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Take it away: the need for designing fecal sludge disposal services for single-pit latrines

Abstract

The Government of Bangladesh is increasingly paying attention to the safe collection and disposal of fecal sludge from pit latrines in rural areas. In this paper, we report on current sludge disposal practices from single-pit latrines, by conducting a survey of 1,091 households with pit latrines in a rural subdistrict of Bangladesh. Almost all households were using their pits, and 90% reported that hiring pit emptiers to empty the pit for reuse was the dominant pit management practice. However, 90% of households also reported that the sludge from these pits would be disposed in the vicinity of their homes, by digging wide and shallow troughs in the soil to absorb the sludge. These results indicate an urgent need to design an organized service that safely transports fecal sludge away for treatment. The National Committee for Fecal Sludge Management, constituted by the Government of Bangladesh, is using these results to design policy for sludge management.

Keywords: sanitation, rural, fecal sludge, emptying, disposal, single-pit latrines

Introduction

Bangladesh has made rapid progress in reducing open defecation; between 2003 and 2015 the rates in rural areas of the country fell from 42% to 2 % (BRAC, 2015; WHO/UNICEF, 2004; WHO/UNICEF, 2015). The single pit latrine has played an important role in this achievement, which need to be emptied when they fill up (BRAC 2015, O'Loughlin et al., 2006).

While the proper use of latrines has been shown to have significant health benefits (Montgomery and Elimelech, 2007, Fewtrell et. al, 2005; Pruss, 2002); the design of toilets such as those prevalent in Bangladesh is predicated on the assumption that the sludge will be safely removed and treated before

re-entering the environment, either for disposal or reuse. Several authors have noted that this may not always be the case. For instance, Boot and Scott (2009) note failure to manage sludge from onsite sanitation in urban Ghana resulted in widespread contamination of the environment and water bodies with raw fecal matter when filled pits were emptied. Improperly managed sludge can also cause increased risk of infection from fecal-oral diseases, including transmission of helminthic infections; as well as injuries to women and children when pits are unsealed or left open (Fewtrell et al., 2005; Fuller et al, 2015; Pruss et al., 2014)

This suggests that simply improving access to single pit latrines is not likely to be enough. In the absence of suitable sludge disposal services; as pits fill up, owners could take one of the following actions: move back to open defecation; seal old pits and install new ones leaving sludge in the ground; or empty the raw, untreated contents of their pit into the environment to allow for its continued use. This in turn could result in a direct loss of the health gains achieved through elimination of open defecation (Schmidt, 2014). Sealing old pits or dumping of waste presents risks in areas where shallow groundwater is the primary drinking water source, and where density of pits is high, both of which hold true in Bangladesh (Shivendra and Ramaraju, 2015, Dzwairo et al., 2006). The health gains made through increasing access to improved drinking water are also likely to be compromised if latrine use reduces, or if raw sludge finds its way back into the environment (Fuller et al., 2014).

The Ministry of Local Government convened a National Committee for Fecal Sludge Management (NCFSM) in 2015 to draft frameworks for sludge management in rural (and urban) areas of Bangladesh, which is envisaged as a first step towards a service that collects and transports sludge from pits for treatment, followed by sludge reuse. This is an important, and timely, development, because any kind of service (either organized or ad hoc) that collects sludge from pits and transports it for treatment does not currently exist in rural Bangladesh.

In this paper we examine how rural households in Bhaluka subdistrict in Bangladesh currently deal with sludge when their single pit latrines fill up. The subdistrict is envisioned by the NCFSM as the scale at which services would be designed.

The findings in this paper provide empirical evidence for the need of a service that manages sludge in a safe matter. These results also provide the building blocks for understanding the financial aspects of sludge management—namely the total costs of transporting sludge, and the private-willingness-to-pay for fecal sludge transportation. Both these components have been studied by the authors, but are beyond the scope of this paper. Combined with results from a trial of treating fecal sludge for reuse, the findings of this paper, and those pertaining to the financial aspects, are being used by the NCFSM to identify feasible management options for fecal sludge which are financially sustainable and technically feasible in rural areas.

Methods

Bhaluka subdistrict lies in Mymensingh district (Figure 1). The Census of 2011 records 106,935 households in the district, with 91, 547 households in rural Bhaluka; the average household has approximately 4 people (Ministry of Planning, 2012). Around 78% of the households live in houses made of brick walls with metal roofs. Ninety-two percent of all households use a latrine, with 67% of the households having access to a sanitary latrine, often a pit latrine (Ministry of Planning, 2012); the remaining 25% are reported to use unsanitary latrines, where sludge (night soil) needs to be removed

every day.[1] [2] Bhaluka subdistrict is broadly representative of a rural district that is not affected by groundwater salinity.

Figure 1: Study site for the survey

During May—July 2014, a sample survey of 1,091 households was implemented to understand current behavioral practices pertaining to pit emptying and sludge disposal. While the Census of 2011 reports latrine coverage, identification of households owning single-pit latrines using the census data is not possible. A random sample was selected using the population of households in Bhaluka whose single-pit latrines were financed by BRAC, a major non-governmental organization, based in Bangladesh and working internationally. BRAC implemented a rural sanitation programme in 250 of the 493 subdistricts in the country during 2006-2014, installing an estimated 250,000 single-pit latrines across

[1] By sanitary latrine, we mean a pit that is (at least partially) lined with concrete rings, and the mouth of the pit is covered by a (usually plastic or ceramic) floor board that is sealed (almost all toilets in rural Bangladesh are squat toilets). By contrast, unsanitary latrines are ones where an unsealed floor board usually made of wood, with a hole in the middle, is placed on an elevated platform, below which sludge accumulates in a bucket or wooden basket; this sludge is removed every night.

[2] The decision to install a latrine is a private decision; unsanitary latrines are cheaper to install, since it involves simply placing a board (with hole) on an elevated platform below which a bucket is placed. Unsanitary latrines may also be installed in places where installing pit latrines is not possible (e.g. in char areas, where seasonal flooding takes place.

Bangladesh (BRAC also supported the installation of other sanitary latrines, but these are separate technologies and are not studied here). In Bhaluka alone, BRAC supported the installation of around 9,000 single pit latrines; BRAC installed single-pit latrines serve 13% of households with a sanitary latrine.

Approximately 1% of rural households with latrines sponsored by BRAC were sampled. Due to limited time and resources, it was not possible to include all villages in the sample. A two-step sampling process was used: first, villages were randomly selected; and then households within selected villages were randomly chosen. Villages that had less than 15 BRAC-financed single-pit latrines were excluded. A simple rule of sampling 40% of BRAC households in selected villages was used. Villages were selected by assigning random numbers, arranging them in ascending order, and including villages sequentially until the sample size reached 1% of rural households. Within selected villages, BRAC households were randomly selected. The sample consists of 1,091 households in 44 villages.

Due to the sampling rule used, the probability of selection for a household situated in a village with fewer BRAC households is higher than that for a household belonging to a village with more BRAC households. Sampling weights are used to address these different probabilities of selection, calculated as the inverse of the product of two probabilities: the probability of a village being selected, and the probability of a household within a village being selected. Finally, all results are reported after accounting for clustering at the village level. The use of sampling weights and clustering of standard errors improves the ability of the sample to make predictions about the population.

A questionnaire was implemented to understand whether households had ever emptied their pits. If so, the respondent was asked: if the pit had been emptied by the household itself; if someone had been hired for the task; and if the sludge has been disposed nearby or transported away. If a household was yet to empty its pit, they were asked what they intended to do when their pits filled up: if they would

empty the pit themselves, hire someone, or seal the old pit and install a new one. If the household indicated that they would empty the pits, they were asked if the sludge would be disposed nearby or transported. Information on the age and depth of the pit, the number of times it had been emptied, and the number of regular users was also collected. Information on household demographics was additionally elicited. The questionnaires were administered to the male head of the household because decisions about installing and emptying latrines are usually coordinated by males.

The University of Leeds Faculty of Mathematics and Physical Science, MaPS and Faculty of Engineering joint faculty research committee approved this study. All official and regulatory permissions necessary for conducting research in Bangladesh were coordinated and obtained by NGO Forum for Public Health. Participation in this research was voluntary, and not remunerated. Potential participants were informed of the aims and purposes of the research, and the amount of time they would have to spare to provide the research team with the relevant data. Data was collected only after respondents had agreed to participate. All responses are anonymous and cannot be used to identify individuals or households.

Results

Summary statistics

The average household size in our sample was 4.56 (Table 1). In 50% of households, the highest level of education was secondary school (Class 6-10); while in 34% of the cases primary education was the highest education level, indicating a literate sample.[3] The mean annual income was USD 1,246, amounting to approximately USD 2.8/ day after being adjusted for inflation and expressed in 2005 equivalent dollars. This is just over twice the World Bank defined international poverty line of USD

[3] Separately, respondents were asked to rank (on a scale of 1-10) how safe for public health, manual and mechanized practices of emptying would be. The average rank for the manual emptying was 6.4, but for a mechanized process the average rank was 9.5. This indicates that respondents have some awareness regarding the relative risks of manual emptying viz. mechanical emptying.

1.25/day, in 2005 purchasing power parity. Around 66% of households were involved in non-farm occupations, while a similar number reported living in houses with brick walls. Metal sheet was the most common roofing material. Comparing these statistics to the 2011 census indicates that the sample is representative of Bhaluka upazila.

Pit emptying and disposal practices are reported below. Multivariate regressions are used to adjust households' reports on actions taken (or intended actions) with the set of household demographic characteristics specified in Table 1. These regressions improve the precision of estimates, which are more informative than simply reporting raw statistics. All regressions were run using sampling weights, and by clustering standard errors at the village level.

Table 1: Summary statistics for household study (n=1,091 households)

	Mean	Std Dev
No. of family members	4.56	1.71
% households where highest education is		
Class 1-5	0.34	0.47
Class 6-10	0.46	0.5
Class 11-12	0.08	0.27
Beyond Class 12	0.05	0.22
No. concrete liners in the pit	2.36	1.14
Annual household income (USD)	1245.61	1077.83
No. Women/household making toilet-management decisions	1.17	0.66
% households with non-farming income source	0.67	0.47
% households with brick walls	0.68	0.47
% households with metal sheet roof	0.97	0.17

Source: Authors' data

Almost all households with a single-pit latrine are using it

At the time of our study, 99% of households had, and were using a pit latrine. Fifty-five of the 1,091 households reported that the BRAC-provided pit had been faultily constructed. Of these, 44 households had rebuilt a new pit latrine, and 11 has decided to return to open defecation.[4]

Of the 1,080 households with latrines, most latrines were 4 years old, which reflects the time period during which these latrines were installed under the BRAC program. However, a few latrines were older (Figure 2). On average, latrine owners reported 1-2 non-household members also using their latrines, indicating that sanitation services may also extend to those who do not own latrines.

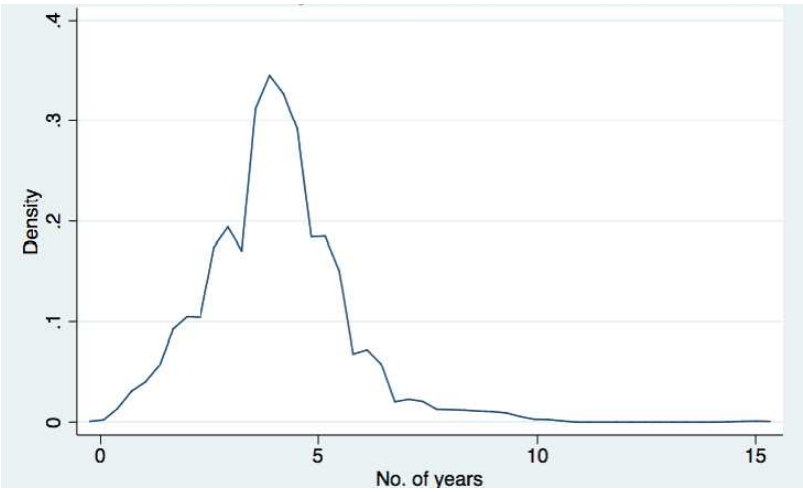

Figure 2: Distribution of the age of toilets (n=1080)

Households empty their pits, rather than abandoning old pits, and digging new ones.

One-fifth of households (216) had emptied their pits at least once; while the remaining had yet to do so. Examining the intended behaviors of 864 households that were yet to empty their pits revealed that 91% intended to empty them when they filled up, while approximately 6% considered installing a

[4] The households that built a second pit latrine did so because the first latrine has not been constructed in a proper manner, leading to either clogging to the latrine, or leakage of fecal materials. Those that had returned to open defecation did so because their old pit latrine had also been constructed in a faulty manner; but this subsample did not build a second latrine, mostly due to financial reasons.

new pit latrine when the current one filled. Overall, 88% of our sample households preferred emptying their pits, rather than abandoning them and installing new ones.

Households hire emptiers to empty their pit, rather than empty themselves

Overall, 90% of the entire sample reported hiring emptiers as the dominant pit-emptying practice. For the 20% of households who had emptied their pits, 88% had hired pit-emptiers to do the job, paying on average BDT 322 (~ USD 4) for their services (Table 2). For the households that were yet to empty their pits, 92% planned to hire an emptier when their pits filled (Table 2)

When pits are emptied, fecal sludge is dumped near the household, and not transported

For the entire sample, 90% of households reported that sludge would be disposed near the premises of their homes. For the 20% of the sample who had emptied their pits, 93% reported disposing the sludge near their premises, usually digging a wide but shallow trough in the ground and allowing the soil to absorb the water, before covering the trough (Table 2, Figure 3). For the 80% of the sample yet to empty their pits, 91% reported that sludge would be disposed onsite (Table 2).

Table 2: Pit emptying and sludge disposal in household study (n=1,080 households)

	Mean [3]	Std. Error
Pit management of households who had emptied their pits (n=216)[1]		
% households that hired emptiers	0.88	0.06
Avg. amt. paid for emptying to sweeper	322	44
% households where fecal sludge locally onsite	0.93	0.06
Pit management of households yet to empty their pits (n=864)[2]		
% households planning to hire emptier when pit fills	0.92	0.03
% households that report sludge will be disposed onsite	0.91	0.03
% households plan to build a new pit when old full	0.06	0.02

Notes:
1. The means are calculated using the subsample of households that had emptied their pits
2. The means are calculated using the subsample of households that had not emptied their pits
3. The means are calculated by regressing responses of each household on a set of predetermined household characteristics, summarized in Table 4, to improve precision of estimates. Sampling weights are used in regressions, and standard errors are clustered.

Figure 3: Current practices for sludge disposal

Conclusions

The current methods for sludge disposal motivate the need for a service that not only empties pits safely (see Balasubramanya et al., 2016a for details); but also transports sludge for treatment. The NCFSM envisages the subdistrict as the scale at which solutions would be implemented. This is an important consideration; locating a treatment site at the subdistrict headquarters would provide economies of scale for the fixed costs of treatment (the equipment and land needed for treating sludge). The costs of transporting sludge to the treatment site are likely to be large and need to be better understood.

Results from the household study indicate that pit latrine owners currently hire pit emptiers, making payments for emptying. With 92% of households in Bhaluka having access to a latrine, the potential to build a vibrant and safe pit emptying and sludge disposal business seems to be quite high. An organized service that empties pits and transports sludge for treatment could capture these payments being made currently for financing part of the transportation costs, at the very least. This would help reduce the burden of the public sector (Al-hmoud and Edwards, 2004).

It is likely that households may be willing to pay more to move sludge offsite than what they currently pay for onsite disposal if they perceive the service to provide better benefits than current practices. Understanding household willingness-to-pay is an important component of designing a sludge transportation service, because it would identify the gap between the costs of transportation and private contributions, creating space for a policy dialogue on how to finance the gap (e.g. Mehta et al, 2005; Nazim uddin et al., 2016; Orphanopoulus, 2005). Public information campaigns that stress the importance of safe sludge disposal may also help to increase the willingness to pay for such services. Bangladesh is no stranger to the use of public health campaigns for increasing awareness and demand for better health outcomes, given the importance of such campaigns in tackling the groundwater arsenic crisis (Ahmed et al., 2006; Balasubramanya et al., 2014; Benner et al., 2013).

In summary, the current practice of widespread on-plot disposal of fecal sludge poses a significant risk to public health and to the environment. There are significant opportunities to achieve public benefits from better management of fecal sludge (Bartram and Cairncross, 2010). Crucially the scale and nature of the problem suggest that an organized intervention, requiring both public and private action will likely be needed to promote and support a sludge management service, which will be essential in the coming years.

In order to maintain progress in reducing the health risks associated with poor sanitation, and for Bangladesh to maintain progress towards achieving its millennium development goals with respect to sanitation, the rapid increase in access to single-pit latrines needs to be associated with improved fecal waste management systems that periodically extract sludge, and transport it away from the community for safe treatment, followed by either reuse or disposal (Kennedy-Walker et.al., 2014). This is attempted for Bhaluka upazila in Balasubramanya et al., 2016b.

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References:

Ahmed, M.F., Ahuja, S., Alauddin, M., Hug, S.J., Lloyd, J.R. , Pfaff, A., Pichler, T., Saltikov, C. , Stute, M., van Geen, A.. 2006. Ensuring safe drinking water in Bangladesh. Science, 314, pp. 1687–1988.

Al-hmound, R.B., Edwards. J. 2004. A means to an end: studying the existing environment for private sector participation in the water and sanitation sector. International Journal of Water Resources Development, 20(4), pp.507-522.

Bennear, L., Tarozzi, A., Pfaff, A., Balasubramanya, S., Ahmed, K.M., van Geen, A. 2013. Impact of a randomized controlled trial in arsenic risk communication on household water source choices in Bangladesh. Journal of Environmental Economics and Management, 65(2), pp. 225-240.

Balasubramanya, S., Pfaff, A., Bennear, L., Tarozzi, A., Ahmed, K.M., van Geen, A. 2014. Evolution of households' responses to the groundwater arsenic crisis in Bangladesh: information on environmental health risks can have increasing behavioral impact over time. Environment and Development Economics, 19(5), pp. 631-647.

Balasubramanya, S., Evans, B., Ahmed, R., Habib, A., Asad, N.S.M., Rahman, M., Hasan, M., Dey, D., Camargo-Valero, M. 2016a. Pump it up: making single-pit emptying safe in rural Bangladesh Journal of Water, Sanitation and Hygiene for Development, 6(3), pp. 456-464.

Balasubramanya, S., Evans, B., Hardy, R., Ahmed, R., Habib, A., Asad, N.S.M., Rahman, M., Hasan, M., Dey, D., Fletcher, L., Camargo-Valero, M. 2016b. Identifying the gap between full costs and household willingness to pay for emptying and transport of fecal sludge in rural subdistricts of Bangladesh: towards sustainable financing solutions. PLOS One, forthcoming.

Bartram J., Cairncross S. 2010. Hygiene, sanitation and water: forgotten foundations of health. PLOS Medicine **7**(11): e1000367.

Boot N.L.D, and Scott R.E. 2009. Faecal sludge in Accra, Ghana: problems of urban Provision. Water, Science and Technology **60** (3), 623-631

BRAC.2005. Open defecation in country has been reduced from 42% in 2003 to 3% in 2014. Accessed on August 17, 2015 at http://wash.brac.net/news-a-media/186-open-defecation-in-country-has-been-reduced-from-42-in-2003-to-3-in-2012 .

Dzwairo B., Hoko Z., Love D., Guzha E. 2006. Assessment of the impacts of pit latrines on groundwater quality in rural areas: A case study from Marondera district, Zimbabwe. Physics and Chemistry of the Earth **31**(15-16), Parts A/B/C, pp. 779-788.

Fewtrell L., Kaufmann R., Kay D., Enanoria W., Haller L., Colford Jr J.M. 2005. Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. The Lancet Infectious Diseases **5**(1), pp. 42-52.

Fuller J. A., Westphal J. A., Kenney B. and Eisenberg J. N. S. 2015. The joint effects of water and sanitation on diarrhoeal disease: a multicountry analysis of the Demographic and Health Surveys. Tropical Medicine & International Health **20**, pp. 284–292.

Kennedy-Walker R., Holderness T., Alderson D., Evans B.E., Barr S. 2014. Network modelling for road-based Feacal Sludge Management. Proceedings of the Institution of Civil Engineers: Municipal Engineer **167**, pp.157-165

Mehta,M. Fugelsnes. T. Virjee, K. 2005. Financing the millennium development goals for water and sanitation: what will it take? International Journal of Water Resources Development, 21(2), pp. 239-252

Ministry of Planning. 2012. Community Report: Mymensingh Zila-June 2012. Population and Housing Census 2011, Bangladesh Bureau of Statistics, Statistics and Informatics Division. Accessed on Feb 13, 2016 at http://203.112.218.66/WebTestApplication/userfiles/Image/Census2011/Dhaka/Mymensingh/Mymensingh%20at%20a%20glance.pdf

Montgomery M., Elimelech E. 2007. Water and sanitation in developing countries: including health in the equation. Environmental Science and Technology **41**(1), pp. 17-24.

Nazim Uddin,S.M., Tempel, A., Adamowski, J.F., , Zifu Li, J.L.,Mang, H.P. 2016. Exploring alternative sources of funding for deploying sustainable sanitation technologies and services in Mongolia. International Journal of Water Resources Development,.DOI: 10.1080/07900627.2015.1121137.

O'Loughlin R., Fentie G., Flannery B. and Emerson P. M. 2006. Follow-up of a low cost latrine promotion programme in one district of Amhara, Ethiopia: characteristics of early adopters and non-adopters. Tropical Medicine & International Health **11**: 1406–1415.

Orphanópoulos, D.2005. Concepts of the Chilean Sanitation Legislation: Efficient Charges and Targeted Subsidies. International Journal of Water Resources Development. 21(1): pp.199-216.

Pruss A., Kay D., Fewtrell L., Bartram J. 2002. Estimating the burden of disease from water, sanitation, and hygiene at the global level. Environmental Health Perspectives **110**(5), pp. 537-542.

Schmidt W.P. 2014. The elusive effect of water and sanitation on the global burden of disease. Tropical Medicine and International Health, **19**(5), pp. 522-527.

Shivendra B.T., Ramaraju H.K. 2015. Impact of Onsite Sanitation System on Groundwater in Different Geological Settings of Peri Urban Areas. Aquatic Procedia **4**, pp.1162-1172.

1 WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. 2004. Meeting the
2 MDG drinking water and sanitation target: a mid-term assessment of progress

3 WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation .2015. Progress on
4 sanitation and drinking water – 2015 update and MDG assessment.