

Report by UWI doctoral researcher Sonia Herrero Ortega (N3)

Project number: N3

First and last name of doctoral researcher: **Sonia Herrero Ortega**

(Working) title of doctoral project: **Greenhouse gas fluxes across interfaces**

Name of supervisors: Prof. Dr. rer. nat. Mark Gessner, Dr. rer. nat. Peter Casper, Dr. rer. nat. Gabriel Singer, Prof. Dr. rer. forest. Birgit Kleinschmit

2. Description of doctoral project and research results achieved to date:

Motivation

Urban water systems comprise a complex network of lakes and other standing water bodies which may be isolated or connected by rivers and canals. The city of Berlin, for example, has more than 50 lakes, thousands of ponds and more than 190 km of natural and artificial waterways. All of these urban surface waters tend to receive high amounts of organic and inorganic compounds, which are likely to exceed those in natural surface waters and affect the metabolism and other characteristics of these aquatic ecosystems. This includes nutrient and carbon inputs that create conditions conducive to anaerobic carbon transformations both in deep layers of stratified waters and in sediments. Methane formation and oxidation are processes of particular interest because methane is a greenhouse gas (GHG) that strongly affects climate. However, reliable estimates of methane emissions from urban surface waters are scarce [1,2,3]. This calls for investigations into the dynamics of this potent GHG in urban lakes, ponds, streams and canals, especially in light of the projected rapid increase in rates of urbanization in the next decades.

My dissertation focuses on determining the patterns and drivers of methane emissions from fresh waters in a metropolitan area under temperate climate. Field measurements have been performed to narrow the currently large knowledge gap about rates and controls of urban GHG emissions so as to provide estimates of methane-emissions across the water- atmosphere interface, which can serve as a basis to inform water policy and management in urban areas.

Current State of Work

Estimates of methane emissions from urban waters resulting from an extensive field study of GHG dynamics and metabolism (figure 1) have been analysed and a manuscript is currently close to being finalized for submission. The results obtained from this study reveal high spatial variability (figure 2) and suggest that urban temperate fresh waters are typically hotspots of methane emissions when compared to published data from unaltered waterbodies .

Given the high emissions rates found at some sites, I also tested the potential of urban sediments to produce methane under environmental conditions involving different chemical stressors in different environmental contexts. The preliminary analyses of these data provide evidence that methane production is present in all sediments studied in the city of Berlin. Furthermore we found that concentrations of 21 synthetic chemical organic micro pollutants and 7 heavy metals were low, generally below detection limits, in both water and sediments. The collected sediments were also low in organic content. A preliminary draft of this study is currently under preparation.

The high heterogeneity of emissions in Berlin's surface waters prompted me to conduct a study in three urban streams at high spatial resolution. This study was performed during summer 2017 during a visit at the Center of Limnology of the University of Wisconsin in Madison, WI, USA. The aim was to identify causes of heterogeneity and the representativeness of single point-measurements made in streams in Berlin. Data analyses are being performed in this data set and preliminary results points towards that heterogeneity within single stream is lower than among different streams.

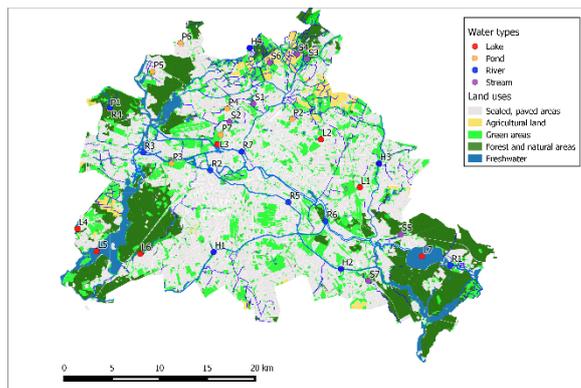


Figure 1: Map of the sampling sites in the metropolitan area of Berlin.

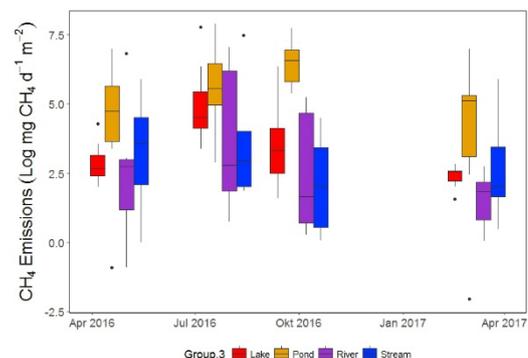


Figure 2: CH₄ flux rates from Berlin field study.

Future Work Planned

For the next 5 months, the following activities are planned. Submission of the CH₄ emission study is intended to an international scientific journal. This study will be the first chapter of the doctoral thesis. The sediment study will be prepared and submitted to a scientific journal. This study will be used in the second chapter of the doctoral thesis. The spatial distribution of GHG fluxes along urban streams studied during the period abroad (UW-Madison, USA, Stanley Lab) will be reported as a scientific article that will be developed during fall 2018. This study will be incorporated into the third chapter of the doctoral thesis. The doctoral thesis will be written and submitted by November 2018.

Collaborations

Planning, field sampling and laboratory analyses greatly benefitted from close collaboration with Clara Romero, doctoral student in UWI project N4. Jonas Scharper, doctoral student in UWI project N5, also provided support in measuring and analysing GHG from sediments in the River Erpe in December 2015, and collaboration with doctoral student Geert Aschermann in UWI project T5 was crucial for analysing organic micropollutants. Kyle Pipkins, doctoral student in UWI project N2, provided additional support for GIS analyses. Finally, there was collaboration with Emily. H. Stanley from UW-Madison, as visiting her lab for one of the studies of the thesis during summer 2017.

References

1. López Bellido, J., Peltomaa, E. & Ojala, A. (2011): An urban boreal lake basin as a source of CO₂ and CH₄. *Environmental Pollution*, 159, 1649–1659
2. Martinez-Cruz, K., Gonzalez-Valencia, R., Sepulveda-Jauregui, A., Plascencia-Hernandez, F., Belmonte-Izquierdo, Y. & Thalasso, F. (2017): Methane emission from aquatic ecosystems of Mexico City. *Aquatic Sciences*, 79, 159–169
3. Smith R, Kaushal S, Beaulieu J, Pennino M., Welty C (2017): Influence of infrastructure on water quality and greenhouse gas dynamics in urban streams. *Biogeosciences*, 14, 2831–2849

3. Comments on the qualification programme and supervision strategy:

I found the common UWI courses very useful, because they provided basic knowledge in different disciplines that facilitated understanding the research of my fellow doctoral students' in UWI during the last three years and communication with them. Furthermore, I liked the gender workshops which were offered to balance the inequalities that women continue to face, including in scientific environments. These courses taught skills that young female scientists are not normally encouraged to develop, such as leadership, team management or career planning.

Participation in the following Research Training Group events:

1. Core courses
 - I – Urban interface processes – fluxes, transport, interactions (3 ECTS)
 - II – Modelling and measuring concepts of interface processes (3 ECTS)
 - III – Urban freshwater ecology (3 ECTS)
2. Elective courses
 - Oral and poster presentation (IGB Berlin, 23.11.2015 - 24.11.2015)
 - General mixed modelling (IGB Berlin 2015) (3 ECTS)
 - Multivariate statistics (IGB Berlin 11.2016) (3 ECTS)
 - Proposal writing (TUB 03.2018)
 - Scientific writing (IGB Berlin 16.-20.04.2018) (3 ECTS)
3. Gender courses
 - Time is honey – the new approach to time, self and workload organization
 - Self-positioning
 - Negotiation
 - Project management
 - Individual coaching (1 session)
4. UWI lectures and IGB seminars: Participated in as many as fieldwork allowed to UWI lectures and IGB seminars (3 ECTS)
5. Other UWI events
 - Orientation Seminar and UWI Opening Ceremony (08. – 09.09.2015)
 - Exposé talks (08.12.2015)
 - Summer school (13. - 14.09.2016)
 - Collegiate seminar (22.09.2016)
 - Interim meeting (19.05.2017)
 - Student Research Council (17. – 18.03.2017)
 - Summer school (06.-08. 09.2017)
 - Summer school (19. -20.09.2018)

Research stays or internships at other research institutions both at home and abroad. For **IRTGs**: University of Wisconsin-Madison, Center for Limnology (23.07.2017-28.08.2017 and 09.09.2017-31.10.2017)

Participation in conferences, congresses, etc., at home and abroad:

2015:

- GHG workshop (19.-23.10.2015, Potsdam, Germany)

2016:

- 18th Conference of the Iberian Association of Limnology (AIL) (4.-8.7.2016, Tortosa, Spain)

2017:

- Wasser Berlin International (28. – 31.03.2017, Berlin)
- 5th Meeting of Fresh Blood for Freshwaters (9.-13.4. 2017, Ceske Budejovice, Czech Republic)
- UWI meets Future Water (26.-28.4- 2017, Essen, Germany)
- 10th Symposium for European Freshwater Sciences (2.- 7.7.2017, Olomouc, Czech Republic)
- IGB Science Day (07.12.2017, Berlin, Germany)

2018:

- Summer meeting of the society Advances in the Science of Limnology and Oceanography (ASLO) (10.-15.06.2018, Victoria, BC, Canada)
- 19th Conference of the Iberian Association of Limnology (AIL) (24.-29.06.2018, Coimbra, Portugal)
- 9th Water Research Horizon Conference (03.-04.07.2018, Dresden, Germany)

4. Individual publications:

I. Articles:

- Bravo, A.G., Kothawala, D.N., Attermeyer, K., Tessier, E., Bodmer, P., Ledesma, J.L.J., Audet, J., Casas-Ruiz, J.P., Catalán, N., Cauvy-Fraunié, S., Colls, M., Deininger, A., Evtimova, V.V., Fonvielle, J.A., Fuß, T., Gilbert, P., Herrero Ortega, S., Liu, L., Mendoza-Lera, C., Monteiro, J., Mor, J., Nagler, M., Niedrist, G.H., Nydahl, A.C., Pastor, A., Pegg, J., Gutmann Roberts, C., Pilotto, F., Portela, A.P., Romero González-Quijano, C., Romero, F., Rulík, M. & Amouroux, D. (2018): The interplay between total mercury, methylmercury and dissolved organic matter in fluvial systems: A latitudinal study across Europe. *Water Research*, 144: 172-182
- Herrero Ortega, S., Catalán, N., Björn, E., Gröntoft, H., Hilmarsson, T.G., Bertilsson, S., Wu, P., Bishop, K., Levanoni, O. & Bravo, A.G. (2018): High methylmercury formation in ponds fueled by fresh humic and algal derived organic matter. *Limnology and Oceanography*, 63, S44-S53
- Catalán, N., Herrero Ortega, S., Gröntoft, H., Hilmarsson, T.G., Bertilsson, S., Wu, P., Levanoni, O., Bishop, K. & Bravo, A.G. (2017): Effects of beaver impoundments on dissolved organic matter quality and biodegradability in boreal riverine systems. *Hydrobiologia*, 793, 135-148

II. Conference, poster presentations etc.:

- Herrero, S & Ladwig, R. (2018): Understanding processes at aquatic interfaces to improve urban surface water management. 9th Water Research Horizon Conference (03.-04.07.2018, Dresden, Germany), oral presentation
- Herrero Ortega, S., Singer, G.A., Gessner, M.O. & Casper, P. (2018): Mineralization of sediment organic matter to CH₄ and CO₂ in urban freshwater bodies. 19th Conference of the Iberian Association of Limnology (AIL) (24.-29.06.2018, Coimbra, Portugal), oral presentation
- Herrero Ortega, S., Romero González-Quijano, C., Casper, P., Kleinschmith, B., Singer, G.A. & Gessner, M.O. (2018): Methane emissions from urban freshwaters: spatio-temporal patterns, environmental drivers and the footprint of a metropolitan area. Summer meeting of the society Advances in the Science of Limnology and Oceanography (ASLO) (10.-15.06.2018, Victoria, BC, Canada), oral presentation
- Herrero Ortega, S., Romero González-Quijano, C., Casper, P., Kleinschmith, B., Singer, G.A. & Gessner, M.O. (2017): Spatio-temporal patterns in methane emissions from temperate urban freshwaters. 10th Symposium for European Freshwater Sciences, (2.- 7.7.2017, Olomouc, Czech Republic), oral presentation
- Herrero Ortega, S., Romero González-Quijano, C., Casper, P., Kleinschmith, B., Singer, G.A. & Gessner, M.O. (2017): Aquatic methane emissions in urban areas. 5th Meeting of Fresh Blood for Fresh Water, (9.-13.4. 2017, Ceske Budejovice, Czech Republic), oral presentation
- Herrero Ortega, S., Catalán, N., Björn, E., Gröntoft, H., Hilmarsson, T.G., Bertilsson, S., Wu, P., Bishop, K., Levanoni, O. & Bravo, A.G. (2016): Effects of beaver damming on the formation of the toxic methylmercury. 18th Iberian Association of Limnology meeting, (4.-8.7.2016, Tortosa, Spain), oral presentation
- Herrero Ortega, S., Catalán, N., Björn, E., Gröntoft, H., Hilmarsson, T.G., Bertilsson, S., Wu, P., Bishop, K., Levanoni, O. & Bravo, A.G. (2015): Do beaver ponds affect mercury methylation by changes in DOM and nutrient status?. 4th Meeting of Fresh Blood for Fresh Water, (14.-17.04.2015, Mondsee, Austria), oral presentation