Integrated approach for evaluating sources and apportionment of agro-contaminants in soil and water bodies

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Introduction

- Inefficient farming practices, farming systems discharge large quantities of agro- and organic chemicals, drug residues and sediments into water bodies.
- These agro-pollutants pose considerable risks to aquatic ecosystems, human health and agriculture.
- Identification and apportionment of pollutants from multiple sources require an integration of approaches.
- Agriculture watersheds for multi-isotope analysis were evaluated and standardized in agricultural catchments in Asia (Australia, China, India, Sri Lanka, Vietnam), Europe (Austria, France, Germany, Ireland, Romania, Slovenia, Switzerland, United Kingdom) and Africa (Morocco and Ghana) in a 5-year coordinated research project (CRP) managed by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture (**Table 1**).

What is the aim of the study?

- To develop protocols and methodologies for using multiple stable isotope tracers to monitor soil, water and nutrient pollutants from agriculture.
- To establish proof-of-concept for an integrated suite of analytical stable isotope tools, and create guidelines to adapt the new toolkit to a variety of agricultural management situations.
- To provide guidelines and decision trees to adapt the new toolkit to a variety of agricultural systems.

Nuclear techniques used included multi-stable isotope ($\delta^{18}O$, $\delta^{2}H$, $\delta^{13}C$, $\delta^{15}N$, $\delta^{13}C$-DIC, $\delta^{15}N$-NO_3 $\delta^{18}O$-NO_3 $\delta^{18}Op$, $\delta^{34}S$) techniques and compound specific stable isotopes (CSSI)-based monitoring approach for evaluating in-situ degradation, transport, transformation and fate of pesticides.

Table 1. Selected countries, study areas and stable isotopes used

Country	Study Area/Catchment	Isotopes used
Australia	Nambeelup Brook	$\delta^{2}H(H_2O)$ and $\delta^{18}O(H_2O)$, $\delta^{15}N(NO_3)$ and $\delta^{18}O(NO_3)$]and $\delta^{34}S(SO_4)$ and $\delta^{18}O(SO_4)$
Austria	ARC, Tulln	$\delta^{18}O$-P
China	Pearl River	CSSI, $\delta^{18}O$, ^{18}O-P
France	Berambadi basin, India / Pearl river	CSSI, $\delta^{13}C$, $\delta^{15}N$
Germany	Berambadi basin, India / Pearl river	CSSI, $\delta^{13}C$, $\delta^{15}N$
Ghana	Densu River Basin	$\delta^{2}H(H_2O)$ and $\delta^{18}O(H_2O)$, $\delta^{34}S(SO_4)$ and $\delta^{18}O(SO_4)$, $\delta^{15}N$(POM) and $\delta^{13}C$(POM)
India	Berambadi Basin	CSSI; $\delta^{13}C$, $\delta^{15}N$
Ireland	Ballinamona/Bunoke Catchments	$\delta^{18}O$-P
Morocco	Sebou River basin	$\delta^{2}H(H_2O)$ and $\delta^{18}O(H_2O)$, nitrates [$\delta^{15}N(NO_3)$ and $\delta^{18}O(NO_3)$]
Viet Nam	Red River delta	$\delta^{15}N(NO_3)$, $\delta^{18}O$, $\delta^{13}C$ $\delta^{15}N(NH_4)$
Romania	Peciu Nou	$\delta^{15}N$, $\delta^{18}O$, $\delta^{2}H$
Sri Lanka	Kothmale reservoir watershed	$\delta^{15}N(H_2O)$, $\delta^{18}O$ (H_2O), and ^{18}O-PO_4
Slovenia	Brežiško polje and Ljubljansko polje	$\delta^{2}H(H_2O)$ and $\delta^{18}O(H_2O)$, [$\delta^{15}N(NO_3)$ and $\delta^{18}O(NO_3)$]
Switzerland	Zurich/Kothmale reservoir watershed	$\delta^{18}O$-P
UK	Chile	FRN, $\delta^{15}N(H_2O)$, $\delta^{18}O$ (H_2O)

Selected results

- Low values of $\delta^{18}O$ indicates that nitrate pollution in groundwater is from soil and not artificial fertilizers. [**Slovenia**](Fig. 1.)
- 25% of pollutant flows were discharged into surface water, while the remaining 75% was absorbed into groundwater. [**Morocco**]
- A protocol for purifying ^{18}O-analysis in phosphate samples developed and a silver phosphate comparison material (Ag_3PO_4) for measurement of the stable ^{18}O labelled phosphate composition prepared an inter-lab comparison.[**Austria, Ireland and Switzerland**]
- Data from $\delta^{15}N$-NO_3 and $\delta^{18}O$-NO_3 showed that chemical fertilizers to maize farmland and dairy excrements of livestock contributed 38% and 37%, respectively, to nitrate pollutant sources in the water body. [**China, Vietnam**]
- CSSI was successfully used to track pesticide degradation and export at catchment scale and identify pesticide sources areas contributing to changes in carbon isotope stable signatures. [Germany, France, India]
- Sulphate concentrations ranged 6–140 mg/L and $\delta^{34}S(SO_4)$ 14.3–26.3 ‰, reflecting inputs from fertilisers, natural acid rock drainage and sulphur reduction. [Australia]
- Three sampling operating procedures (SOPs) produced in 2018 evaluated and standardized in agricultural catchments by the CRP participants.

Conclusion and Outlook

Stable isotopes and CSSI provides a good understanding of pollution load seasonal trends and identification of their sources which are critical for improving land management practices and water quality.

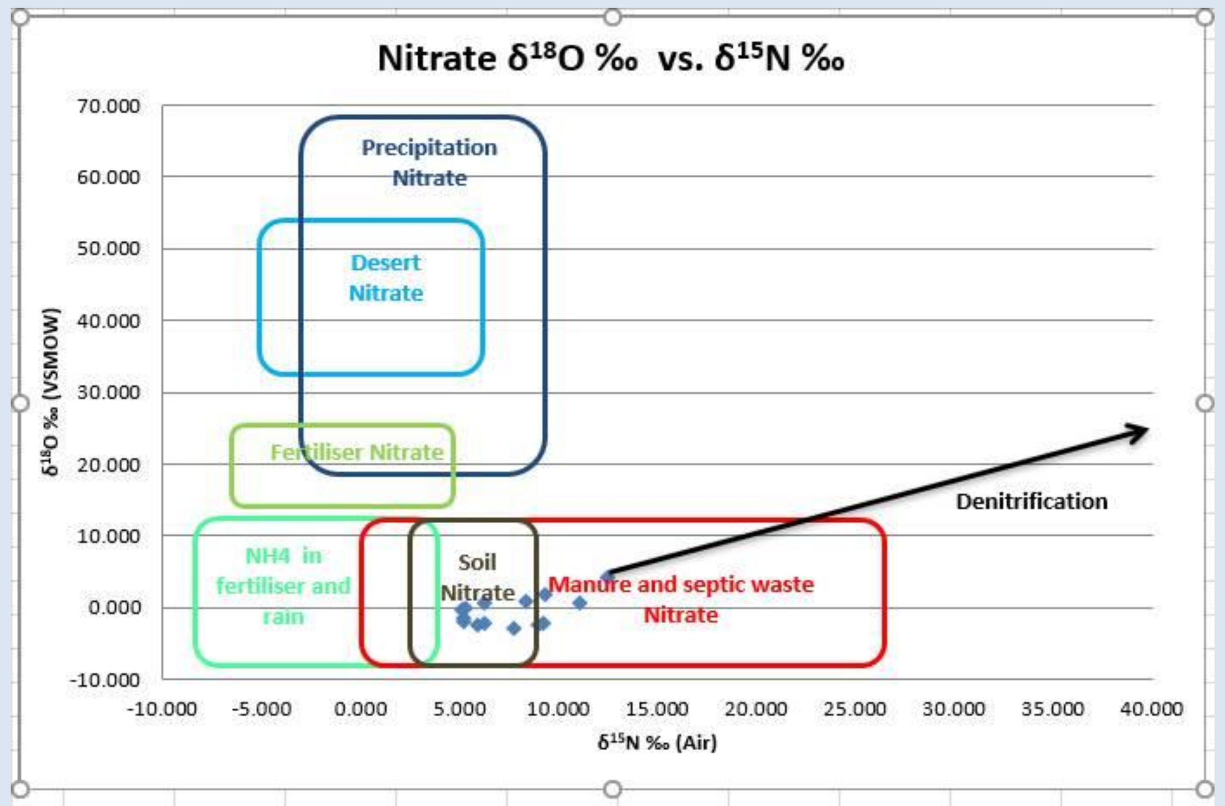

Fig. 1 Groundwater samples in a typical soil nitrate box in Slovenia

Fig 2 Sampling water for stable isotope analysis on the campaign on the Densu River Basin in Ghana

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