Tracking de-sludging vehicles through axle load sensor

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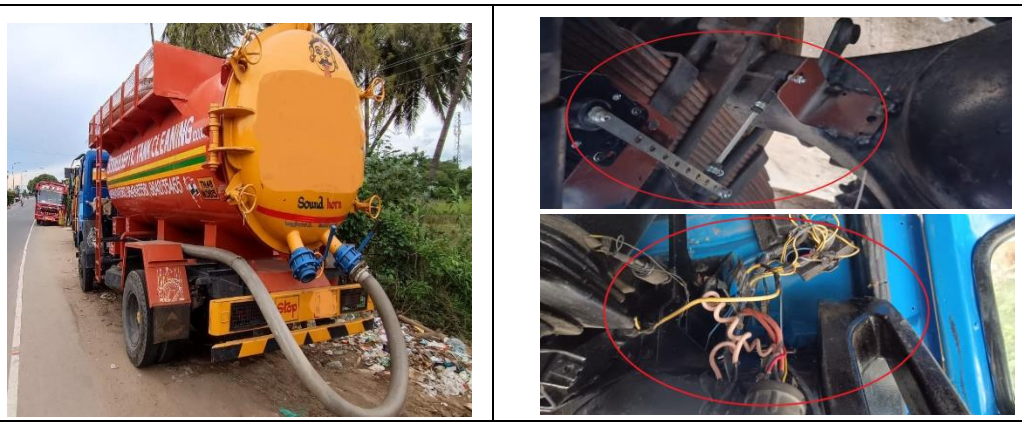
Summary
Tamil Nadu is a rapidly urbanising state that has been establishing and scaling up sustainable FSSM, leading the way in innovating technologies and operating models in sanitation. Safe collection, handling, and transport of FS is an integral part of a septage management programme. This paper documents the use of load axle sensors with GPS technology in the de-sludging vehicle to understand the movement of the vehicle, de-sludging and disposal locations, travel distance and time, and the time for de-sludging and decanting. These learnings help determine the location of current disposal, service area, and planning of decanting facilities.

Introduction
De-sludging vehicles collect and transport septage to designated decanting facilities, eliminating the need for manual emptying and reducing the risk of human contact with FS. As per the Tamil Nadu Urban Local Bodies (Amendment) Act (2022), the desludging vehicle must install a GPS device to monitor the de-sludging and decanting activities.
However, GPS can only track the movement of the vehicle and not locate de-sludge locations and whether operators were safely decanting the FS at the designated spot. Identification of the desludging and decanting locations with loaded quantities using GPS technology is difficult and a highly time-consuming process. The time required to analyse each vehicle could be a challenge for the ULBs as they scale this monitoring strategy.
Therefore, a study done on this aspect by the TNUSSP intended to identify the possibilities of monitoring the de-sludging vehicles using a load sensor with GPS technology.

Methods
Axle load sensors are available in two varieties: pressure sensors and position sensors. The position sensors are for leaf spring suspension vehicles, which gives the status of the vehicle (loaded/ non loaded) by measuring the deflection of the leaf spring. The pressure sensors are for air suspension vehicles, measures the pressure of the compressed air in the suspension circuit.
The study preferred the position axle load sensor to monitor the selected de-sludging vehicle with leaf spring suspension, due to its cost-effectiveness and lower accuracy range requirement. The rate of deflection from the sensor was integrated with GPS and the status of the vehicle location with load variations could be analysed.

Field implementation: A position axle load sensor with GPS connected to an IoT device was installed in a de-sludging vehicle with 10000 litres capacity providing services in an urban area of Tamil Nadu. The operator used the three designated decanting facilities located in the service area of the vehicle for decanting purposes.
The sensor installation is depicted in the figure 1 provided below.

Figure 1: Sensor installation in selected desludging vehicle

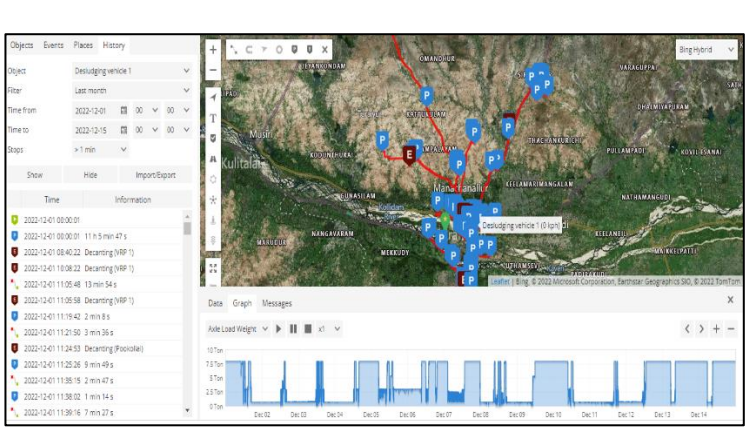


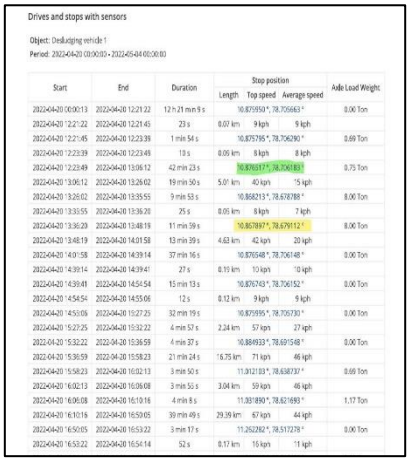
Implementation cost (software, hardware, and installation cost): For a simple GPS monitoring system, it is usually around USD 80, while that for an axle load sensor with GPS is USD 740.

Institutional arrangement: Private vendor provides axle sensor device to ULB and ULB coordinates with desludging operator for installation and monitoring.

Monitoring method: During de-sludging and decanting of FS, the sensor captured axle load weight data corresponding to the movement of spring attached to the body of the vehicle. Server software processes and analyses the received data to generate analytical reports for a selected period of time. Thus, the quantity of FS loaded/ unloaded, duration, latitude, and longitude were recorded, and the corresponding locations were identified as the de-sludging/decanting points. These outputs have been remotely monitored since April 2022 using either the mobile app or the customized web application.

Figure 2: Screenshot of web application and monitoring report



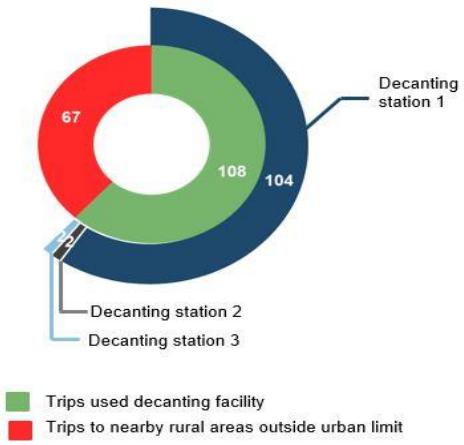


Results and Discussions

De-sludging locations: From a sample data of two and half months from the date of installation, 175 de-sludging locations were captured, covering a service area of 90 km^2 including both the urban and rural areas.

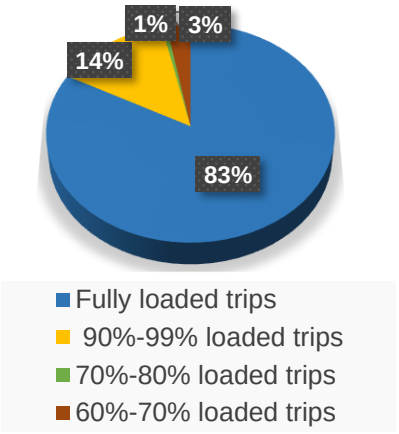
Decanting locations: The vehicle operator decanted FS at three designated decanting facilities in 108 trips out of 175. The pie chart shows the summary of trips which include trips used the decanting facility and trips to nearby rural areas outside the urban limit.
It was identified that the decanting station 1 was frequently visited as most trips were made to neighbourhoods around that station and remaining trips were to nearby rural areas outside the urban limits. Less than 3% of the trips had more than one desludging stop, according to the analysis.

Figure 3: Summary of trips



FS quantity loaded/ unloaded: Total quantity of FS loaded/unloaded was found to be 1.717 million litres from 175 trips. The designated decanting facilities received 62% of the overall FS quantity loaded, while the remaining trips were made to nearby rural areas outside the urban limits.
The load quantities varied with trips, with more than 90% of the vehicle capacity being loaded with FS on 168 trips. This describes that the desludging operator focused on filling the tank during his travels to make those trips profitable for him.

Figure 4: FS quantity loaded vs trips



Travel distance and travel time: Analysis showed that the average travel time between the de-sludging and decanting locations was 25 minutes. Situations such as truck parked overnight between de-sludging and decanting exempted from average time calculation. For rural areas, the average distance between the de-sludging and decanting location was 3.42 km, it increased to 7.85 km in the urban limit. In urban limit, the maximum and minimum distances are 20.57 km and 1.77 km, respectively, whereas in rural areas, they are 20.48 km and 0.35 km.

De-sludging and decanting time: A sample data set of one month was analysed to identify the time taken for de-sludging the FS from the containment into the vehicle and decanting the same into the decanting facility.
The respective time was identified from a graphical representation obtained from the monitoring website. The rising limb of the graph depicts the desludging of containment with increasing vehicle axle load and

Figure 5: Graphical representation of desludging and decanting

the falling limb illustrates the decanting. The average time for de-sludging, and decanting were around 11 minutes and 5 minutes, respectively.

Challenges in scaling

The major challenges associated with scaling this monitoring technique are as follows.

1. Requirement of an efficient monitoring system within the ULB
2. Highly priced system: Possibility of vehicle owners with a greater number of vehicles refusing to adopt
3. Lower acceptance among de-sludging operators for installation fearing regular monitoring of their activities.
4. Possibility of vehicle operators tampering with device
5. Difficulty in orientation for desludging operators about proper desludging and decanting due to frequent changes in personnel.

Conclusion

This study aimed to identify the possibilities of monitoring the movement and de-sludging activities of vehicles using axle load sensors. Monitoring helps identify the service area of the vehicle, the desludging and decanting locations, quantity of FS collected, travel time and distance between desludging and decanting locations, and time for desludging and decanting. The analysis of travel distance and time aids for planning additional decanting facilities. Additionally, the vehicle was discovered to be loaded overnight and parked, so it is advised to keep the decanting station open at night as well.

Field teams are working on upgrading the system with an ultrasonic load sensor for more accuracy at an affordable cost. Also, the option of incorporating the sensor output with the FSSM application to plan schedule de-sludging, auto deduction of decanting fee and real-time plant utilisation rate, etc., are under progress.

References

1. Tamil Nadu Urban Local Bodies (Amendment) Act, Government of Tamil Nadu, 2022
2. Tamil Nadu Urban Local Bodies and Chennai Metropolitan Area Septage Management (Regulation) Rules, Government of Tamil Nadu, 2022

Abbreviation

FS	- Fecal sludge
FSSM	- Fecal sludge and septage management
GPS	- Global Positioning System
IoT	- Internet of Things
TNUSSP	- Tamil Nadu Urban Sanitation Support Programme
ULB	- Urban local body
USD	- United states dollar