Conclusions from project LoV-IoT relevant for Trafikverket

Project reference TRV 2017/111856

Trafikverket participated in Luft- och vattenövervakning – Internet of things (LoV-IoT) by a subproject financed from Trafikverket to include and contribute with needs identified for Trafikverket.

For air quality measurement an increased air quality monitoring network around large infrastructure projects are of interest for Trafikverket which is a major customer. At these sites, emissions are typically closely dependent on activity that can cause large variations in air quality over short distances. A denser measurement network around these sites may be very useful for adequate control of air quality as well as for assessment of suitable mitigation measures.

For water quality measurement we have identified that the main benefit that the city sees is predictive maintenance. To develop a solution for predictive maintenance you need at least a water level sensor and preferably also a turbidity sensor to predict how much load it has been on a system over time. This prediction can be used to alert the city water board that a system needs to be cleaned to keep its performance. Part of these ideas is further developed in the EU-Project SCOREwater [1].

From the project SCOREwater (Periodic Technical Report Part B, 1st period) we have further investigated what will be needed and we suggest that research and innovation is focused on how to scale up systems. To start predictive maintenance of wastewater systems should be prioritized since volumes could be expected there, one could expect OPEX/CAPEX gains and failure to in time identify clogging and sedimentation can lead to odour, overflow and make the impact of flooding events more severe, leading to damage to property and business. By creating a first volume market also other areas as, environmental monitoring, could benefit later.

Online monitoring of pollutants from storm water and combined sewage and stormwater systems are usually not a legal requirement, or even allowed for reporting. There are therefore little incentives for utilities and other actors to invest in sensing technologies for water quality monitoring. This challenge has been identified when addressing the market of environmental monitoring of constructions sites. The United States has stricter regulations on monitoring pollutants of stormwater. Market analysis shows that the United States has a more thriving market and several growth companies commercializing sensing technologies. There are market ready or near market ready sensing technologies for turbidity, ph and conductivity. It would therefore be beneficial to set legal requirements on online monitoring of pollutants from storm water and combined sewage and stormwater systems. I could be wise to start with some key parameters like turbidity, ph and conductivity. Without such requirement there will be little incentives for utilities and other actors to invest in sensing technologies for water quality monitoring. One interesting area to start with could be environmental monitoring of storm water from larger constructions sites like for example infrastructure projects, since there are already today monitoring requirements on these projects. Online monitoring with low-cost sensing technologies could also open up for the possibility to have requirement to monitor smaller construction sites, that today only must make qualitative environmental reports without measurements since laboratory testing is too costly, and thereby improve the overall water quality.

Trafikverket together with Park och Natur and Trafikkontoret all have stormwater infrastructure so collaboration between these actors and the main responsible for the water entering recipients Kretslopp och Vatten is key.

Summary and conclusions below are taken from reports provided by Miljöförvaltningen in the City of Gothenburg.

Svensk sammanfattning och slutsatser av intresse för Trafikverket

Trafikverket deltog i Luft- och vattenövervakning – Internet of things (LoV-IoT) genom ett delprojekt finansierat av Trafikverket. Detta för att kunna följa projektet samt bidra med de specifika behov trafikverket har.

Trafikverket är en stor beställare när det kommer till infrastrukturprojekt i städerna. Infrastrukturprojekt är en potentiell källa till utsläpp av både luft och vattenföroreningar och ett utökat mätnätverk av enklare sensorer för övervakning är av intresse.

Luftemissioner kring infrastrukturprojekt är starkt kopplade till de aktiviteter som utförs på platsen och stora lokala variationer kan ses. Ett utökat mätnätverk kring dessa projekt skulle kunna ge upphov till bättre monitorering och kontroll av luftkvalitén och att man har möjlighet att sätta in åtgärder tidigare för att minska utsläppen.

För vattenmätningar ser vi att den största nyttan är prediktivt underhåll av ledningssystemet för dag- och spillvatten. För att kunna erbjuda en lösning för prediktivt underhåll behöver man kunna mäta både nivå och turbiditet vilket ger en uppskattning av belastning över tid. Belastningsuppskattning för systemet kan användas som indikator för att spola rent systemet för att bibehålla prestandan i ledningarna. Delar av dessa slutsatser är vidareutvecklade inom EU-projektet SCOREwater (www.scorewater.eu).

Inom projektet SCOREwater (Periodic Technical Report Part B, 1st period) har vi ytterligare undersökt möjligheterna för ett övervakningssystem av vattenkvalité och våra slutsatser så långt är att det behövs ytterligare satsningar på att effektivt skala upp övervakningssystem. Till att börja med bör man prioritera prediktivt underhåll då detta på kort sikt kan leda till besparingar, minskad miljöpåverkan eller minskad förstörelse på grund av översvämningar. Här ser vi också att det finns potential för en volymmarknad. Genom att skapa en volymmarknad för prediktivt underhåll så skapas förutsättningarna för att nyttja tekniken även för miljöövervakning.

Övervakning av föroreningar från dagvatten eller kombinerade system är idag inte ett lagkrav varför det idag finns begränsad möjlighet att nyttja ny teknik för detta ändamål i städer eller vid infrastrukturprojekt. I USA har man striktare krav och detta kan förväntas införas även i Europa. Det finns idag produkter som är nära kommersialisering eller som redan finns på marknaden för att mäta turbiditet, pH och konduktivitet. Det skulle därför vara möjligt att sätta lagkrav på övervakning i nära realtid för föroreningar i ledningsnätet. Utan lagkrav kommer det finnas lågt incitament för att investera i teknik för vattenövervakning från varken staden eller andra som påverkar ledningsnätet som t.ex. Trafikverket. Genom att det kommer ny teknik baserat på IoT, vilket har möjlighet att kunna vara enkel och billig att använda, så finns det även möjlighet att ställa lagkrav även på mindre byggarbetsplatser. Idag behöver inte mindre byggarbetsplatser genomföra faktiska mätningar då detta är för kostsamt. Ett skärpt lagkrav skulle då kunna leda till en förbättrad vattenkvalité i stort då det finns många mindre byggarbetsplatser i städerna.

Trafikverket tillsammans med Park och Natur, Kretslopp och vatten samt Trafikkontoret har alla dagvattenledningar så ett förbättrat samarbete och utbyte av information kring vattenkvalité är viktigt och något som kan förbättras genom ny teknik för vattenövervakning men kanske främst genom att data görs tillgängligt mellan aktörerna.

Summering och slutsatser nedan är hämtade från rapporter tillhandahållna av Miljöförvaltningen i staden Göteborg. https://goteborg.se/wps/portal/start/kommun-o-politik/kommunens-organisation/forvaltningar/forvaltningar/miljoforvaltningen/miljoforvaltningens-rapporter-och-trycksaker/rapporter-fran-miljoforvaltningen?uri=gbglnk%3A2016326143938300

Summary

Environmental monitoring lays the foundation of all environmental work. The status needs to be monitored to be able to put in necessary measurements to reduce the negative impact on human health and on the environment that the emissions have.

LoV-IoT was an innovation and development project which explored the possibilities to complement air and water monitoring with the use of sensors and Internet of Things (IoT).

LoV-IoT was one of the projects within the strategic innovation program IoT Sverige. IoT Sverige is one of the 17 strategic innovation programmes funded by Vinnova, The Swedish Energy Agency and Formas.

For further reading go to the webpage "Rapporter från miljöförvaltningen" where all reports from the project are found. The reports are named as follows:

R2020:15 LoV-IoT Luft- och vattenövervakning med Internet of things – Integrering av projektresultaten i en kommun

R2020:16 LoV-IoT Luft- och vattenövervakning med Internet of things – Affärsplattformar

R2020:17 LoV-IoT Luft- och vattenövervakning med Internet of things – Utbildning och medborgarforskning

R2020:18 LoV-IoT Air and water monitoring with Internet of things – Air quality

R2020:19 LoV-IoT Air and water monitoring with Internet of things – Water

R2020:20 LoV-IoT Luft- och vattenövervakning med Internet of things – Dataplattform

R2020:21 LoV-IoT Luft- och vattenövervakning med Internet of things – Koncept för att använda sensordata för att validera spridningsmodeller

Conclusions

The conclusions below are from reports:

R2020:18 LoV-IoT Air and water monitoring with Internet of things – Air quality

R2020:19 LoV-IoT Air and water monitoring with Internet of things – Water

Air quality monitoring

The work in the LoV-IoT project has shown that the low-cost air quality sensor (LCS) platforms can indeed be very useful and have many suitable applications. However, it is important to take the performance limitations and maintenance, calibration and post-processing needs into account when integrating LCS platforms in air quality monitoring. Experiences from the LoV-IoT project can be summed up in the following conclusions regarding suitable applications:

- For citizen science and communication purposes – Due to their low cost, these sensors are suitable for incorporation in outreach activities and used for citizen science. The citizens can be allowed to build and experiment with the sensors and there is room for trial and error also in a limited budget. However, it is still important to plan how the sensors should be used in advance and what the use should add and contribute to. It is also important to make sure that the participants are aware of limitations in data quality and applications.

- For complementary measurements - due to the limitations in ability to correctly measure absolute pollutant concentrations, LCS technology should not replace reference measurements but only be used to complement these and to extend station density. As LCS of the same type generally react similarly to external factors, such as change in meteorology, a sensor measuring parallel to the reference instrumentation can thus be used to identify and calibrate for such biases in the whole LCS network.

- Measurements with limited spatial extent - due to the sensitivity to changes in meteorology, LCS networks should only be applied within a spatially limited area, where the meteorological conditions do not differ to the extent that a different bias is created within the sensors in the network.

- Measurements with limited temporal extent– due to the tendency for drift in sensor performance with time, LCS networks should only be applied within a time period limited to well within the expected life span of the sensors. It is also recommended to identify and calibrate for drift for all studies intended for longer time periods.

- For identifying patterns – as sensors of the same type react similarly to change in both the intended pollutant as well as biases, these sensors are well suited for assessment of patterns and identification of deviations from these patterns within a smaller geographic area.

- For initial rough measurement and indication – in situations when a rough indication of rapid change in air quality is needed, LCS networks may be suitable for an early warning system or as a tool for a rapid first assessment. Such situations could for example be during a fire or during sudden major pollution release from, for example, industrial processes. This requires a good understanding of the sensor response to change, and generally follow-up measurements with high quality instrumentation.

In practice, this means that LCS networks are suitable for assessing the changes in air pollutant concentrations around places of interest, in studies with limited spatial and temporal extent. Such an application could, for example, be assessing the detailed variations in pollutant concentrations around a school in order to identify the most polluted microenvironment, perhaps to assess where mitigation efforts such as barriers between pollution sources and exposure locations should be focused. As with all measurements it is vital that the location and orientation of sensors and sensors inlets/filters are carefully selected to represent the intended area and to avoid biases.

It could also be an increased air quality monitoring network around large infrastructure projects. At these sites, emissions are typically closely dependent on activity that can cause large variations in air quality over short distances. A denser measurement network around these sites may be very useful for adequate control of air quality as well as for assessment of suitable mitigation measures.

As previously stressed, it is vital that the proper maintenance and post processing is applied when using LCS technology. It is important to remember that using LCS technology does not limit the need for maintenance and calibration of the sensor technology. The sensors will need continuous calibrations, preferably through comparative measurements before and after use in the field. Just like any sensor technology, the LCS may break down and malfunction, and thus require maintenance, repair or replacement. While the replacement cost may be low for LCS, the need for validation and calibration remain for each replacement unit. If more sensors are used, the need for maintenance will increase. This is important to take into consideration when planning measurement campaigns with a large number of sensors.

Water Quality monitoring

The innovation project is based on public sector needs in environmental supervision of water, with focus on storm- and waste-water infrastructure and operation.

The project shows that massive deployment of low-cost sensors is an attractive method to collect data and get visibility of a vast infrastructure such as stormwater and sewage systems in a city. Dedicated IoT networks such as LoRaWAN give sufficient network coverage also down in wells and into the sewage system, low battery consumption for the communication enables long life length. The IoT devices supporting off the shelf sensing probes are relatively cheap which gives low total cost of ownership per measurement.

The project shows also that the main limitations are on the measurement probes, to get long life length, low maintenance cost and high measurement accuracy. Especially the sensors placed into the water are exposed to residue and harsh environment during maintenance operations such as pipe cleaning with high pressure water.
Further, the measurement probes are typically more expensive than the communication and control units and have high battery consumption.

The outcomes of the project are insights and experiences how to deploy sensors in a city and to understand what measurements from more simple sensors can be used for. The main benefit that the city sees is predictive maintenance. To develop a solution for predictive maintenance you need at least a water level sensor and preferably also a turbidity sensor to predict how much load it has been on a system over time. This prediction can be used to alert the city water board that a system needs to be cleaned to keep its performance. Part of these ideas is further developed in the EU-Project SCOREwater [1].