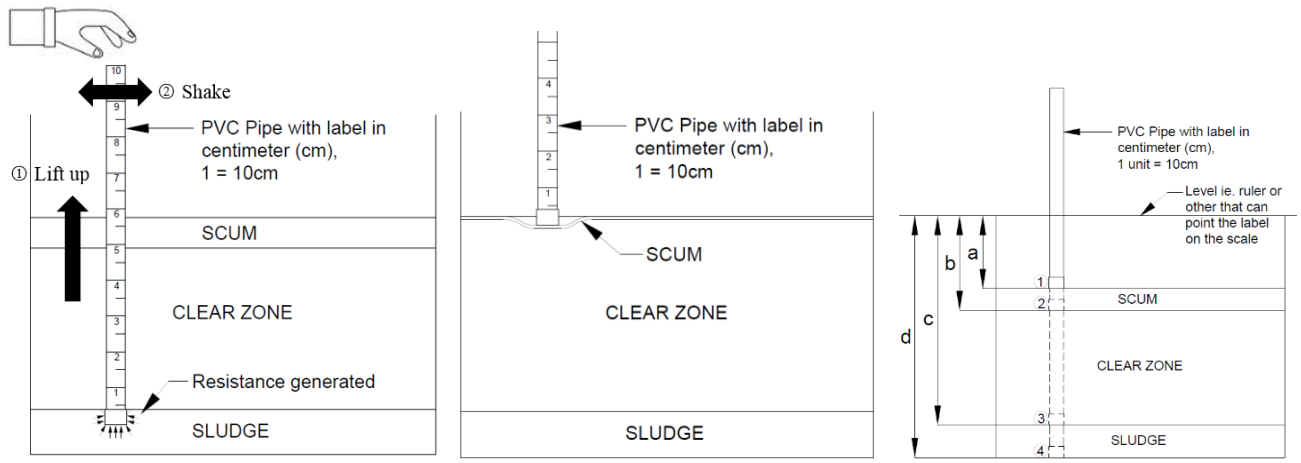
A total of 262 septic tanks were measured, but only 224 data were plotted in Figure 6. This was due to the exact date of the previous desludging event for the remaining 38 septic tanks that were unavailable. Furthermore, Table 2 and the footnotes below demonstrated how the faecal sludge in percentages (%) are back-calculated for an average desludging frequency for 50% and 30% thresholds for the effective working volume.

Table 1 Comparison between sludge judge and modified PVC pipe

Comparison in Terms of	Sludge Judge	Modified PVC Pipe
Easiness to acquire reading	Fair	Required practice
Approximate time for one measurement	At least 10 minutes was required	No more than 2 minutes
Disturbance	The large disturbance was expected due to water tightness and leakage at the float ball valve	Comparatively quicker
Cleaning	Troublesome to clean	Easy to clean
Sludge thickness	Only suitable for ultra-soft sludge	For soft to stiff sludge

(a) (b) (c) (d)

Figure 4. (a) Modified PVC pipe for faecal sludge measurement; (b) Plug on at the joint for extension; (c) De-plug at the joint; and (d) Sealed tip



(a) (b) (c)

Figure 5. (a) The schematic diagram of sludge, clear zone and scum measured by modified PVC pipe; (b) Measurement of thin scum by modified PVC pipe; and (c) Illustration on data collection (in thickness) by modified PVC pipe

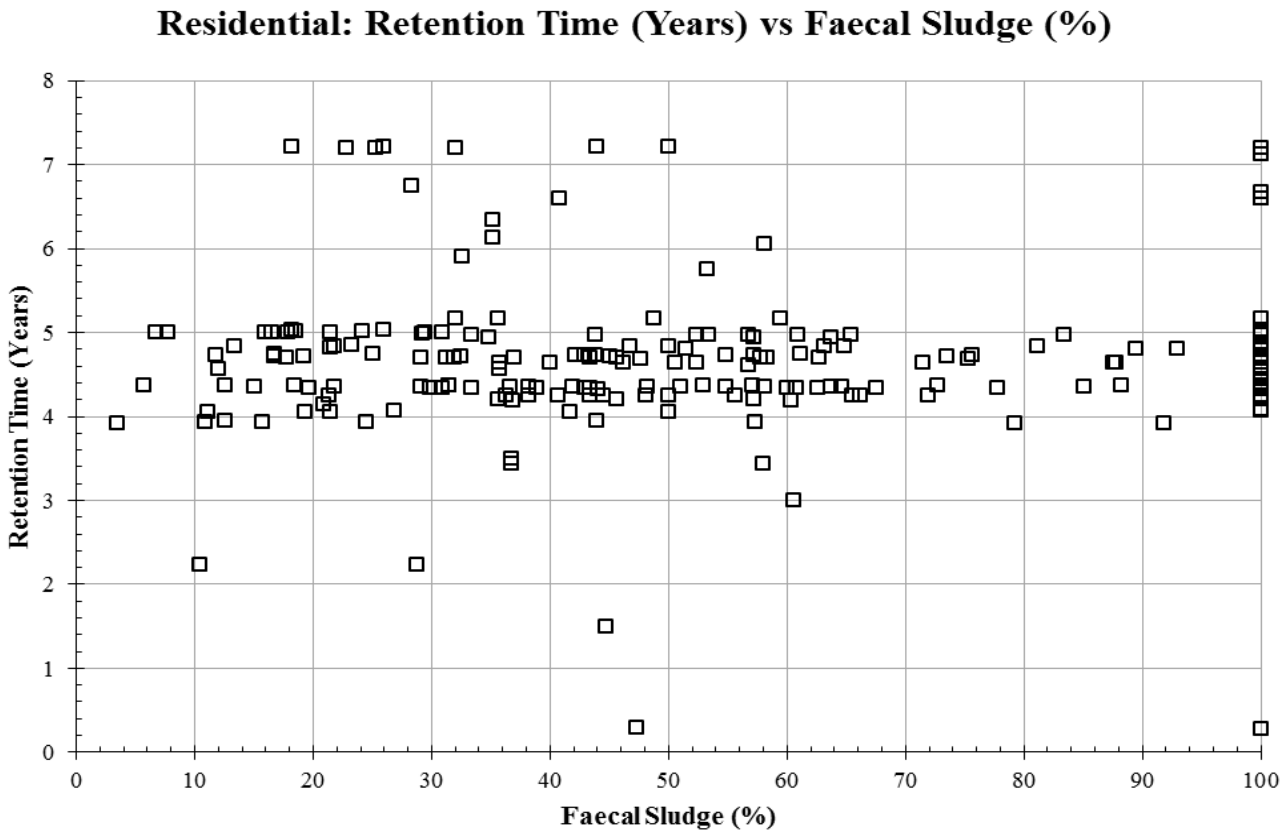


Figure 6. Retention time in years versus the measured faecal sludge in percentage for septic tanks in residential areas, Sibu Sarawak

4 RESULTS

It can be observed that the plotted points are scattered and spread along with the faecal sludge percentage as shown in Figure 6. The reason for such wide variance was that most of the measured septic tanks were only limited to those which were desludged within +/- 4.5 years intervals.

5 DISCUSSION

The modified PVC pipe was an efficient tool to be adopted in faecal sludge measurement compared to the typical sludge judge. This device minimized disturbances leading to a stabilized faecal sludge. Also, its required time for a complete measurement was 5 times lesser than sludge judge.

Table 2. An estimated sample calculation of the desludging frequency using 50% and 30% thresholds

(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)
Map Ref.	Previous Desludged Date	Date of Measurement Before Desludge	Duration		Measured thickness (cm)			Effective Working Depth (cm)	Scum + Sludge (cm)	% Feacal Sludge	Estimated Desludging Frequency Using 50% Threshold (Year)	Estimated Desludging Frequency Using 30% Threshold (Year)
			Days	Years	Scum	Clear Zone	Sludge					
R10*	1 Feb 2011	15 Mar 2018	2599	7.22	2	42	40	84	42	50	7.2	4.3
R16	28 May 2012	27 Mar 2018	2129	5.91	10	90	40	140	50	35.7	8.3	5.0
R100	5 Dec 2013	26 Jul 2018	1694	4.71	0	44	74	118	74	62.7	3.8	2.3
R122	17 Dec 2013	3 Aug 2018	1690	4.96	0	0	130	130	130	100	2.3	1.4
R138	22 Apr 2014	6 Aug 2018	1567	4.35	0	33	40	73	40	54.8	4.0	2.4

Notes: Sample Calculation for Map Ref. R10*
Days (d) = Years (e) = 15 Mar 2018 (c) – 1 Feb 2011(b) = 2599 Days = 7.22 Years
Effective Working Depth (i) = Scum (f) + Clear Zone (g) + Sludge (h) = 2 + 42 + 40 = 84 cm
(j) = Scum (f) + Sludge (h) = 2 + 40 = 42 cm
% Faecal Sludge (k) = (j)/(i) = 42/84 = 50 %
Estimated Desludging Frequency Using 50% Threshold (l) = 50 % / [50 % (k) / 7.22 Years (e)] = 7.2 Years
Estimated Desludging Frequency Using 30% Threshold (m) = 30% / [50 % (k) / 7.22 Years (e)] = 4.3 Years
Assumptions: (a) The microbiological activities were being ignored; (b) Micro-environmental factors such as pH, temperature and acidity were being ignored; (c) Sizes and geometry of septic tanks were being ignored; and (d) Prismatic septic tanks were assumed.

Table 3 summarized the estimated average desludging frequency for 30% and 50% thresholds using the interpolation method

Table 3: Estimated desludging frequency based on 30% and 50% thresholds by the interpolation method

Area	The Percentage (in ratio) of Total Sludge and Scum thicknesses to Effective Working Depth	
	30%	50%
Residential (in years)	3.82	6.36

A mandatory 4 years deluging frequency was observed between the back-calculated 3.82 and 6.36 years. Therefore, it can be concluded that the existing implemented mandatory desludging frequency is adequate for the residential area. Furthermore, this study has also indicated the potential to adjust the existing mandatory 4 years desludging frequency to a longer retention period for cost-effective consideration.

6 CONCLUSION

This study aims to physically quantify the accumulated faecal sludge within the known retention time for the residential areas in Sibu Sarawak, East Malaysia. A modified PVC pipe was proposed and adopted due to the problems encountered by sludge judge at the beginning of the on-site measurement. Compared to sludge judge, this pipe was a better option in terms of efficiency in which a shorter time was required. Furthermore, the estimated average desludging frequency for 30% and 50% thresholds were 3.82 and 6.36 years, respectively. This study discovered that the existing mandatory 4 years desludging frequency was adequate for

residential areas. The potential to adjust the mandatory 4 years desludging frequency to a longer retention period was worth considering for cost-effective reasons. However, the complex influences of microbiological activities, micro-environmental factors and septic tanks sizes or geometries reported by other studies on faecal sludge production were not considered.

DISCLAIMER

The authors declare no conflict of interest.

ACKNOWLEDGMENTS

This study was supported by the internal study grant provided by the University College of Technology Sarawak (UCTS/RESEARCH/4/2017/05). The authors express gratitude to the Sibu Municipal Council (SMC) for the permission received to carry out measurements with the appointed desludging contractors.

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