PIT SCANNER

Digital measurement of sludge volumes in latrine pits

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Background

Knowing the volume of sludge contained in a pit latrine at a point in time provides essential data for calculating the rate of accumulation of faecal sludge in latrine pits. This data feeds into:

- The design of on-site sanitation systems that are appropriately sized for the number of people served;
- The design of pit-emptying programmes and faecal sludge management business models;
- Design and testing of the real effectiveness of pit-additive chemicals that claim to reduce rates of sludge accumulation in pits.

The sludge volumes contained in latrine pits are difficult to estimate in-situ, for a number of reasons:

- Sludge tends to form a heap underneath the pedestal, which is not always positioned at the centre of the pit (Figure 1);
- Pit sludge can be relatively dry and consolidated, and contain considerable quantities of non-faecal matter (e.g. clothing). This prevents estimates of sludge depth by driving a measuring stick through the sludge to the bottom of the pit (Figure 2);

FIGURE 1 Sludge heap under pedestal (pedestal positioned over top of image)

FIGURE 2 (a) Dry sludge removed from pit; (b) Solid sludge and non-faecal matter prevents measuring stick reaching bottom of pit

Pit scanner concept

The pit scanner uses a laser device to scan the surface of the sludge contained in a latrine pit. The laser performs vertical-plane scans, with a stepper motor rotating the scanner in the horizontal plane, in a user-defined number of steps. The set of vertical scans taken are used by the scanner software to produce a 3D surface image of the pit contents. The scan data can be analysed to determine the free volume remaining in the pit between the surface of its contents and the scanner level. To measure changes in pit contents, the scanner software can subtract the volumes calculated by two scans on the same pit to produce a figure for the volume added or removed from the pit. It is important to locate the scanner accurately in the same position for the two scans, which is facilitated by the design of the support system.

Production of scan data

The pit scanner is positioned over the hole in the toilet floor slab (Figures 3 and 4). The laser device is lowered to a set depth in the pit and levelled.

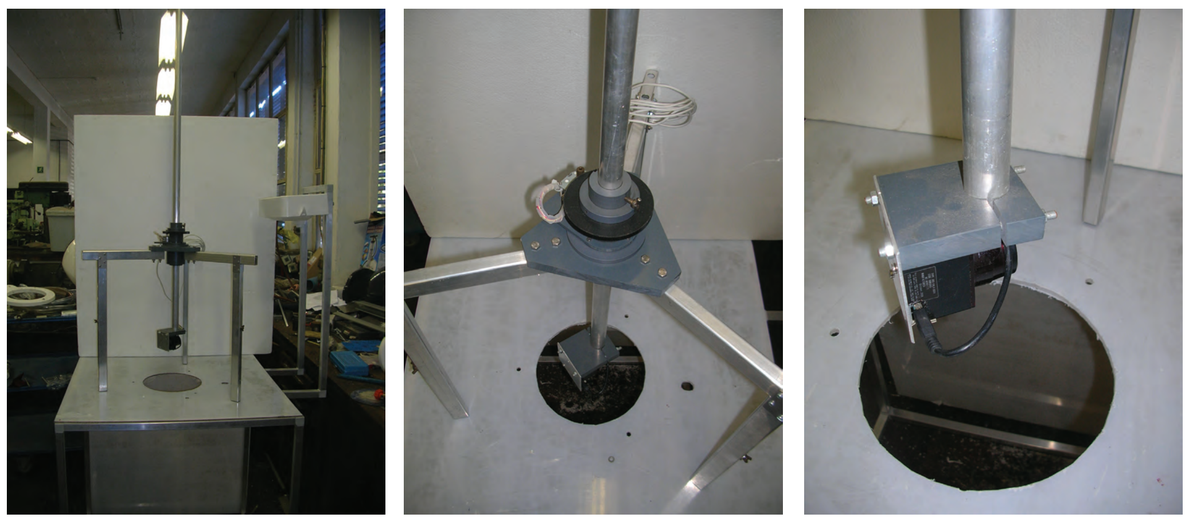

FIGURE 3 (a) Scanner in position over model pit; (b) Laser device lowered through hole; (c) Laser scanner

FIGURE 4 (a) Pedestal in position; (b) Pedestal removed—view into pit

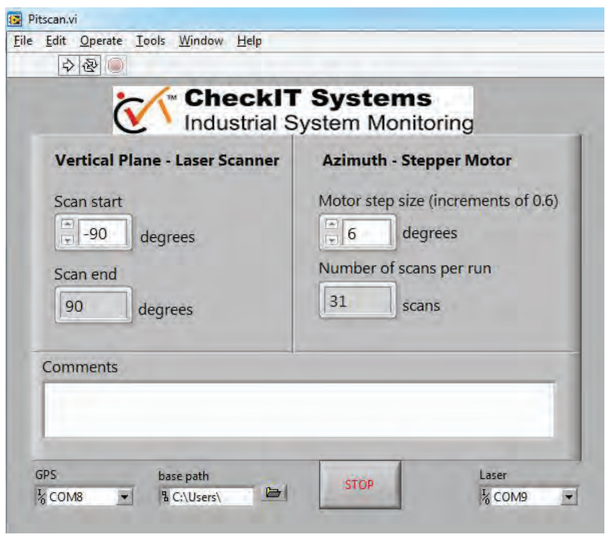

FIGURE 5
Scan acquisition software front panel

Volume calculation

The data that the scanner stores are the azimuth, elevation and distance from the scanner to each point in the walls and surface of the pit. The software first converts these to x, y and z coordinates relative to the scanner. The volume is calculated by constructing a set of tetrahedra, each with its apex at the scanner, and its base on the pit surface (Figure 6).

The total volume is the sum of the volumes of the tetrahedral elements.

The scanner occasionally does not receive an adequate reflection from a surface, resulting in an invalid measurement. Too many of these can upset the volume calculation. To provide a check , the programme has an option to fit planes to the four walls, and the bottom surface, and calculates the volume of the resulting box.

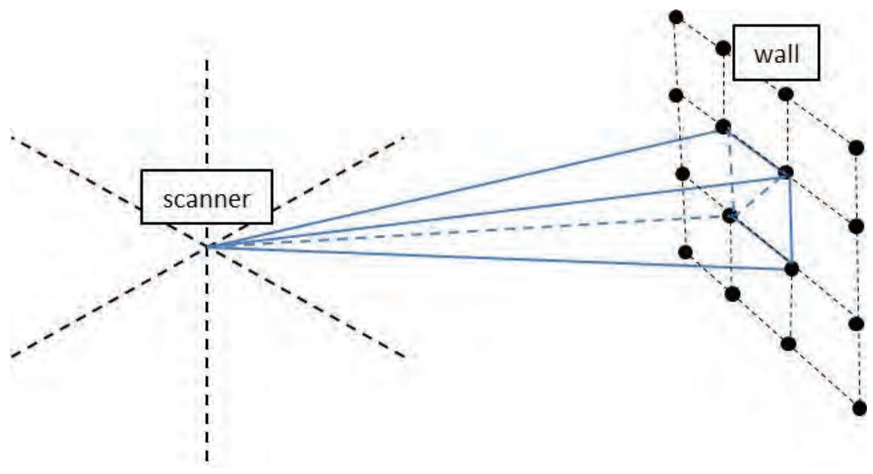

FIGURE 6
Tetrahedral element used to calculate volume

The programme calculates the difference in total volume between the full and empty pit scans to produce a figure for the volume of sludge removed. Surface images of the full and empty pit are also generated (Figure 7).

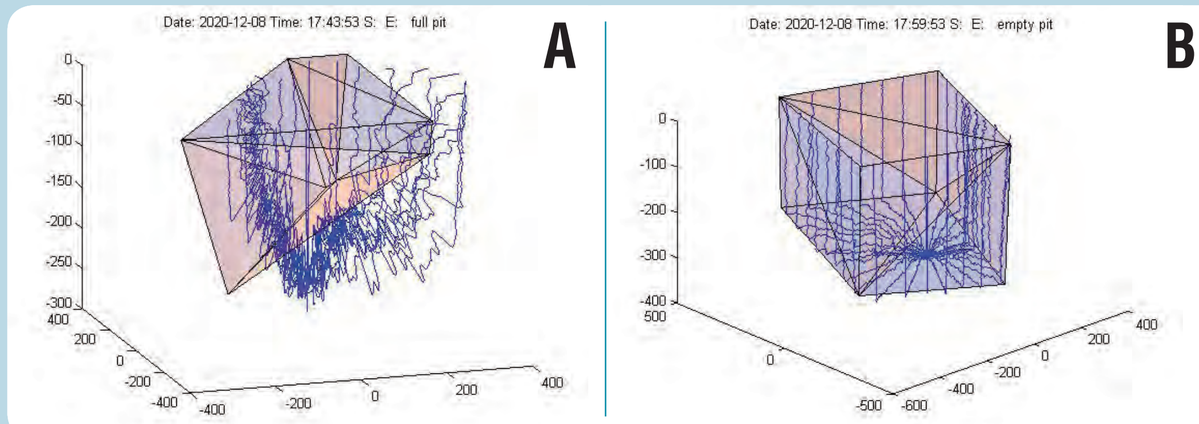

FIGURE 7 (a) Full pit surface image; (b) Empty pit surface image

Pit additives

Numerous chemical additive products are sold that claim to reduce the rate of accumulation of sludge in a pit, or even reduce the actual volume of sludge already present in a pit. Some additives are dosed in significant volumes of water. Sludge often accumulates in a pile in the section of the pit under the pedestal (Figure 1). Pouring water down the pit has the effect of spreading the pile, which tends to make the volume of sludge contained in the pit appear smaller. Sequential scans of the entire surface of the sludge pile can more accurately determine if any actual volume reduction has been achieved by the additives.