Passive Sampling Devices to Improve the Monitoring of Anthropogenic Pollutants in River Catchments in India

Report of Researcher Exchange May 2017

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INDIA-UK
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The India-UK Water Centre promotes cooperation and collaboration between the complementary priorities of NERC-MoES water security research.

भारत-ब्रिटेन जल कें द्र एमओईएस-एनईसीआरसी(यूके) जल सुरक्षा अनुसंधान के पूरक प्राथमिकताओ के बीच सहयोग और सहयोग को बढ़ावा देने के लिए करना है

Front cover image: Kolkata, India (Emma Bennett, IUKWC)

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Executive Summary

This report documents and discusses activities undertaken during a Researcher Exchange funded by the India-UK Water Centre (IUKWC) on the topic of "The use of passive sampling devices to improve the monitoring of anthropogenic pollutants in river catchments in India". This exchange enabled Professor Gary Fones, from the University of Portsmouth, UK to conduct a 12-day exchange visit hosted by Dr Pryinka Jamwal at the Ashoka Trust for Research in Ecology and the Environment (ATREE) in Bangalore, India from 8-19 May 2017. This report provides background on the rationale for conducting the research exchange on the topic of 'Improving freshwater monitoring frameworks and data for research and management', as well as a review of the objectives. This is followed by a description of the activities undertaken during the exchange and a summary of the themes and outcomes arising from a one day workshop conducted on the topic of 'Surface water quality monitoring: Key issues, challenges and the way forward'

1. Activity Leads

The Researcher Exchange was supported by the India-UK Water Centre (IUKWC) and led by the Activity Leads:

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The Researcher Exchange was held at ATREE in Bangalore, Karnataka, India.

2. Researcher Exchange Aims

The India-UK Water Centre is based around five key cross-sectoral themes and aims to deliver a portfolio of activities across these themes. This activity focused on the theme of improving freshwater monitoring frameworks and data for research and management.

This IUKWC Researcher Exchange was conducted to help address current gaps in knowledge with regards to the use of passive sampling devices (PSDs). Their use and utility in the Indian aquatic environment and how the data obtained could assist and support key river basin management decisions relating to water quality. PSDs are simple to use, low cost technologies, being deployed in-situ for extended periods (1-4 weeks). These provide either time-weighted average concentrations or can screen for the presence or absence of chemicals. They yield information difficult to ascertain by use of infrequent spot/grab water sampling. Water companies and environment agencies now use these tools extensively across the UK/Europe to provide information for river catchment management plans and to target key remedial actions. This approach is presently not used in the Indian sub-continent for monitoring the quality of freshwater. This exchange explores the potential for the introduction of novel monitoring solutions to enable a better understanding of the range and concentrations of pollutants (i.e. metals, nutrients, non-polar and polar organics) in selected rivers in India and how these data can be used to improve catchment management.

There were five main objectives identified as part of the exchange:

- The first objective was classroom dissemination; this was to be delivered through a number of seminars at ATREE and at other institutions/stakeholders. Here, the available PSDs for different pollutants, spot/grab sampling, field use, analytical protocols, data analysis and interpretation would be described. How these link to other water quality parameter and assess the Integration of PSDs into the management of freshwater catchments.
- The second objective was to assess laboratory capability both at ATREE and at other laboratories visited during the exchange for their potential for the preparation of PSDs and analysis of different classes of pollutants sequestered by the devices.
- The third objective was fieldwork; this would include identification of impacted sites within the Vrishabhavathy and Suvarnamukhi catchments. Along with the identification there would also be demonstrations of deployment/retrieval of PSDs.
- The fourth objective was to undertake training with staff at ATREE so they became familiar with the protocols for the use of PSDs for different chemical classes.
- The fifth objective was to be based round a number of meetings with both staff at ATREE and at other institutions to determine potential future collaborations. These would include funding opportunities, staff/student exchanges and the applicability of use of PSDs in other river catchments in India. From previous all ready established collaborations there would be discussions as how to precede with a journal article relating to the pollution by metals within the Vrishabhavathy catchment and with the recent passive sampler deployments in Bangalore.

3. Activity Structure

3.1. Description of Exchange Activities

This Researcher Exchange was conducted between the 8th and 19th of May 2017. The exchange enabled knowledge-sharing activities aimed at bringing together the visiting researchers expertise in passive sampling and the host institutions understanding of the river basin system in the Bangalore region (and other regions in India) and how PSDs could help in obtaining data that would further improve catchment management. This was initially achieved through a number of meetings with key staff members at ATREE who have been involved in water quality monitoring. This was followed by a number of site visits, visits to key stakeholders and other institutes to present the use of PSDs. Finally a one day workshop was held at the end of the exchange to discuss the way ahead in terms of the challenges facing surface water quality monitoring. The key activities are outlined below relating to the proposed exchange activities.

3.2. Classroom Dissemination

In total three research seminars were delivered during the research exchange. A seminar (Figure 1) with a question and answer session was held at ATREE for members of staff and invited guests. The question and answer session involved discussion of how passive samplers could be used in the Indian aquatic environment. Other topics discussed included cost, type of contaminants (polar organic contaminants, metals and nutrients), deployment issues, biofouling, analytical analysis issues and potential of deployment in different aquatic environments – such as groundwater.

Subsequent seminars entitled ‘Use of passive sampling devices for monitoring polar and emerging (non-regulated) pollutants in river catchments’ were also given at the Indian Institute of Technology, Madras (IITM) in Chennai and also at the Indian Institute of Science (IISc) in Bangalore.

A presentation on the use of passive samplers (including the Chemcatcher®) was given as part of a meeting with officials of the Karnataka State Pollution Control Board (KSPCB). The meeting took place at the headquarters in Bangalore. Present at the meeting were, Dr. Gary Fones (University of Portsmouth); Dr. Priyanka Jamwal (ATREE); Mr. T. Mahesh (Technical advisor to the Chairman KSPCB); Mr. N R Raju (Environmental Officer, KSPCB); Mr. M. N Yogananda (Environmental Officer, KSPCB); Dr. B. Naggapa (Senior Scientific Officer); Mr. Sridhar (Environmental Officer, KSPCB). The meeting highlighted the need for a different way of thinking with regards surface water quality. The two key points highlighted during the presentation (Figure 2) and meeting were (i) pollutant inputs that infrequent spot sampling could miss and that passive samplers both in the time weighted average mode or screening mode could detect (ii) the range of pollutants that passive samplers can be used to detect including emerging contaminants and those with very low concentrations in the environment. Key lessons learnt from the meeting are that a pilot study needs to be undertaken in the region to show the utility of different types of passive samplers and also to investigate what adaptations need to be undertaken for using passive samplers in the Indian sub-continent.

Figure 1. ATREE seminar advert

Figure 2. Presentation at the Karnataka State Pollution Control Board (KSPCB)

3.3. Fieldwork

One of the key objectives of the exchange visit was to identify known contaminated sites for future work. Locations visited included Jakkur Lake, Jakkur Lake sewage treatment works and the River Vrishabhavathy. These sites were assessed for their suitability (logistics including safety, security and location) to be used for future PSD deployments to test the utility of these devices in Indian surface waters. One of the key issues with using passive sampler devices in India is the current unknown of using them in this environment. The majority of passive sampler deployments throughout the world have been in Europe and the USA and not in the somewhat harsh (increased concentrations, higher temperature, complex mixtures and matrix) Indian sub-continent aquatic environment. The Jakkur lakes site was deemed an ideal location to undertake a number of validation and calibration experiments, particularly at the treated effluent point that flows into the lake (Figure 3a and 3b).

Other sites including the Suvarnamukhi and Vrishabhavathy catchments were also assessed to include urban and more rural sites as best places for Chemcatcher® passive samplers trials. These are to highlight the utility of the devices both in capturing missed events due to infrequent spot water sample monitoring and forensic monitoring to build up a picture of the contaminants in a catchment. A number of sites in the Vrishabhavathy catchment were highlighted (Figure 4A and B).

Figure 3a and b: Potential deployment site for UoP Chemcatcher® passive samplers at Jakkur Lake sewage treatment plant (STP)

Figure 4a and b: Potential deployment site for UoP Chemcatcher® passive samplers in the River Vrishabhavathy catchment.

3.4. Future Planning

A number of meetings both at ATREE and at other institutes were undertaken during the exchange visit. A discussion meeting was held with Professor Ligy Philip at IITM with regards the use of passive sampler devices for monitoring of emerging contaminants in Indian River catchments. During the visit to IISc a meeting was held with Professor Mohan Kumar to discuss future collaborations and potential funding routes with regards using passive sampler devices for monitoring contaminants in Indian River catchments. After the presentation a discussion took place with Prof. M. S. Mohan Kumar and Prof. M. Sekhar (Figure 5) as to how passive samplers could potentially be used in groundwater environments. A number of other meetings were held with members of ATREE staff to see how passive sampling could be used in their research programmes. An in-depth meeting was held with Dr Jagdish Krishnaswamy to see if passive samplers could be included in some ATREE projects were the hydrology system was already well defined and understood. An evening meeting was held in Bangalore with Rajesh Parishwad (Royal Society of Chemistry) and Sunil Kumar (Foreign and Commonwealth Office) to discuss an upcoming British Council Researcher Links Workshop Grant that Fones, Jamwal, Philip

and Mohan Kumar were working on in collaboration with Dr Richard Allan at the James Hutton Institute, UK. This has subsequently been funded and will be held in Bangalore in November 2018.

Figure 5. Post presentation discussion on the use of passive samplers in groundwater environments

A number of future planning meetings were held between Fones and Jamwal to discuss future collaborations and also on-going collaborative work. Previously (March 2017), Chemcatcher® passive samplers (with Seedcorn funding from the Science Faculty, University of Portsmouth) had been deployed at a number of sewage treatment plants (STPs) in the Bangalore region. Replicate Horizon Atlantic Chemcatcher® passive sampling devices (fitted with the HLB-L receiving phase and overlain with a PES diffusion limiting membrane) were deployed at both the inlets and outlets of Brigade Gateway, Jakkur, Royal Manor and Vrishabhavathy Valley sewage treatment plants. Discussions were held over protocols for deployment and retrieval and how best to proceed with the interpretation of the data.

Figure 6a and b: Deployment of UoP Chemcatcher® passive samplers at Jakkur Lake sewage treatment plant (STP)

3.5. Publications

Another of the key objectives within the exchange was publications. Fones and Jamwal met to discuss a paper on water quality and metal pollution. Jamwal had previously undertaken sampling in the Vrishabhavathy river catchment using spot water sample collection and a high temporal resolution sampler (ISCO automated sampler). This had shown large inputs of metals during the early hours of the morning, thus being missed by infrequent spot sampling. Fones undertook some additional analysis on the samples at UoP for an extra suite of metals and for inter laboratory comparisons. The metals paper is still in preparation with submission to be by the end of 2018. The data obtained as part of the pilot study was disseminated at the 2018 International Passive Sampling Workshop held in Dublin, May 2018. The data and methodology will also be used in an application note to be published by Bruker.

3.6. Laboratory Capability and Staff Training

During the exchange the laboratories at ATREE and IITM were visited and the equipment available ascertained. Outcome from this is that for passive sampling to be embedded into Indian institutions a number of recommendations were made. These include the setting up of designated laboratory space for the preparation of passive sampling device along with a separate space and equipment for the extraction and sample preparation of the extracts prior to analysis. Passive samplers can measure a wide range of contaminants including nutrients, metals, non-polar and polar organic contaminants, radionuclides and organometallics. The capability of the laboratory to undertake these analysis can inform which passive samplers can be used now and what new analytical equipment would need to be used or where the analysis could be outsourced. Currently ATREE would be capable of undertaking nutrient and metal passive sampler work, whilst IITM have the capability to undertake some of the organics analysis.

3.7. Workshop

A one day workshop “Surface water quality monitoring: Key issues, challenges and the way forward” was organized as part of the research exchange programme. The workshop was hosted by ATREE at their Bangalore campus. The purpose of the workshop was to bring together scientists and stake holders in the Bangalore region to discuss water quality monitoring. Main

topics were the current practice and what we are missing by using these techniques and how the data and subsequent management can be improved by using real time sensors and time weighted averaged passive sampler devices. Legislation and type of contaminants were also key discussion points. More than 35 participants attended the workshop coming from ATREE, IISc Bangalore, Bangalore University, CSIR-CFTRI (Mysore), Azim Premji University, Namma Bengaluru Foundation, One Bangalore for Lakes, CDD Society, FANSA and other interested stakeholder groups. The workshop included presentations and a facilitated breakout group discussion and feedback session. The group discussion was driven by four key questions:

1. Do you have specific catchments with known problems that you would like to investigate?

2. Which specific compounds (in a priority order) would you be interested in looking for?

3. Are passive samplers an acceptable tool for use within Indian regulation monitoring and in monitoring raw water for subsequent use in potable supplies?

4. Other than passive samplers - what other monitoring techniques would be more applicable?

As well as the four questions, five outcomes were put forward for consideration and endorsement.

1. Endorsement of the need to take this work further via grant proposals and other funding streams

2. Endorsement of a future workshop – to include legislation

3. A list of target compounds for which the analytical methodology needs to be developed

4. The availability of test catchments for trials of improved monitoring strategies including passive samplers, real time sensors, high resolution sampling etc.

5. How could a potential market for the use of passive samplers including training be best facilitated?

The final question poised was where to apply for funding? The feedback sessions resulted in a number of ideas as well as poising some new questions. These points are further discussed in Activity Conclusions and Outputs.

Figure 7. A total of 35 participants from governmental, non-governmental, and academic institutions took part in the mini-workshop, held at ATREE in Bangalore. Participants took part in presentations including extended question and answer sessions.

Participants took part in presentations including extended question and answer sessions. Interactive group sessions in the afternoon looked at water quality issues and the use of passive samplers through a series of questions.

4. Activity Conclusions and Outputs

Activities conducted during the researcher exchange provided numerous opportunities to discuss the potential use of passive sampling devices in surface water quality monitoring in Indian River catchments.

4.1. Key Themes Arising

This IUKWC Researcher Exchange enabled knowledge exchange and discussion of key issues relating to water quality monitoring and how passive sampling could be used as a complimentary tool. Current monitoring is overseen by the Central Pollution Control Board. Despite establishing a National Water Quality Monitoring Network comprising 1429 monitoring stations in 28 states on various rivers and water bodies across the country, water quality monitoring in Indian surface waters is still a difficult task. There is little systematic work through monitoring programmes (that still rely on traditional spot samples of water) to identify and characterise pollutants (particularly emerging contaminants such as pharmaceuticals and pesticides), sources or specific locations for further action and remediation. As Indian water quality monitoring programmes are being developed there is now the opportunity to utilise new technologies such as passive samplers. Some of the key points that arose relating to the use of passive sampler devices in India:

- The need for a comprehensive list of the types of pollutants that passive samplers can be used to monitor for;
- The utility and robustness of passive samplers in Indian surface waters compared to UK

and European waters;

- Which aquatic environments can passive samplers be deployed in – low flow lakes, ground waters, highly contaminated;
- Do Indian institutions have the requisite laboratory and analytical facilities;
- Specific demonstration networks of passive samplers needed;
- Need for regulatory standards for surface waters for a growing list of key contaminants – can passive samplers be used in a regulatory context?

4.2. Conclusions and Next Steps

The key conclusions from the exchange are that passive samplers would be a useful and complimentary tool for water quality monitoring in India. However, more information is needed to determine the utility and robustness of such devices in the Indian surface water context. The next key step is to undertake a series of passive sampler network demonstrations in selected catchments to enable end-users and stake holders to see at first-hand how to use passive sampler technology. Another key next step will be in the training of Indian colleagues and dissemination of information to stake holders and other end users. This exchange also enabled preliminary exploration pathways for collaboration between ATREE and the University of Portsmouth, and this will inform efforts to explore additional opportunities for collaboration in the future.

Back cover image: Kolkata, India (Emma Bennett, IUKWC)

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