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Preliminary tests of sensors to detect sewer network blockages

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ABSTRACT. ***Sewer blockages are a major problem in cities worldwide; these blockages are usually caused by a combination of fat, oil and grease waste and sanitary items that enter the network. This paper reports on preliminary tests of sensors to detect sewer network blockages in order to develop an advance warning system. Data from an ultrasonic level sensor were somewhat inconsistent while temperature records seem to be make more sense. The data capture level varied from 70-88% compared to what was originally planned, so data gaps are a concern. Further analysis is required along with testing of other sensors to determine which combinations work best.***

Keywords. Fats, grease, IoT, oils, sensors, sewer, warning system, waste management.

Introduction

While some urgent repairs are required occasionally for communication and water networks, there is a growing problem of emergency works and traffic diversions caused by sewer blockages in large cities due to "fatbergs" - a term that has been coined over the past decade or so to describe large conglomerations of fat, oil and grease (FOG). Fatbergs are particularly prevalent in the UK and often hit the media headlines when they are compared to the size of a double-decker bus or jumbo jet (Curran, 2015). The largest fatberg to date was found in London in September 2017; "the 800-foot-long, 130-ton blob the size of 11 double-decker buses was blocking a 270-yard stretch of sewer" (Onyanga-Omara, 2017).

While some estimates suggest that FOG is the primary cause of blockages in 50-75% of cases, there is also another major influencing factor with Non-Flushable Products (NFPs) such as sanitary towels and "flushable" wipes which may end up in the sewer. Resulting inconveniences and damage may include sewer overflows into water bodies, flooding of property and emergency roadworks with traffic diversions to remove the fatbergs (Curran, 2015).

To deal with this growing global FOG problem in sewer collection systems, significant research has been devoted to three aspects: (i) the formation of FOG deposits (e.g., mechanisms and kinetics), (ii) the source of chemical constituents involved in FOG deposit formation, and (iii) engineering solutions used to mitigate the problems caused by FOG (He, De los Reyes, & Ducoste, 2017). Major efforts have been made in cities in terms of education campaigns and inspections of food service establishments to reduce FOG entering sewer systems (Wallace, Gibbons, O'Dwyer, & Curran, 2017). It appears that a combination of technology, education and regulation should be used in order to deliver effective results.

Apart from the environmental and economic costs associated with blockages and subsequent overflows, the safety of workers going into sewers to remove fatbergs is also a concern. While preventative maintenance is useful to reduce the occurrence of blockages, the response tends to be reactive to clean up after an overflow has happened.

With the advent of low cost sensors connected to an Internet of Things (IoT) network (Morgan, 2014), it should be possible to develop inexpensive solutions that could be widely deployed in sewers, an asset class that has suffered from serious underinvestment. This approach can be combined with analysis through Geographical Information Systems (GIS) to identify hotspots for high frequency of blockages. Some efforts have been made to test IoT sensors in sewers (Adhikari, 2016) although there are existing communication technologies that can also serve the same purpose.

The objective of this study was to carry out preliminary tests on low cost IoT-sensors to monitor a sewer system.

Materials and Methods

Ideally, a range of IoT-enabled sensors would be selected that could measure indicators of blockages occurring in sewers. Such parameters could include sewage flowrate and level along with gas concentrations in the headspace above the sewage. Due to resource limitations, sensors were selected based on cost, availability and likely reliability. An ultrasonic sensor ("KotahiNet- Internet of Things," 2018) was selected with the capability of measuring liquid level. A multipurpose sensor ("Siconia TM Multi-purpose devices," 2018) was also chosen which could measure temperature, pressure and humidity. A bracket was constructed to allow the installation of the devices just under a manhole lid on the campus sewer network at University College Dublin. This location was considered ideal as it was effectively like a small town with a residential population and food service establishments. An advantage of the installation just under the manhole cover was that personnel were not required to enter fully in the sewer, thus reducing the health and safety risk of being overcome by H_2S gas.

Results and Discussion

The data collected included sensor values, time and date stamps, along with battery and signal strengths. While the sensors were set up to send data at intervals of one minute (level) and 15 minutes (temperature), there were occasions when the values were not recorded. The depth to sewage was collected 70% of the time while the temperature data were recorded 88% of the time. It is not certain why that happened but most likely, there were intermittent communication issues.

Figure 1 shows the depth from the ultrasonic sensor to the sewage level in the manhole measured each minute over a 24 hour period. The stable level was 1.36 metres but spiked once to 1.71 metres and several times as low as 1.06 metres. It seems that these extremes are unlikely at one minute intervals, so further investigation is necessary. However, the level was at 1.36-1.37 metres the vast majority of the time. One could expect such changes as flow will vary depending on water usage (e.g. kitchens, bathrooms, etc.) upstream. It may require a more robust sensor for this application to eradicate the unexpected fluctuations in the data.

Figure 2 shows the air temperature in the manhole as measured every 15 minutes during a sampling day, the same period as illustrated in Figure 1. The ambient temperature above ground was reported to vary between 8.5-20.0^{0}C at Dublin Airport according to the nearest official meteorological records (Met Éireann, 2018) on the same day. The minimum air temperature (14.6^{0}C) under the manhole cover occurred between 5am and 7am while the minimum ambient temperature was recorded at 3am and the maximum at 3-4pm, slightly earlier than that (15.4^{0}C) below ground.

Further analysis is required to examine trends in temperature. The flow records in the water supply network could prove useful along with energy use in buildings to understand influence of flow and heating of water (e.g. showers) throughout the day. Other non-invasive temperature sensors could be used to determine the actual temperature of the sewage.

Based on preliminary findings in this study, it is clear that it would be better to have replicate sensors for temperature, level and other parameters (e.g. H_2S) at least for more robust trials to determine not only if there is a blockage building up in the sewer but if it is safe for personnel to enter. Having more than one sensor is useful to get a better understanding of what is happening. If sewage level is rising in a manhole, it may well coincide with increasing H_2S levels. It is also important to determine the durability of sensors through long term use, considering that a sewer is a very challenging environment with high levels of moisture and gases present. The transmission of data must also be reliable though the communication network.

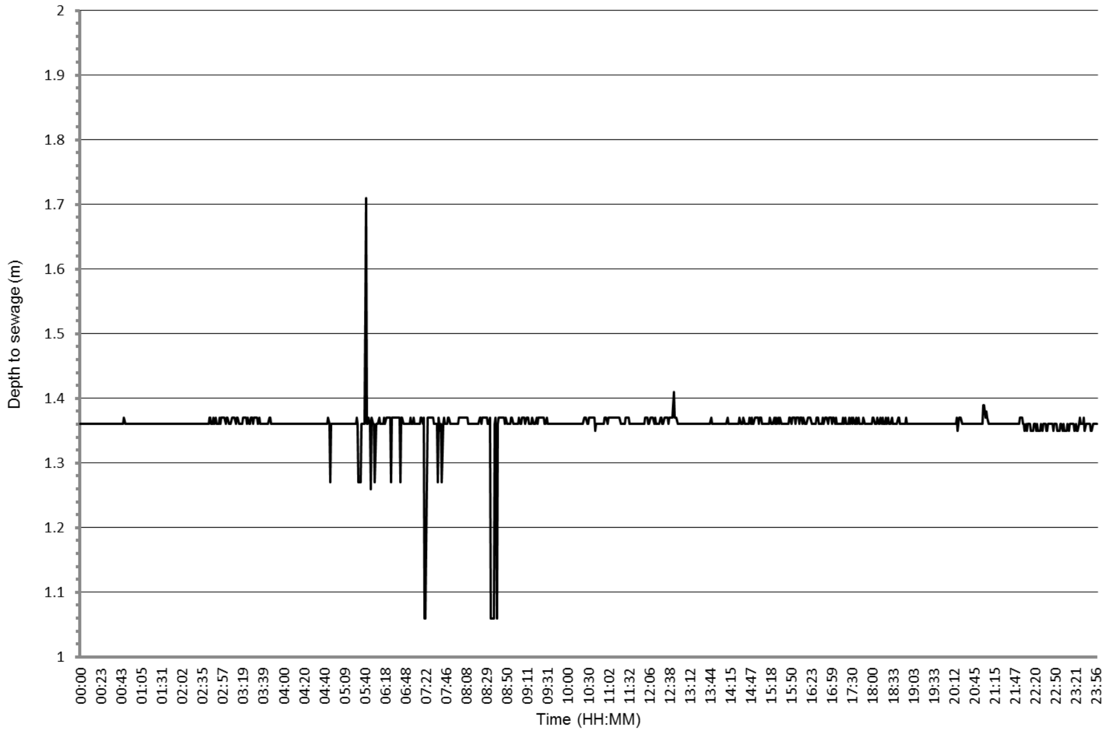

Figure 2. Graph of depth to sewage level as measured every minute during a sampling day.

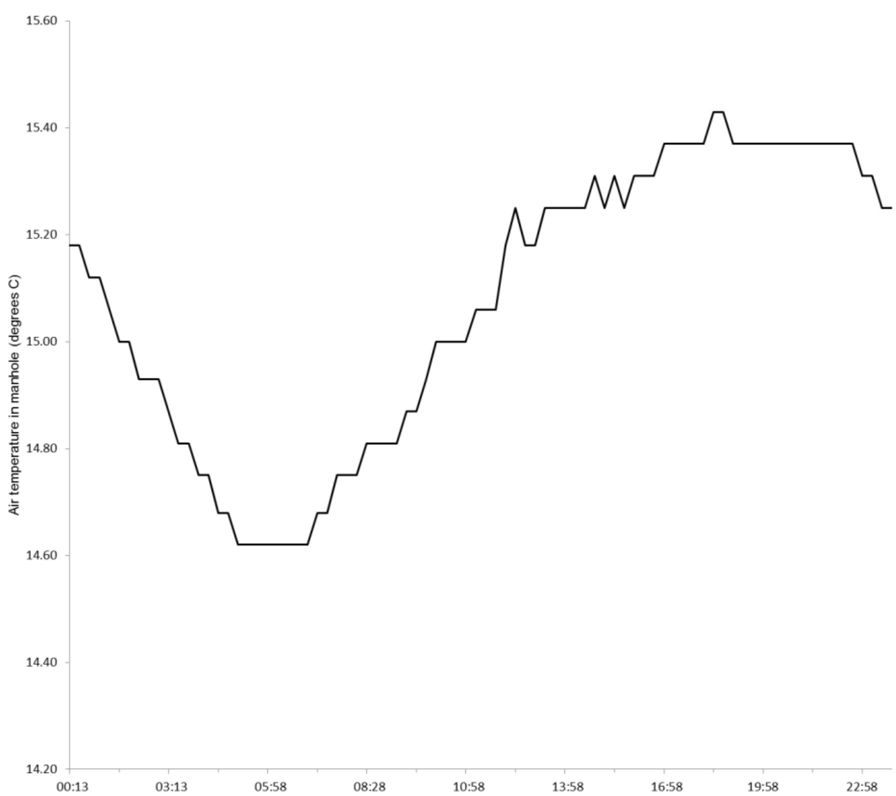

Figure 2. Graph of air temperature in the manhole as measured every 15 minutes during a sampling day.

Conclusion

Preliminary results from a trial of low cost, IoT-enabled sensors in a sewer show promise as a monitoring option to provide an advance warning system for blockages. However, data from an ultrasonic level sensor that was tested were somewhat inconsistent while temperature records seem to be make more sense. The data capture level varied from 70-88% compared to what was originally planned, so data gaps are a concern too. Further analysis is required along with testing of other sensors to determine which combination works best.

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