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# A global synthesis of dual nitrate isotope values in rivers and groundwaters

**Ioannis Matiatos**[1] and the IAEA Coordinated Research Project on Isotopes to study nitrogen pollution and eutrophication of rivers and lakes[*]

[1]International Atomic Energy Agency, Vienna, Austria

[*]A full list of authors appears at the end of the abstract

Exponential human population growth and the rapid co-development of agricultural and industrial sectors have caused a sharp increase of nitrogen loading to rivers and groundwaters worldwide since the 1950s. Reactive nitrogen species (e.g., nitrate, ammonium) are widely distributed compounds in rivers and groundwaters primarily as a result of diverse agricultural activities utilizing N-containing fertilizers and anthropogenic non-point sources, such as the disposal of sewage by centralized and individual systems, animal feeding operations, and elevated atmospheric N deposition. Systematic efforts to identify global patterns in nitrogen loss processes using nitrogen isotopes have mostly targeted soil and plant systems but remain rather limited for surface and/or groundwater systems. Here, synthesized published (4,492) and new data (425) for nitrogen and oxygen isotopes of nitrate in rivers and groundwater generated under an IAEA Coordinated Research Project, which aimed to utilize the application of nitrogen isotope techniques to assess nitrogen pollution in rivers and groundwaters, are presented. Among the two water types, we found that groundwater had higher average nitrate concentrations (~5.0 mg $L^{-1}$ $NO_3$-N) versus rivers (~2.0 mg $L^{-1}$ $NO_3$-N), slightly higher $\delta^{15}N$ and much higher $\delta^{18}O$ (+7.6 ‰ and +4.3 ‰, respectively) compared to rivers (+7.0 ‰ and +1.8 ‰, respectively). Seasonal variations in the concentrations and the isotopic compositions of N-species were found to be temperature related, given that biological activity increases with water temperature. Across a range of Köppen climate types, we found the $\delta^{15}N$ and $\delta^{18}O$ of $NO_3$ in rivers systematically increased when moving from temperate to tropical climates, following the increase of the average air temperature.

**IAEA Coordinated Research Project on Isotopes to study nitrogen pollution and eutrophication of rivers and lakes**: Leonard Irwin Wassenaar (International Atomic Energy Agency, Austria, L.Wassenaar@iaea.org), Lucilena Monteiro (International Atomic Energy Agency, Austria, L.Monteiro@iaea.org), Alejandro Garcia Moya (Centro de Estudios Ambientales de Cienfuegos,Cuba, garciamoya90@gmail.com), Pascal Boeckx (Ghent University, Belgium, Pascal.Boeckx@UGent.be), Lhoussaine Bouchaou (Université Ibn Zohr, Morocco, lbouchaou@gmail.com), Viraj Edirisinghe (Sri Lanka Atomic Energy Board, Sri Lanka, viraj@aeb.gov.lk), Widad Fadhullah (Universiti Sains Malaysia, Malaysia, widad@usm.my), Joseph Richmond Fianko (University of Ghana/ Ghana Atomic Energy Commission, Ghana,

jrfianko@yahoo.com), Daren Gooddy (British Geological Survey, UK, dcg@bgs.ac.uk), Nerantzis Kazakis (Aristotle University of Thessaloniki, Greece, kazakis@geo.auth.gr), Greg Michalski (Purdue University, USA, gmichals@purdue.edu), Diego Rivera (University of Concepcion, Chile, diego.dirivera@gmail.com), Asuncion Romanelli (Universidad Nacional de Mar del Plata, Argentina, aromanel@mdp.edu.ar), Elisa Sacchi (University of Pavia, Italy, elisa.sacchi@unipv.it), Prasanta Sanyal (Indian Institute of Science Education and Research Kolkata, India, psanyal@iiserkol.ac.in), Li Siliang (Tianjin University, China, siliang.li@tju.edu.cn), Fredrick Tamooh (Kenyatta University, Kenya, tamooh.fredrick@ku.ac.ke), Thi Nguyet Minh Luu (Vietnam Academy of Science and Technology, Vietnam, luu.minh@ich.vast.vn), Jason J. Venkiteswaran (Wilfrid Laurier University, Canada, jvenkiteswaran@wlu.ca), Nina Welti (University of Eastern Finland, Finland and CSIRO Agriculture and Food, Australia, Nina.Welti@csiro.au)