Method to Estimate Quantities and Qualities of Faecal Sludge

The design of appropriate management and treatment solutions for faecal sludge depends on knowing its quantities and qualities. Previously there has been no method to determine reasonable estimates of quantities and qualities; however, Sandec's research is addressing this need. Miriam Englund[1], Juan Pablo Carbajal[2], Linda Strande[1]

Introduction

Reasonably accurate estimations of quantities and qualities (Q&Q) of faecal sludge are very important for the design of appropriate management solutions. For example, under-designing faecal sludge treatment plants will result in risks to public health, and over-designing them will waste financial resources. Determining Q&Q of faecal sludge in a city is like counting fish in a lake. It is complex and difficult and hidden under water (fish) or the ground (faecal sludge), but it is possible to make reasonable estimations. Doing so, however, requires prior knowledge, research and structured approaches to make sure that the assumptions reflect the reality.

Determining Q&Q of faecal sludge is much more complicated than with sewer-based sanitation, where wastewater is relatively homogenised during transport in the sewer. There is a huge diversity observed at the level of each individual toilet. The Q&Q method provides a way to make weighted averages for an entire area, versus trying to predict what is happening in individual containments of faecal sludge.

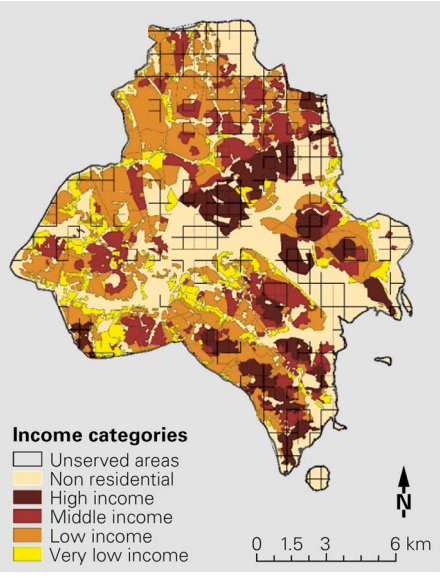

Figure 1: Income categories and areas without service provision is an example of SPA-DET that can be used as predictors of faecal sludge Q&Q [2].

The Q&Q method is an approach to data collection to make practical estimates at a reasonable cost. Further development and use of standard methods in the faecal sludge management field will result in more comparable and accurate results. The method has evolved with time, from basic Sludge Production or Sludge Collection methods [1] and will continue to change to meet the demands of this rapidly growing sector. It was developed and then field-tested in Kampala, Uganda, Hanoi, Vietnam, and Dar es Salaam, Tanzania, with more field-trials in India and Nepal planned for the coming year. The method is appropriate for any scale, from small communities to entire cities, and is applicable worldwide.

Method for data collection

The method for data collection is based on the hypothesis that types of demographic, environmental and technical (DET) data that can be spatially analysed (SPA), can be used as predictors of faecal sludge Q&Q. It is important to note these are correlations, not necessarily causation, but if consistent relations are observed, they can be used as predictors. An example of SPA-DET is income level, shown in Figure 1 for Kampala. Overall, statistical relationships have the power to increase the accuracy of the estimations, while reducing or making efficient use of costs. Figure 2 is an overview of the steps employed in the method summarised in Figure 1.

Set objectives

First, it is necessary to define clear objectives for the study, as planning for different management solutions could require different forms of data collection. For example, one scenario could be planning for the design of a treatment plant in a city with no previous existing treatment, or planning to implement a regular interval desludging program for a community. For the treatment plant, estimates are needed for the total volume and strength of faecal sludge influent that is expected upon commission, in addition to projecting future growth. For the

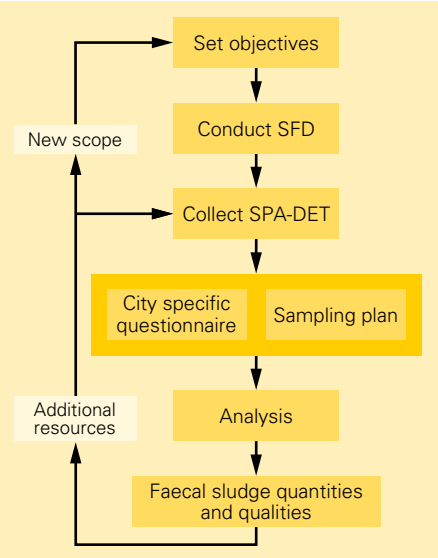

Figure 2: Schematic of the iterative steps in the method to determine quantities and qualities (Q&Q) of faecal sludge.

desludging program, however, estimates are needed for the rates of faecal sludge accumulation, emptying frequencies and "pumpability" of sludge.

Conduct a SFD (Shit Flow Diagram)

The excreta flow diagram or SFD estimates safely or unsafely managed fractions of excreta flows in a neighbourhood or city to understand the current sanitation situation [3]. The method provides fractions of total excreta, but does not estimate actual flows or quantities of faecal sludge. Prior to planning sanitation solutions, it is imperative to have a solid understanding of the current situation. In addition, implementing the SFD makes one familiar with the types of SPA-DET data that is available to use in the Q&Q method.

Collect SPA-DET

Types of DET data include: demographic (e.g. income level, number of users, housing density, family size, and patterns of urban development – building type, property usage, informal settlement, industrial, commercial or markets); environmental (soil

characteristics, elevation, groundwater and hydrology); and technical information (access to piped water or type of onsite containment). This information can be obtained from research institutes, national bureaus of statistics, government bodies, water authorities, desludging businesses, NGOs, and other stakeholders in faecal sludge management.

City specific questionnaire

Following collection of SPA-DET data, a context specific questionnaire is developed based on the study objectives and available information. The questionnaire will be used to interview customers and service providers during both emptying operations and sludge delivery, and treatment plant operators. Examples of collected data include: containment information (containment technology, lined or unlined, number of users and volume); user behaviour (e.g. cleansing method, water usage, solid waste, etc.); and emptying operation (manual or mechanical emptying, emptying frequency, truck size, fully emptied, etc.).

Sampling plan

The number of samples collected during the study will depend on available resources. Ideally, adequate samples can be collected to ensure statistical significance. Even if this is not possible, however, collecting data as outlined in the methodology increases the power of conclusions that can be made from it. Once the sample size is determined, then a sampling plan needs to be designed to ensure adequate representation of all types of intended SPA-DET that representatively covers the entire study area.

Analysis

It is recommended to use the laboratory methods presented in the forthcoming book for sample analysis (Figure 3) [4]. The possibilities for analysis of the collected data will depend on resources and capacities, from straightforward predictions to complicated modelling approaches. One of the most important conclusions is that faecal sludge Q&Q should not be assumed to follow symmetrical, normal distributions. This means that another type of summary statistics other than means and standard deviation needs to be considered, in contrast to the current status quo in the field.

Additional resources and/or new scope

As additional resources become available, the sample size could be increased and further sampling and data collection can be conducted. As additional information is obtained, the possibility to develop models that reliably predict actual conditions increases. The entire method should be revisited as new or modified objectives are developed. Sustainable long-term planning requires adaptive planning for population growth and increased infrastructure.

Conclusion

Types of SPA-DET data were found to be predictors for faecal sludge Q&Q in Kampala, Hanoi, and Dar es Salaam. In Kampala, high-income areas had lower TS concentration (7* g TS/L faecal sludge) than low-income areas (29* g TS/L faecal sludge) [5]. The actual reasons for this could be many, i.e. water connections, quality of construction of faecal sludge containment, or types of waste streams going into containment. Other observed predictors were water connection, black water only, solid waste, number of users, containment volume, emptying frequency and truck size.

In addition, correlations can be observed amongst types of characteristics. In Kampala, this correlation between COD and TS was $COD = 0.88 \cdot TS + 3.3$ with an R^2 of 0.86 [5]. A correlation between COD and TS were also confirmed in a neighbourhood in Dar es Salam. Once established, these relationships could be used to extrapolate COD based on TS analysis, thereby reducing analytical costs and resources.

Further, data from Hanoi and Kampala were used to build a mathematical model to predict TS and emptying frequencies from SPA-DET data (in preparation). The model's accuracy was improved by splitting into two different models for septic tanks or pit latrines. This is a first attempt at developing city-wide and multiple city models, and the approach will continue to be refined with further research.

* Median value

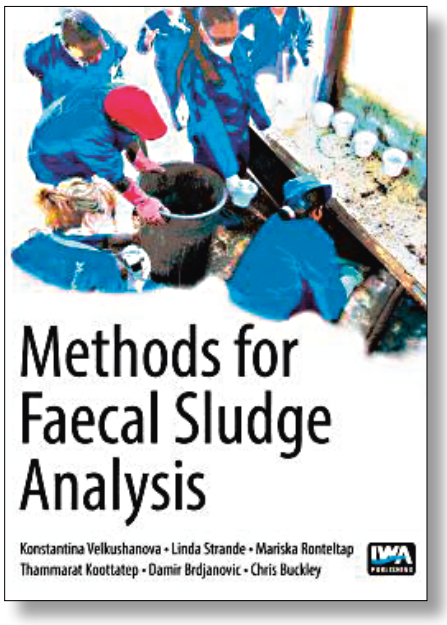

Figure 3: Cover page of forthcoming book, Methods for Faecal Sludge Analysis.

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