LOTUS

LOW-COST INNOVATIVE TECHNOLOGY FOR WATER QUALITY MONITORING AND WATER RESOURCES MANAGEMENT FOR URBAN AND RURAL WATER SYSTEMS IN INDIA

LOTUS NEWSLETTER N°1

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Welcome from the Coordinators!

Dear Reader,

We are delighted to present to you the first edition of our LOTUS project newsletter.

In this first newsletter, we would like to familiarise you with the LOTUS project and what it is about, but also share first results and on-going developments.

Launched in February 2019, LOTUS is a project funded by the Directorate General Environment under the European Union Horizon 2020 Research and Innovation Programme and by the Indian Government.

Water quality is a growing issue in India and beyond. India is facing severe challenges in the provision of drinking water, waste-water treatment and management of water systems. Only around 30 percent of the population has access to drinking water from a treated water source, often only for a few hours during a few days each week. 37.7 million Indians are affected by water-borne diseases annually, including a large number of children. The rapidly industrialising economy and the urbanisation stress the water system even more, and in many regions, there is a shortage of water for agriculture, aggravated by climate change.

These issues need solutions that are adapted to the conditions in India and can be provided at low cost so that a large fraction of the Indian people can profit from them. This is what LOTUS aims to do.

The LOTUS solution is based on an innovative sensor. It includes tailor-made decision support tools to exploit the capabilities of the sensor. It also relies on a specific approach to co-creation.

Indeed, LOTUS aims to be co-designed and co-produced in India, and to have a wide, diverse and lasting impact for the water sector in India due to intense collaborations between European and Indian, commercial and academic partner.

Lotus solution will be applied to six different scenarios: drinking water networks, water tankers, groundwater borewells, river water, irrigation systems, and wastewater plant outlets.

Interested to follow up on the project's activities and progress? Then check out the Project website regularly and register to the project's mailing list to make sure you will not miss our upcoming newsletters.

On behalf of the project team,

LOTUS project coordinators,

Dr. Bérengère LEBENTAL
Ecole Polytechnique, IFSTTAR, CNRS, France
berengere.lebental@ifsttar.fr

Professor Ravi Gudi,
Indian Institute of Technology, Bombay
ravigudi@iitb.ac.in

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LOTUS first year in a snapshot

LOTUS was officially launched one year ago in Delhi, India. This first year was the opportunity to start our activities, as well as polish and adjust the workplan for LOTUS to deliver a high-quality result. This first year was characterised by cooperation, communication, and a fast pace.

Cooperation: The LOTUS team cooperated efficiently to plan and develop activities efficiently all along this first year. While delving in the details of the use cases required the team to adjust its plan, each and every partner agreed to rearrange its activity and re-allocate resources to enable these use cases to happen in the best possible conditions, proof of the high motivation and implication of the entire project team.

Communication: Working in multicultural environment always is a challenge. LOTUS gathers partners from seven different European countries and five Indian regions, with different background and cultures. During this first year, all partners have learnt to know each other throughout three intense gatherings: two of them took place in India (February 2019, December 2019) and one in Paris (June 2019). These physical meetings have generated excellent interpersonal relations, which are facilitated through multiple WhatsApp conversations which have become a living tool of LOTUS project management.

Fast pace: LOTUS activities are on track! This is the result of continuous involvement of all partners throughout this year, making sure to advance with their tasks and support each other in implementing their activities, enabled by smooth communication and continuous adaptation.

Meet our team

The LOTUS project is composed of 23 partners from seven European countries and five Indian regions. The project brings together EU and Indian prominent organisations with the aim to co-create, co-design and co-develop innovative robust affordable low-cost sensing solutions for enhancing India's water and sanitation challenges in both rural and urban area.

Want to know more about us? All partner profiles can be found on our project website.

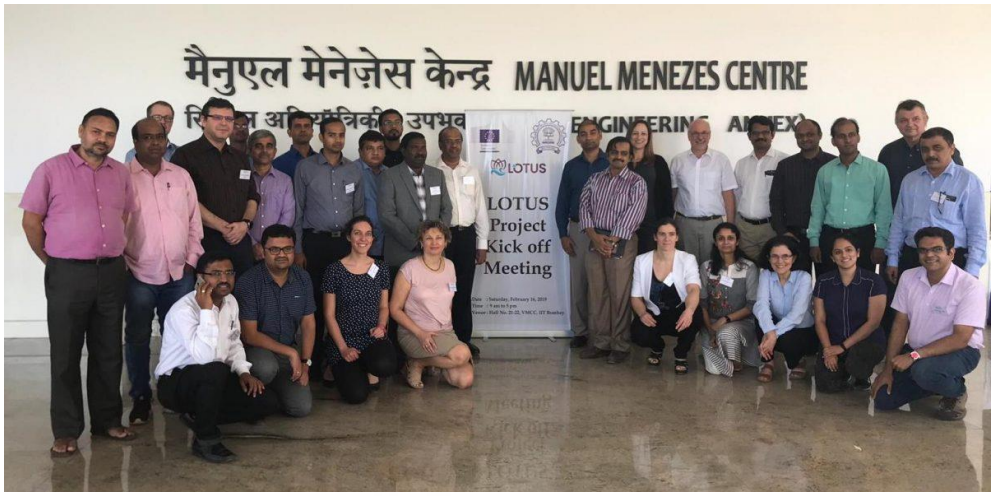

Figure 1: LOTUS team in Mumbai, 14/02/2019

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First project meetings and events

14-15 February 2019: Joint Kick-off Meeting in Delhi and project kick-off in Mumbai, India, a great opportunity to get to know each other and launch the project.

20-21 June 2019: Consortium Meeting in Paris, France, time to prepare a solid workplan based on the first six months' project activities.

29 November & 3-7 December 2019: Co-creation workshops and technical workshops in three Indian cities to refine the specification of the LOTUS sensor.

5-6 December 2019: Consortium Meeting in Mumbai, India, the opportunity to review progress and to finetune coming activities to keep the project on track.

Figure 2 LOTUS team in Ecole Polytechnique, France, 21/06/2019

First field-ready LOTUS sensors about to cross the finish line

While the technology on which LOTUS is based has previously proven viable in lab settings, prior devices stayed calibrated for only a few days at a time, making them unsuitable for use in the field. As such, our focus has largely been on improving device stability in order to bring performance in line with the threshold required for field use. After an experimentation phase, we can gladly report that the stability issue is nearing resolution as the team has significantly improved longevity via optimisation of the fabrication process.

With the solution to device stability in view, we have taken another significant step toward putting LOTUS sensors to work in real world situations. We have thus started a phase of batch production of our sensor chips in parallel to setting up an assembly line for small-series sensor production and to preparing at software level the system integration of the probes.

Delivery of the first field-ready LOTUS sensors is expected on-time by mid-March 2020, while the testing of LOTUS pre-series in Sense-City model water loop will start mid- February 2020.

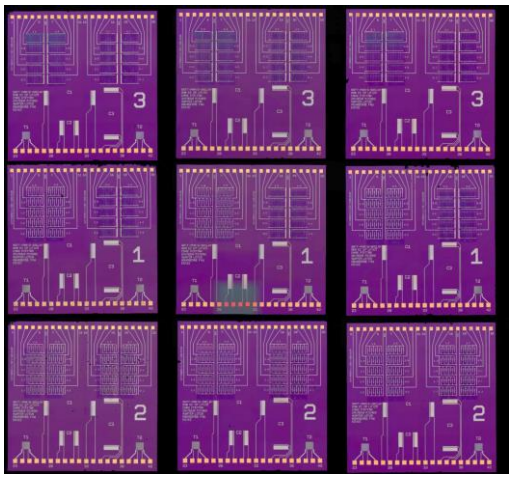

Figure 3: First batch fabrication of LOTUS sensor chips

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Many of the first sensors will be deployed to Guwahati, Assam, India where they will be used to improve trust in the city's water distribution system. Once deployed, our sensors will become a valuable asset to water managers in the area as they aim to direct public water consumption to the city-run network.

Other sensors in the first group will be used in conjunction with a tanker-mounted chlorination station. Many urban and rural areas of India rely on tanker-based solutions for water distribution as inground networks are either underdeveloped or unreliable. While tanker water providers have stepped in to address increasing distribution needs, lab tests show that water delivered via tankers is often unfit to drink once it reaches consumers. Combining LOTUS sensors with LOTUS tanker-mounted chlorination solution provides a path toward increased water quality for tanker-distributed water.

LOTUS co-creation workshops took place in India in December 2019

Co-creation is at heart of the LOTUS concept. The technological solution aims at being co-designed and co-produced with both Indian and European teams. The objective of the co-creation workshop was to understand the needs of the final users, in order to ensure that LOTUS solution matches the market needs, and to co-create features of an "ideal sensor" together with them, taking into account the social foundations, regional characteristics and the network building aspect.

Four co-creation workshops took place in India in December 2019, in three different locations, Guwahati, Jalgaon, and Bengaluru.

The overarching goal was to create a shared vision on water quality solutions, and to provide co-specifications for the technical requirements of the sensor, using participatory methods.

The participatory approach (small group method/World Café method) has been used to create a space where everyone has the chance to speak. Information was collected in different ways including personal brainstorming, quiet reflection, and group discussions.

The workshops have enabled to create expectation baseline, co-specification of the requirements around the use cases and definition of priorities from the final-user perspective. Results were transmitted to the technical teams and are currently under analysis to feed the specification of the LOTUS solution.

Figure 4: Opening session of the Jalgaon co-creation workshop, 03/12/2019

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Discover our use cases!

LOTUS aim is to bring the sensor technology from the lab to the field. The LOTUS sensor will hence be deployed in five use cases, all across India. The goal of these use cases is to test the sensor is widely different context for a large variety of use. LOTUS sensor will therefore be used to:

- Ensure the quality of the water distributed through the Guwahati Water Distribution System;
- Provide information about the ground water and river quality in Guwahati, Varanasi and Bengaluru.

In this case, LOTUS sensor will support the mapping of water contaminants and their dynamics in water:

- Monitor the quality of water distributed through water tankers in Bengaluru and inform end-users in real-time;
- Monitor and control innovative wastewater treatment plants in Chennai and Warangal
- Support the functioning of an automated drip-irrigation system in Jalgaon

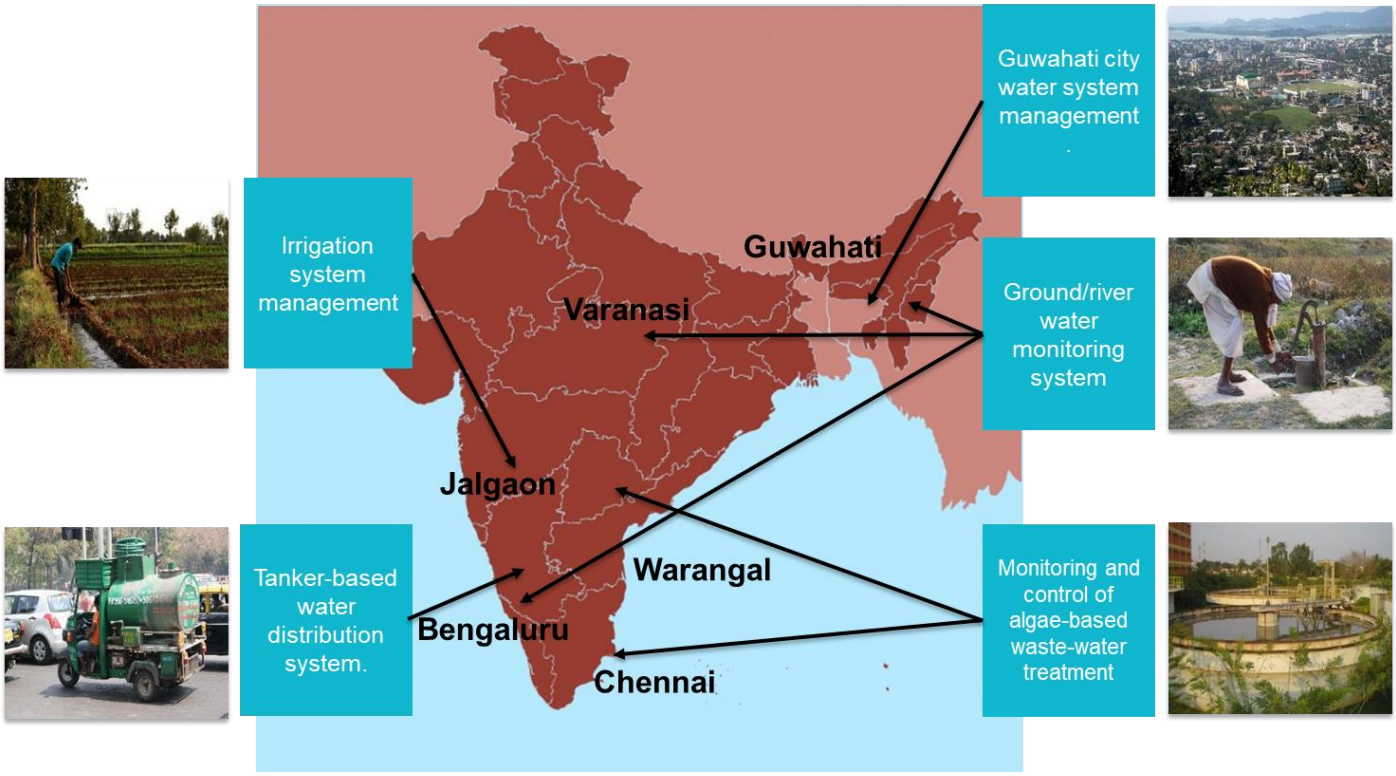

Figure 5: LOTUS use cases

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First steps to optimise the Guwahati water distribution network

Guwahati faces a problem of irregularity in water supply, with sharp seasonal variation. In general, the water has high turbidity levels, especially during the monsoon season as the water carries a large amount of silt. Therefore, the settlement process takes longer than usual. During the floods, polluted water enters into the water distribution pipes through the cracks and holes, which reduces the water quality further. The intermittent water supply aggravates the water quality as pipes fill with dirt when water is out.

An area of the existing water distribution network in Guwahati which is currently supplied intermittently was identified as a use case in order to demonstrate how to improve water supply conditions with the aim of moving towards continuous supply. This area is referred to as "Zoo Road" zone. The Zoo-Road network is currently divided into smaller distribution areas in order to manage water supply into the zone using a rotational programme covering a 1-hour supply time per day per distribution area in the zone. The customers have ground tanks in order to store water. These tanks have no flow control and in case of overflow water is lost.

LOTUS team at University of Thessaly is currently actively collecting data and information regarding the water supply and distribution network, water users as well as the intermittent water supply regime. This information once collected, collated and analysed, will form the basis for the development of a network optimisation strategy to improve the intermittent water supply regime with a goal to transition to 24x7 operation. A hydraulic model for the water distribution network using EPANET will also be developed. Altogether, this will enable to improve the water quality in the pipes of the city.

Figure 6: Guwahati Panorama

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A new anomaly detection tool is underway

To address the challenges in the operation of water distribution systems, the University of Exeter is currently developing a new technology. Convolutional Neural Networks (CNNs) have been identified as a promising machine learning tool for anomaly (pipe burst and leakage) detection. CNNs are the state-of-the-art deep learning algorithms in extracting key features so that anomaly can be effectively detected from huge and complex raw monitoring dataset. Fanlin Meng from the University of Exeter is currently building a CNN model (DenseNet, illustrated in the figure below) and is aiming to test it on a benchmark case study by June 2020. Fanlin is also working with IITB on sensor placement and assisting IITG on model calibration and simulation of intermittent water supply.

In parallel, Dr. Chris Sweetapple (C.S.) joined the LOTUS project in January 2020 and has been working with EGM on building LOTUS Cloud. Discussions have been made on which hydraulic and water quality simulation platform of water distribution systems to adopt that suits the Guwahati use case. The first version of LOTUS Cloud will be presented in May 2020.

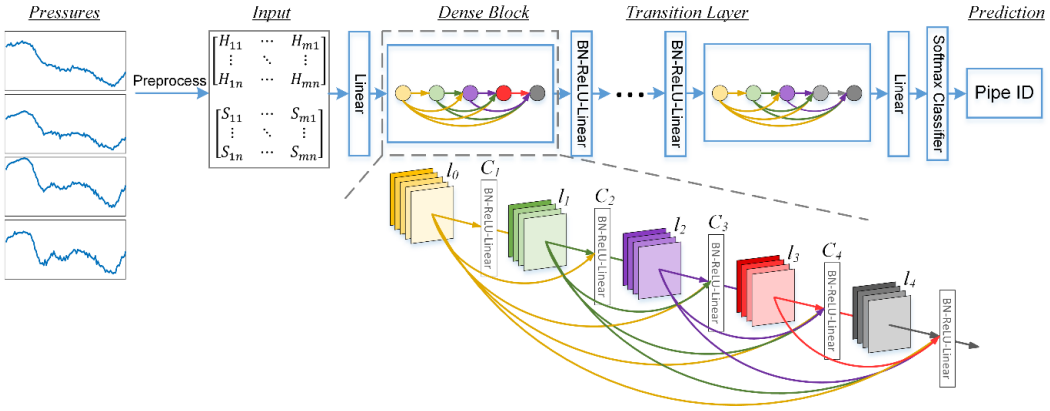

Figure 7: Convolutional Neural Networks Scheme

NIT Warangal will be associated to the LOTUS consortium

The National Institute of Technology, Warangal, India (NITW) will be added as an external partner (so-called third-party) to the LOTUS consortium. The Process Control research group led by Dr. A. Seshagiri Rao will carry out experiments with the LOTUS sensor in a laboratory scale biological wastewater treatment plant to demonstrate how it can contribute to improving the efficiency of such plants. Prof. Sebastian Engell from TU Dortmund, Germany, visited NITW on November 29, 2019 and discussed with the members of the group on possible ways of verifying the LOTUS sensor for automatic control of biological wastewater treatment plants. He also delivered an invited lecture at NITW on 'Multistage model predictive control' which triggered lively discussions.

The Process Control Group at NITW currently comprises one Associate Professor, Dr. Seshagiri Rao, 5 PhD students and 4 Masters students. The activities of the group are focused on advanced process control and wastewater treatment.

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LOTUS involved in the fight against arsenic and fluoride contamination

Guwahati area is an abundance of groundwater available at a shallow depth of 2-4 m, which encourages people to use dug wells, hand pumps or bore wells, especially as only 30% of the population of Guwahati has access to piped-water supply. Several researchers, however, have expressed concerns towards groundwater quality in the Assam region due to significant arsenic and fluoride contamination.

It is well documented that high levels of arsenic exposure cause chronic health effects which include cancer, skin pigmentation, skin lesions, respiratory, neurological and haematological effects in human. Excessive fluoride also causes major health problems such as are dental fluorosis, skeletal fluorosis, and deformation of bones in children as well as adults.

To demonstrate contamination of the water, groundwater samples of post monsoon season were collected from government and private tube wells sources. Samples were analysed using Ion Chromatography (IC) and Atomic Absorption Spectrometry (AAS) instruments. The results of all cations and anions showed concentration of fluoride, iron and manganese in groundwater samples. The dissolved arsenic concentration was measured in out of 25 groundwater samples. The results of groundwater parameters have suggested that the concentration of arsenic, fluoride, iron and manganese is beyond the permissible limit of Bureau of Indian standards drinking water guideline. Winter season groundwater sampling has been scheduled between 10th to 20th February 2020.

While these sampling campaigns provide very valuable information on the status of groundwater in Guwahati, LOTUS aims at making the information collection process smoother. Instead of sending samples to the lab, LOTUS sensor will show in real time the water quality of the well under inspection. This will allow to build an accurate map of arsenic and fluoride contamination in Guwahati ground water, thus reducing the risk of poisoning for the population.

Figure 8: Groundwater well

In parallel, to build a conceptual groundwater model for Guwahati city, LOTUS team gathered a numerical arsenic contaminant transport model for Guwahati city, lithology for 25 borewells, Brahmaputra river head stage data and metrological data (i.e. rainfall and temperature). In addition, lithology data, groundwater table and groundwater quality data have been requested to the central groundwater board (CGWB) and public health engineering department (PHED) concerning 63 locations of Guwahati city. Based on the preliminary results locations of groundwater monitoring stations, where exactly LOTUS sensors should be deployed will be decided for Guwahati city.

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