Annual Report 2018
of the IAHS-ICT activities

Prepared by Christine Stumpp

International Commission on Tracers - members:

Christine Stumpp	Austria	President, 2017-2021
Przemyslaw Wachniew	Poland	Secretary, 2015-2019
Josep Mas Pla	Spain	Vice President, 2015-2019
Maki Tsujimura	Japan	Vice President, 2015-2019
Zhonghe Pang	China	Vice President, 2015-2019

Period: July 2017 – April 2018

The members of the commission organized conferences and special sessions at conferences related to the application and development of tracer methods in hydrology. They gave oral presentations on tracer methods at national and international conferences and were active in strengthening the cooperation with partner organizations. The ICT contributed to the discussion of the "23 Unsolved Problems in Hydrology" initiative.

1) Commission members' conference organization

(i) Organization of the international EGU Leonardo Conference 2017 ("Water stable isotopes in the hydrological cycle"), Oct 2017, Germany; 70 participants presented and discussed recent research progress in the field of water stable isotope applications in hydrology at the EGU Leonardo conference; four main topics were covered including (1) Analytical developments and monitoring systems, (2) Ecohydrological Processes, (3) Climate models and water balance, and (4) Water fluxes, transport and transit times; the Leonardo Lecture was given by Jeff McDonnell and the Junior Leonardo Lecture by Maren Dubbert.

(ii) After the EGU Leonardo conference, a follow-up workshop on "Water ages in the hydrological cycle" was organized (25 participants; national financial support through "Wassernetzwerk Baden-Württemberg") with the goal to foster inter-disciplinary discussion about approaches, methods and models to determine water age and transit times throughout the hydrological cycle.

(iii) Organization of the 30th Anniversary Symposium, the Japanese Association of Hydrological Sciences ("Perspective of Hydrology Contributing to Sustainable Future Earth –What are Big Issues for Hydrology Tackling in Next Generation?-"), Oct 2017, Tokyo, Japan; one key note lecture (by Toshio Koike, "Hydrology and Social") and 4 presentations and discussion were performed, 70 participants joined.

2) Commission members' cooperation with partner organizations

(i) Participation to IAEA RCA "Assessing Deep Groundwater Resources for Sustainable Management through Utilization of Isotopic Techniques", November 2017, Colombo, Sri Lanka.

(ii) Participation to IAEA CRP "Application and development of isotope techniques to evaluate human impacts on water balance and nutrient dynamics of large river basins".

3) Commission members' conference session organization

(i) Organization of the Session, "Residence time of groundwater / surface water and water / mass cycle processes in watershed" in the Japan Geoscience Union Meeting (JpGU) 2018, May 2018, Makuhari, Japan, with invited lectures by Uwe Morgenstern and Michael Stewart.

(ii) "Isotope and tracer methods: flow paths characterization, catchment response and transformation processes", EGU conference session, April 2017 and 2018.

4) Commission members' projects

(i) organization of the Bilateral Joint Research Project, "Quantifying groundwater residence time and storage volume by isotope and noble gas as tracers" Japan Society for the Promotion of Science (JSPS), under the collaboration between the University of Tsukuba and the GNS Science, New Zealand.

(ii) EU Water JPI program, PERSIST on the occurrence and persistence of emerging contaminants in groundwater;

(iii) Spanish National Program on Water Resources, REMEDIATION, developing strategies for water resources remediation, specifically nitrate and emerging contaminants;

(iv) dissemination of the application of tracer techniques within the framework of the EU research project BONUS Soils2Sea.

(v) Spanish National Program on Water, IMPACT (2018-2021), was granted for assessing the hydrogeological control of the antibiotic distribution in groundwater that involves optimizing monitoring strategies.

5) Commission contribution to the "23 unsolved problems in hydrology" initiative

(i) How to use tracers in an integrative way to better understand the source, path and age information of (reactive) compounds in catchments? Tracers can be used to get an integrative understanding of hydrological processes in catchments over a range of spatial and temporal scales. We have a set of different artificial and environmental tracers available that have been used for answering specific research questions (e.g. age of water) in individual compartments (e.g. soil, groundwater). However, we are still lacking multi-tracer approaches for answering more complex research question in modern hydrology helping to solve the environmental problems of the 21st century by adoption a more holistic approach. This includes identifying classes of compounds or even developing new, smart tracers to better understand hydrological and biogeochemical processes in catchments; particularly in unique and extreme environments such as high temperature and high pressure multi-phase systems or where we want to study the fate of emerging contaminants. It also requires to integrate tracers with methods from other disciplines and to consider soils and groundwater as important storage and reactors –which are not fully mixed - in catchment studies.

(ii) Why do we get discrepancies in the prediction of transit times when using different methods and/or different tracers? Transit time of water and contaminants are important state variables in hydrology. It gives information on mean ages or age distribution of water at a given point that entered the system in the past. Transit times are of particular importance to link flow and transport processes and thus, should be included in water quality studies for assessing the vulnerability of water resources and for improving management strategies by considering time lags in response to undertaken measures. For example, transit times or lag times are of utmost importance to understand why some catchments are more sensitive to land use changes than others. The main unsolved problem is, however, that different methods or different tracers can provide different results of transit times and therefore we only get apparent transit times. These discrepancies are caused by ignoring (i) heterogeneities (e.g. preferential flow paths or immobile water zones), (ii) non-stationarity and (iii) non-linearity of the flow domain or (iv) by taking tracers only covering a certain range of ages and thus ignoring mixing with young or older water fractions. Further, we need to find methods for fully describing the entire distribution of transit times which is currently limited by missing well-established tracer methods for some age ranges.

6) ICT Workshop for IUGG

The commission proposed to organize the workshop "Tracers for understanding the sources, pathways and fate of pollutants in the hydrological cycle" for the IUGG General Assembly in Montreal, 2019. Water pollution is one of the biggest environmental challenges. Pollutants cause the worldwide deterioration of water resources and aquatic ecosystems. Assessment and mitigation of water pollution rely on identification of its sources and pathways and on quantification of the removal processes in groundwater and surface water environments. These issues provide a cross-disciplinary research challenge which can be addressed with the application of multiple artificial or

environmental tracers, including isotopic, gaseous and ionic species for tracing water flow and transport through the hydrological cycle. Hydrological tracers are indispensable for understanding flow paths and dynamics of water flow in the subsurface, as well as of runoff patterns in catchments. Stable isotope signatures of pollutants (e.g. of N, C, B) can provide unique insights into their origin and processes resulting in their removal or transformation within the hydrological cycle. The integrative nature of information provided by tracers makes them suitable for the application in a wide range of spatial and temporal scales, from soil column to aquifers to large river catchments. Tracers are essential for the evaluation of lag times associated with pollutant transport through the groundwater system that is a crucial factor in the programmes of measures undertaken to improve water quality in catchments. Furthermore, tracer data are used for verification and calibration of conceptual and numerical models of hydrological systems. We invite contributions that demonstrate how environmental and artificial tracers improve the understanding of pollutant transport in hydrological systems of any size and type.