

*Origin, implications, and management strategies for
nitrate pollution in water in vulnerable zones in
Andalusia*



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April 24th, 2023



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Consejería de Agricultura,
Pesca, Agua y Desarrollo Rural

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*Andalusian Institute of
Agricultural and Fisheries
Research and Training (IFAPA)*



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research
centers

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EUROPE

The EU Water Framework Directive (Directives 2000/60/EC & 2006/118/EC)

Thresholds to achieve good chemical status in groundwater and good ecological status in surface waters.

Directive 91/676/CEE

Despite the measures implemented since 1991 to minimize agricultural nitrate pollution in water resources, nitrate concentrations still frequently exceed the surface and groundwater limits (50 mg/L).

~ 40%
Nitrate vulnerable zone

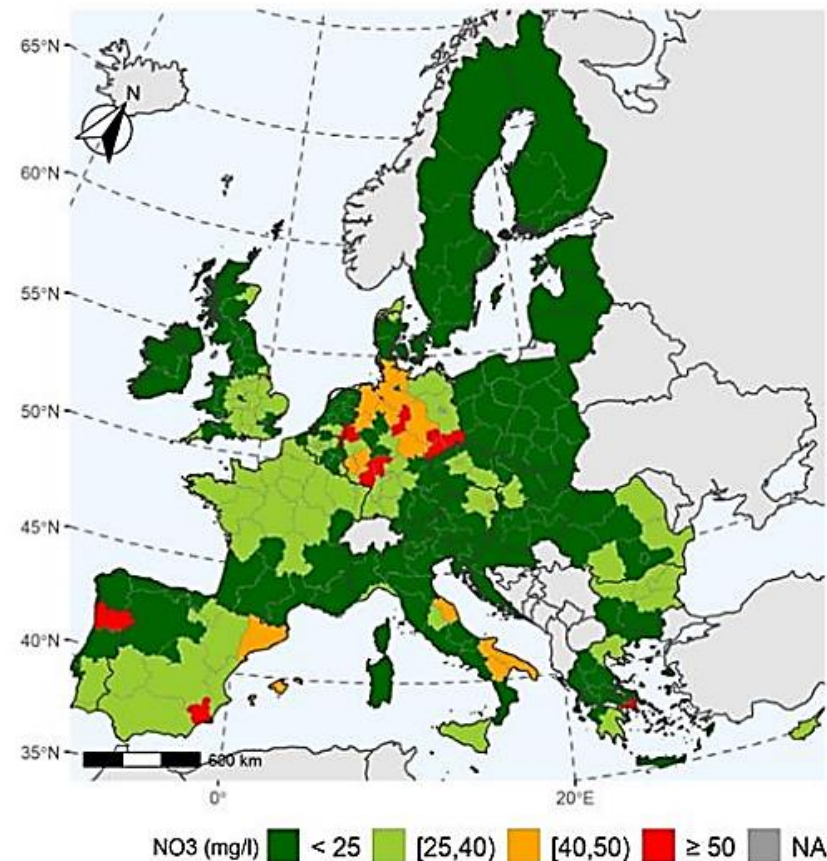


Fig. 1. Average concentration of nitrates in groundwater for the period 2016-2019 in Europe

SPAIN

Spanish Law 47/18 January 2022

It considers the following to be waters affected by nitrates:

- ✓ Surface waters: a nitrate concentration < 25 mg/L
- ✓ Groundwaters: a nitrate concentration < 37.5 mg/L

~ 20%
Nitrate vulnerable zone

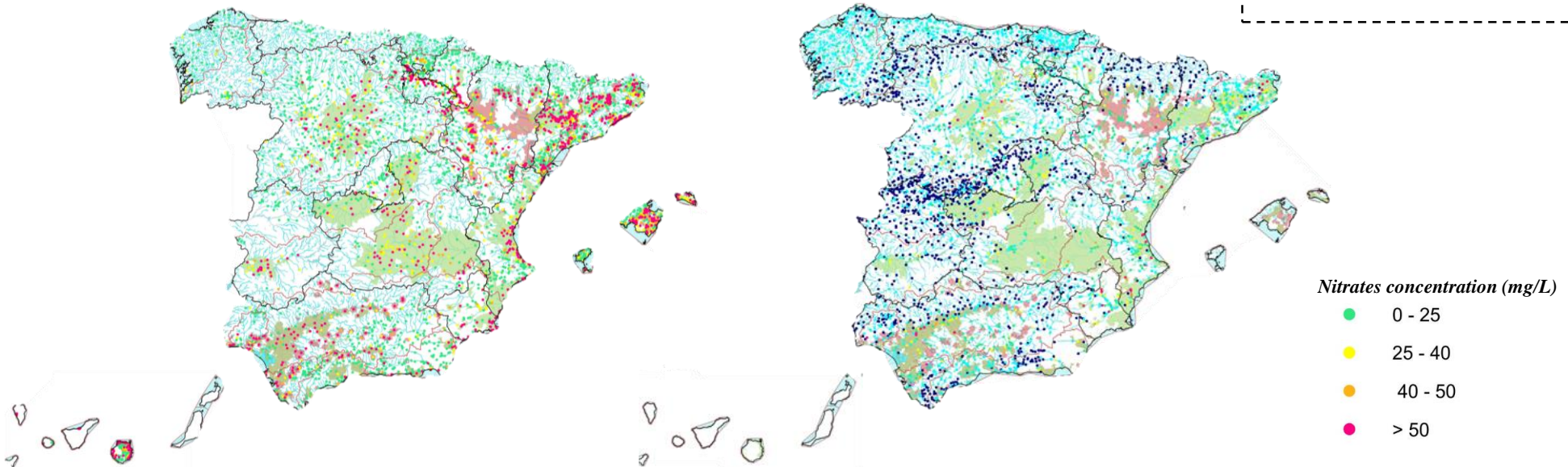


Fig. 2. Average concentration of nitrates in (A) surface waters and (B) groundwater in Spain for the period 2016-2019

ANDALUSIA

Regional Law 36/2008

24 agricultural areas with nitrate concentration levels >50 mg/L

Order of June 1, 2015

Performance Program applicable in areas vulnerable to nitrate contamination in Andalusia, entails restrictions regarding:

- ✓ Total fertilization (Kg N/ha)
- ✓ Types of fertilization and periods
- ✓ Monitoring of agricultural practices, ...

Order of November 23, 2020

35 agricultural areas with nitrate concentration levels >50 mg/L

~ 26%
Nitrate vulnerable zone

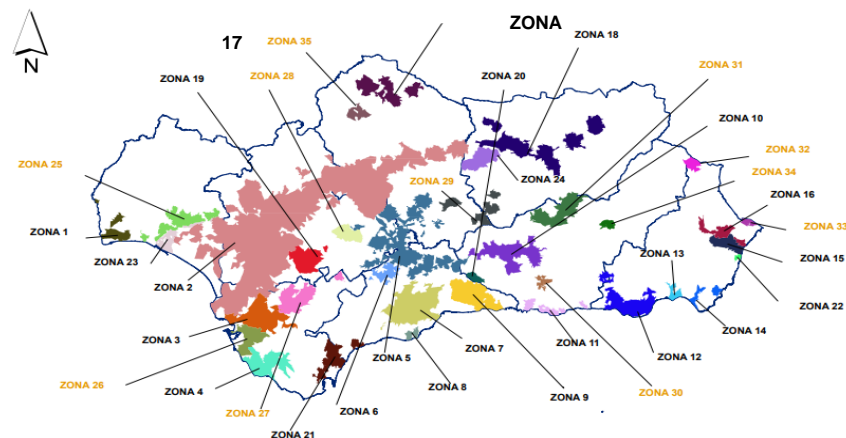


Fig. 3. Map of nitrate vulnerable áreas in Andalusia

The General Directorate of Agricultural and Livestock Production has requested that **IFAPA** take action in support of an institutional demand.

The aim of this action is to develop a project that evaluates the effectiveness of the measures currently established in the current **Action Program**. The project should also propose complementary measures in cases where the current measures are insufficient. Additionally, the project should study the main sources of contamination by nitrates.

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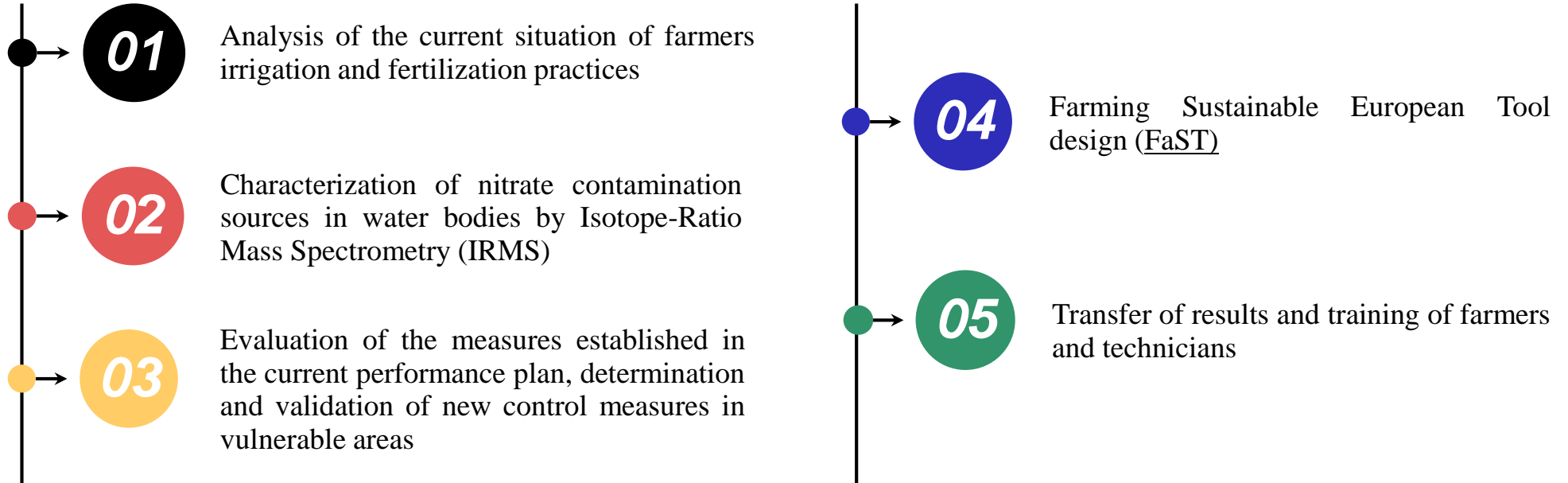
3. Project

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A study on the main sources of contamination & evaluation of environmental impact mitigation measures derived from nitrogenous fertilizer use in nitrate vulnerable areas in Andalusia.

AIMS OF THE PROJECT



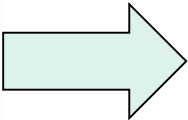
01

Analysis of the current situation of farmers irrigation and fertilization practices

Assessment of the current management of irrigation and fertilization practices followed by the farmers in different crop systems in areas vulnerable to nitrate contamination

- Survey of farmers, technicians and service companies
- Selection of the sample and execution of questionnaires

DETALLES DE LA ENTREVISTA	
Zona de estudio:	
Número de encuesta:	
Fecha:	
<p>Antes de empezar: Esta encuesta es anónima. Los datos facilitados voluntariamente a través de esta encuesta serán almacenados y utilizados por el IFAPA para realizar estudios estadísticos y de mejora del manejo del riego y abonado en los principales cultivos de la región, no siendo accesibles a terceros para finalidades distintas para las que han sido autorizados.</p> <p>El objetivo de la encuesta es realizar un estudio de las zonas en riesgo de contaminación por nitratos, para buscar medidas correctoras y facilitar al agricultor alternativas que le permitan gestionar la fertilización de forma eficiente.</p>	
DATOS DEL AGRICULTOR/A	
Edad: _____	Sexo: _____
Relación jurídica con la explotación:	
<input type="checkbox"/> Titular <input type="checkbox"/> Arrendatario/a <input type="checkbox"/> Asalariado/a <input type="checkbox"/> Familiar del titular <input type="checkbox"/> Otro	
Nivel de estudios:	
<input type="checkbox"/> Ninguno <input type="checkbox"/> Primaria <input type="checkbox"/> Secundaria <input type="checkbox"/> Formación profesional (FP) <input type="checkbox"/> Universitario	
Formación agraria:	
<input type="checkbox"/> Ninguna <input type="checkbox"/> Formación no reglada (cursos de agricultura) <input type="checkbox"/> Formación profesional agraria <input type="checkbox"/> Formación universitaria agraria <input type="checkbox"/> Otra (indicar: _____)	
Experiencia como agricultor/a. Años de dedicación a la agricultura (indicar meses/años): _____	

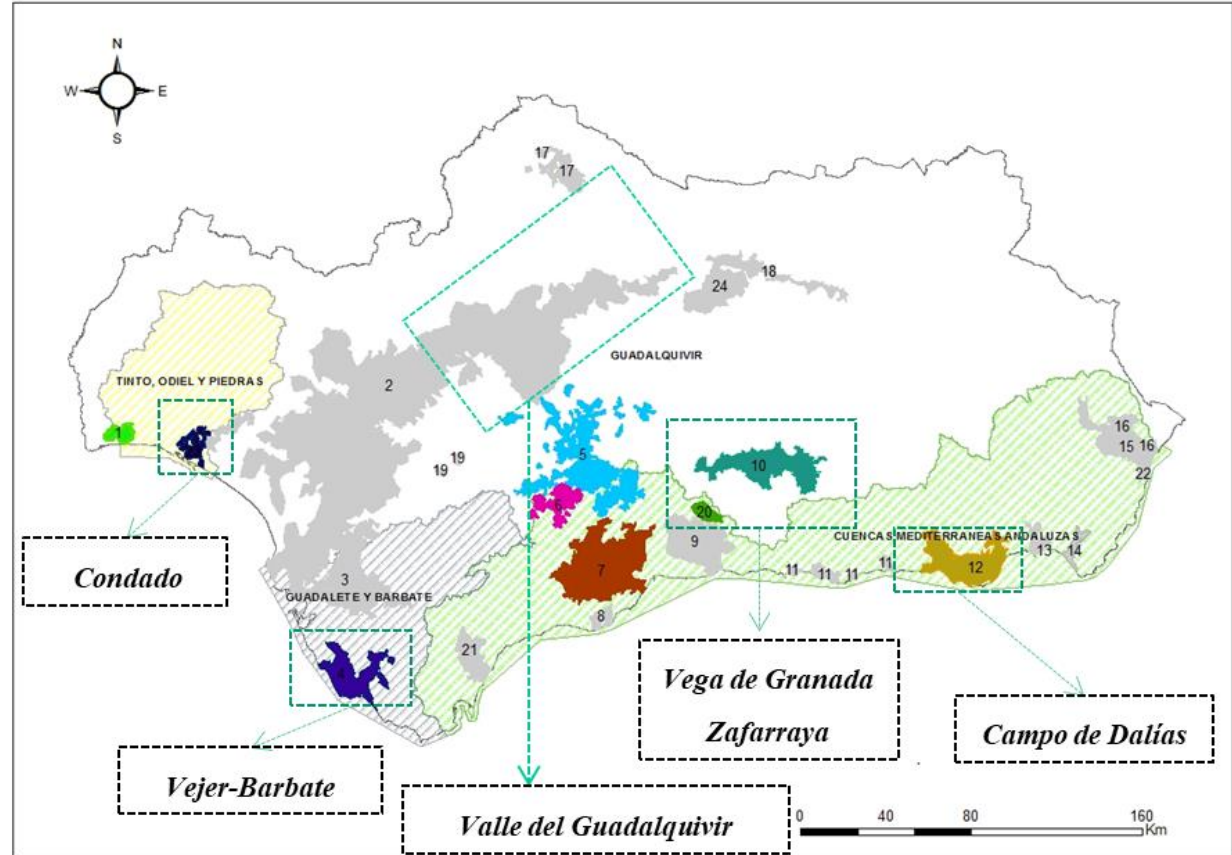
- 
- I. Farmer/technicians data**
 - II. General information/ crop details**
 - III. Fertilization and irrigation management**
 - IV. Regulations and measures**

03

Evaluation of the measures established in the current performance plan, determination and validation of new control measures in vulnerable areas

7 study areas

1. Condado
2. Valle del Guadalquivir (Bajo Guadalquivir)
3. Valle del Guadalquivir (olivar)
4. Zafarraya
5. Campo de Dalías-Albufera de Adra
6. Vega de Granada
7. Vejer-Barbate

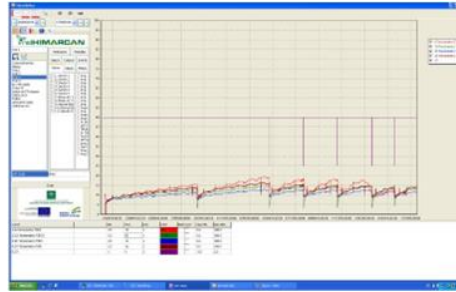


03

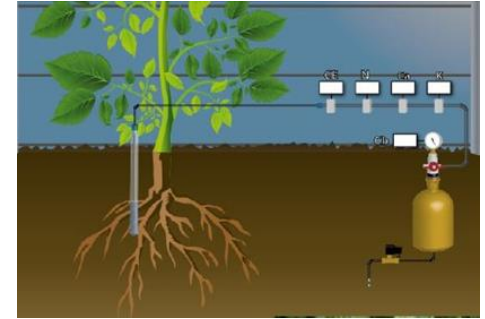
Evaluation of the measures established in the current performance plan, determination and validation of new control measures in vulnerable areas

1. Monitoring and study of the farming system

✓ **Humidity conditions:** tensiometers, FDR probes, monitoring



✓ **Residual NO₃ in soil:** Ceramic suction probe



✓ **NO₃ in irrigation water:** Ion selective electrodes



04

Farming Sustainable European Tool design (FaST)

Development of an APP to determine the needs of nitrogen fertilization in different crops.



A simple calculation tool



Provide technicians and farmers with the necessary calculations and decision-making for the subsequent adoption of the recommendations

Phase 1: 2020-21

- Development of the FaST tool
- Algorithms for crop fertilization

Phase 2: 2021-2022

Evaluation and validation in selected zones:

- Llanos de Antequera-Vega de Archidona
- Campo de Dalías



Transfer of results and training of farmers and technicians

Course

Sustainable Nitrogen Management in Agriculture

Provide the necessary tools to efficiently and sustainably manage nitrogen fertilization in crops

Training workshops and seminars

1. Optimization of Irrigation Water and Fertilization in **Herbaceous Crops**
2. Seminar for the Management of Irrigation and Fertilization in **Extensive Crops**
3. Cotton Group Meeting. March 10, 2022. Results of Irrigation and Fertilization in **Cotton Cultivation 2021**
4. Participation in presentation workshop of results "Results of Experimentation in the Management of **Herbaceous Crops** under Deficit Conditions". December 13, 2022.
5. Current analysis of irrigated **herbaceous crops**. March 25, 2022. Technical workshops of the Chipiona agro-food trade fair

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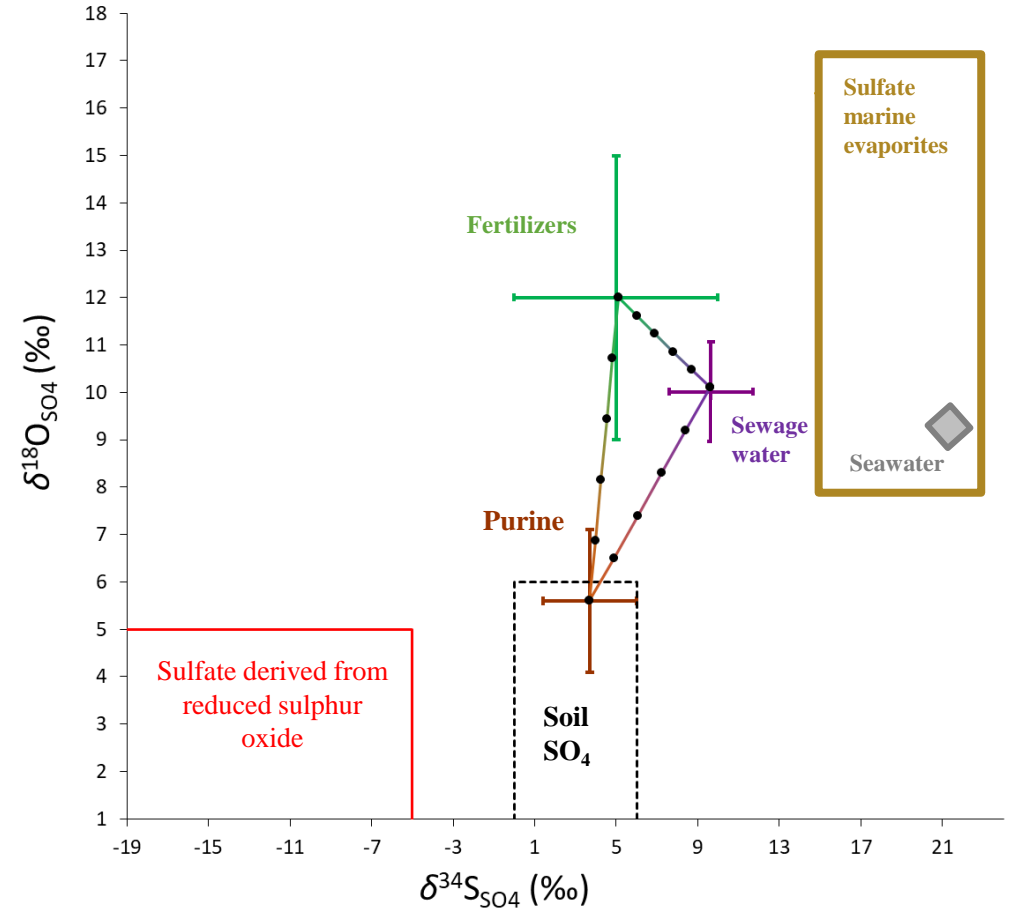
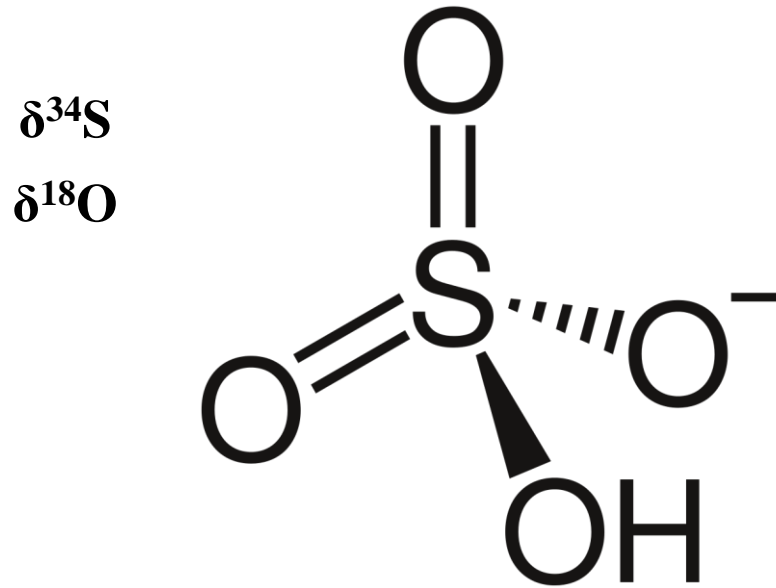
5. Summary

02

Characterization of nitrate contamination sources in water bodies by Isotope-Ratio Mass Spectrometry (IRMS)



Complementary information



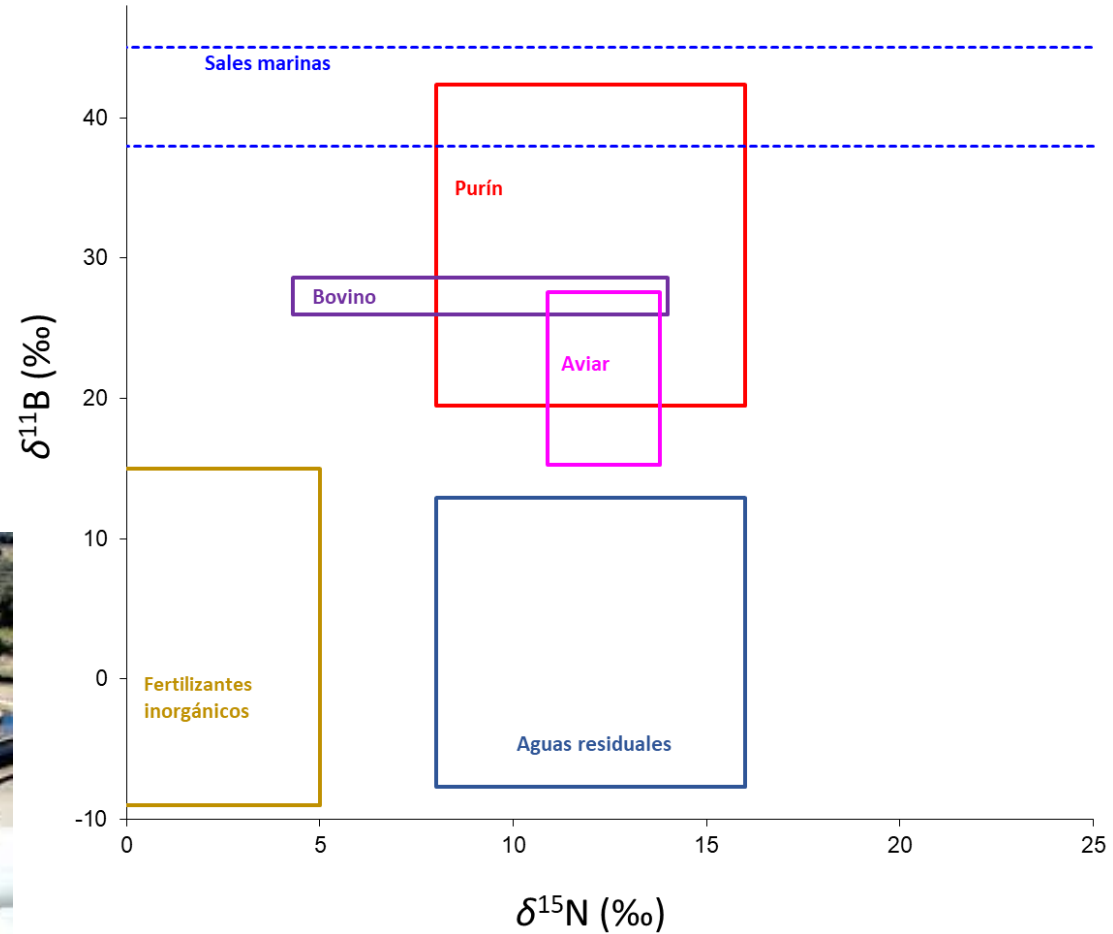
Additional information

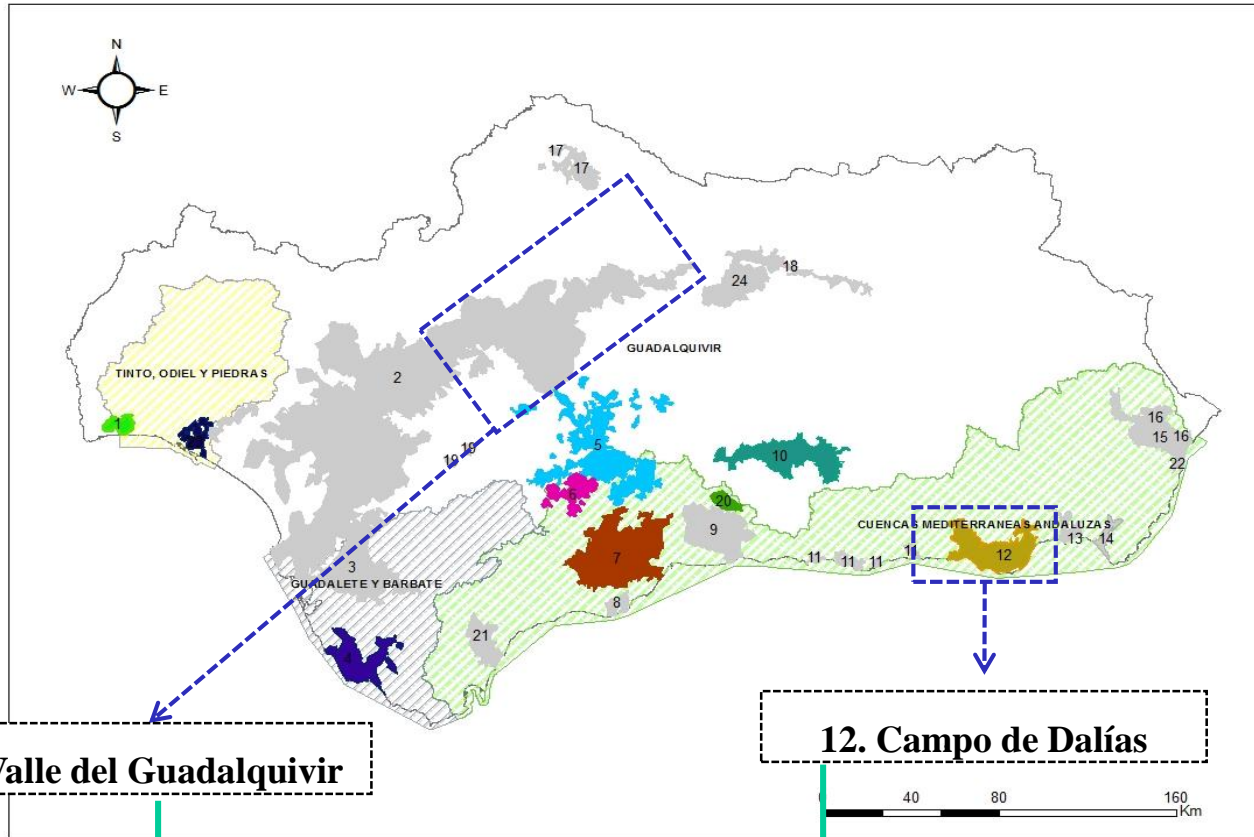
$\delta^{11}\text{B}$
 $\delta^{15}\text{N}$

Nitrates for organic contamination



Junta de Andalucía





Two nitrate vulnerable áreas

2. One of the main important Andalusian olive trees cultivation (Valle del Guadalquivir)
12. The largest intensive horticultural crop zone (Campo de Dalías)

Two periods

(May-June/October-November)

2021 and 2022 years

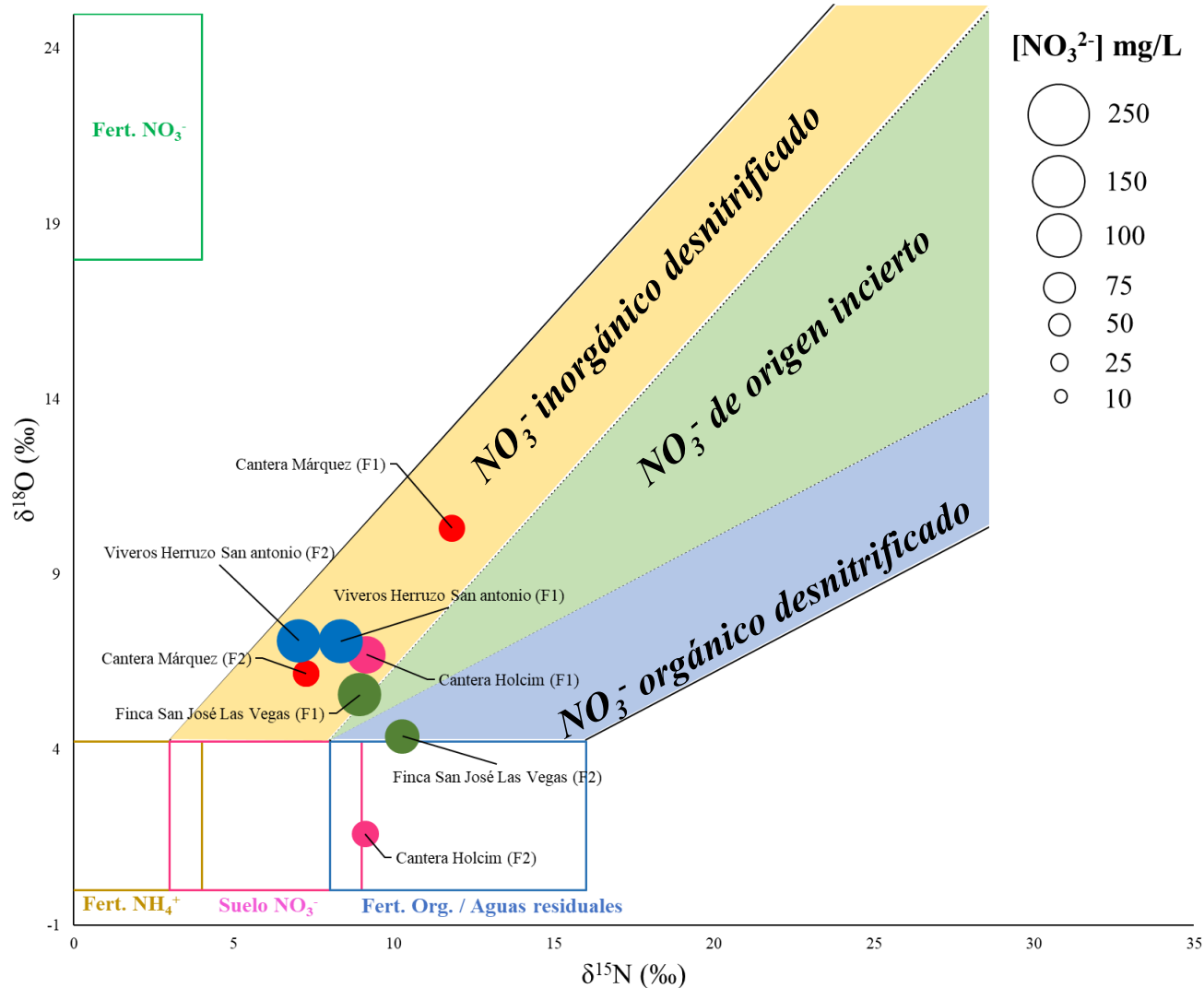
10 Sampling points

10 Sampling points

80 samples

Guadalquivir

Zone name	Waters	2021		2022	
		May-Jun	Oct-Nov	May-Jun	Oct-Nov
Cantera Márquez	Groundwater	33	44	39	49
Cantera Holcim	Groundwater	66	45	64	33
Herruzo San Antonio	Groundwater	94	101	120	135
San José Las Vegas	Groundwater	96	65	104	116
Fuente Zumacarejo	Surface	48	70	70	-
La Corregidora	Surface	60	50	82	82
Cortijo Retruco	Surface	21	19	5	5
Begíjar	Surface	72	49	82	77



Viveros Herruzo San Antonio

inorganic denitrified NO_3^- (2021)

FINCA SAN JOSÉ LAS VEGAS:

Uncertain NO_3^- (May-Jun 2021)
organic NO_3^- (Oct-Nov 2021)



The isotopic geochemistry of N and O in nitrate can be consistent with an organic origin for both campaigns. However, the analysis of sulfates is necessary

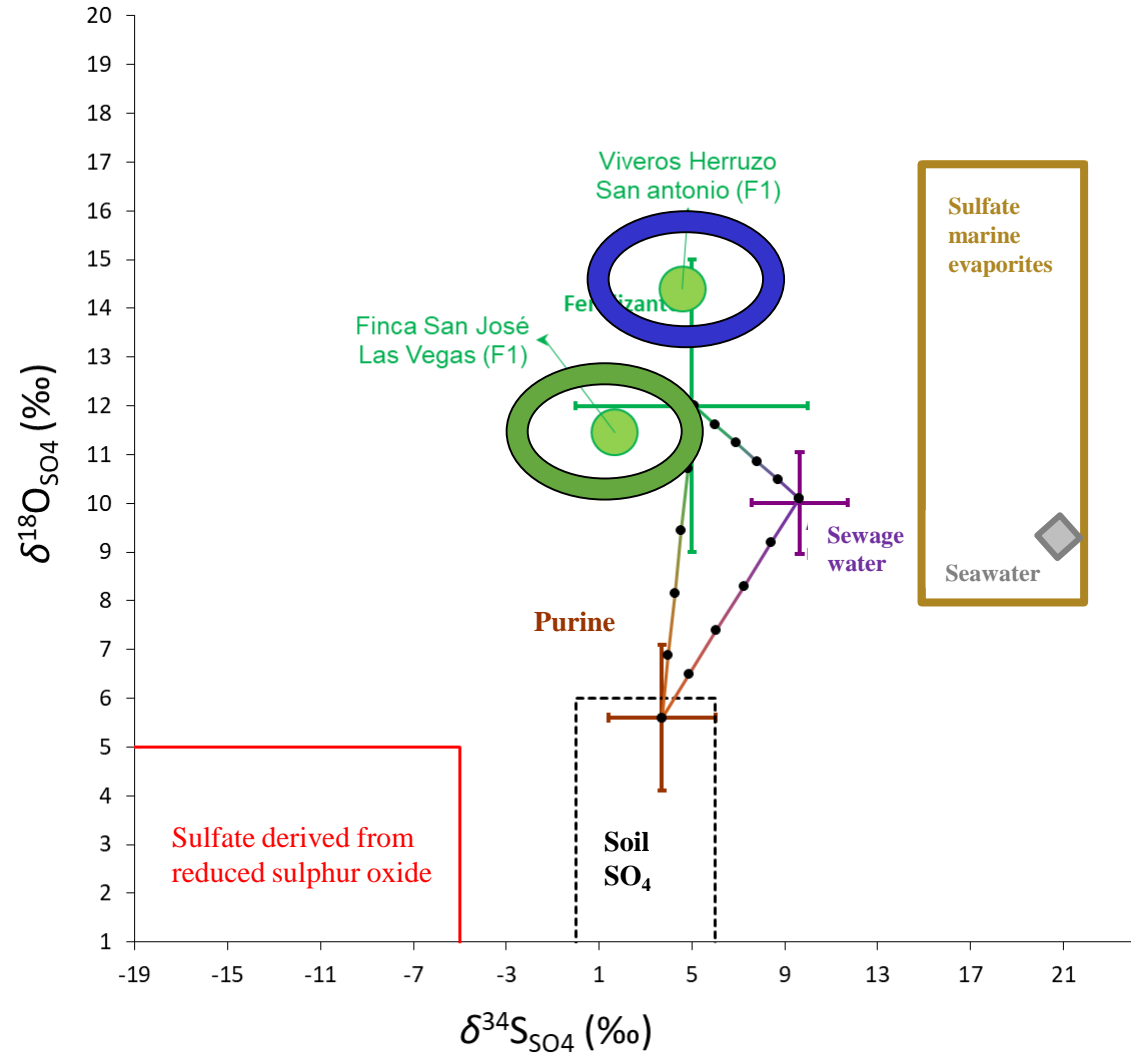
VIVEROS HERRUZO SAN ANTONIO:

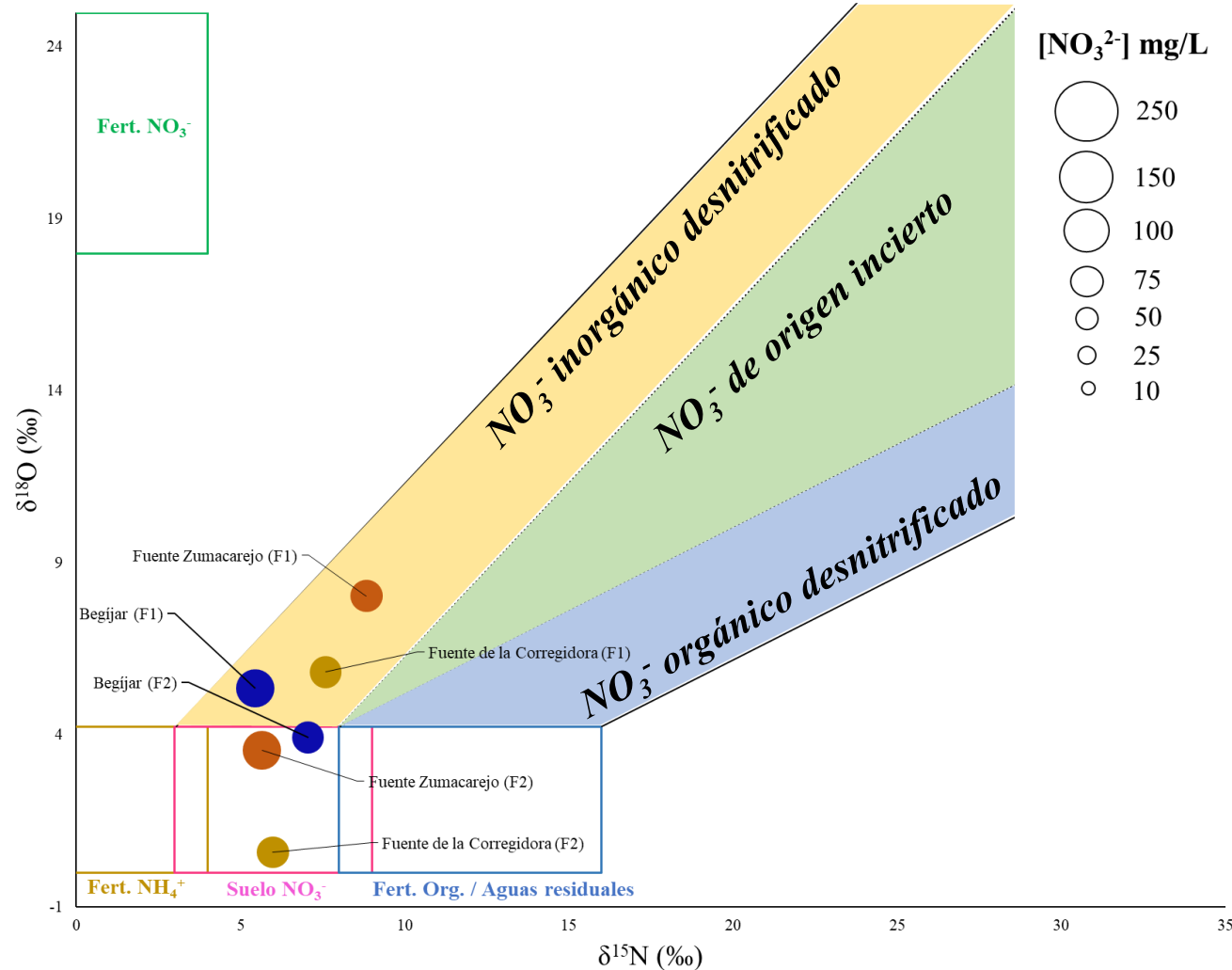
Period	$\delta^{34}\text{S}-\delta^{18}\text{O}-\text{SO}_4^{2-}$
May-June 2021	Fertilizers

FINCA SAN JOSÉ LAS VEGAS:

Period	$\delta^{34}\text{S}-\delta^{18}\text{O}-\text{SO}_4^{2-}$
May-June 2021	Fertilizers

NEXT STEP: B analysis



**FUENTE ZUMACAREJO**

inorganic denitrified NO_3^-
(May-June 2021)

Inorganic ¿organic? NO_3^-
(Oct-Nov 2021)

FUENTE DE LA CORREGIDORA:

inorganic denitrified NO_3^-
(May-June 2021)

Inorganic ¿organic? NO_3^-
(Oct-Nov 2021)

BEGÍJAR:

inorganic denitrified NO_3^-
(May-June 2021)

Inorganic ¿organic? NO_3^-
(Oct-Nov 2021)

FUENTE DEL ZUMACAREJO:**Period** $\delta^{34}\text{S}-\delta^{18}\text{O}-\text{SO}_4^{2-}$

May-June 2021

Inorganic Fertilizers

FUENTE DE LA CORREGIDORA:**Period** $\delta^{34}\text{S}-\delta^{18}\text{O}-\text{SO}_4^{2-}$

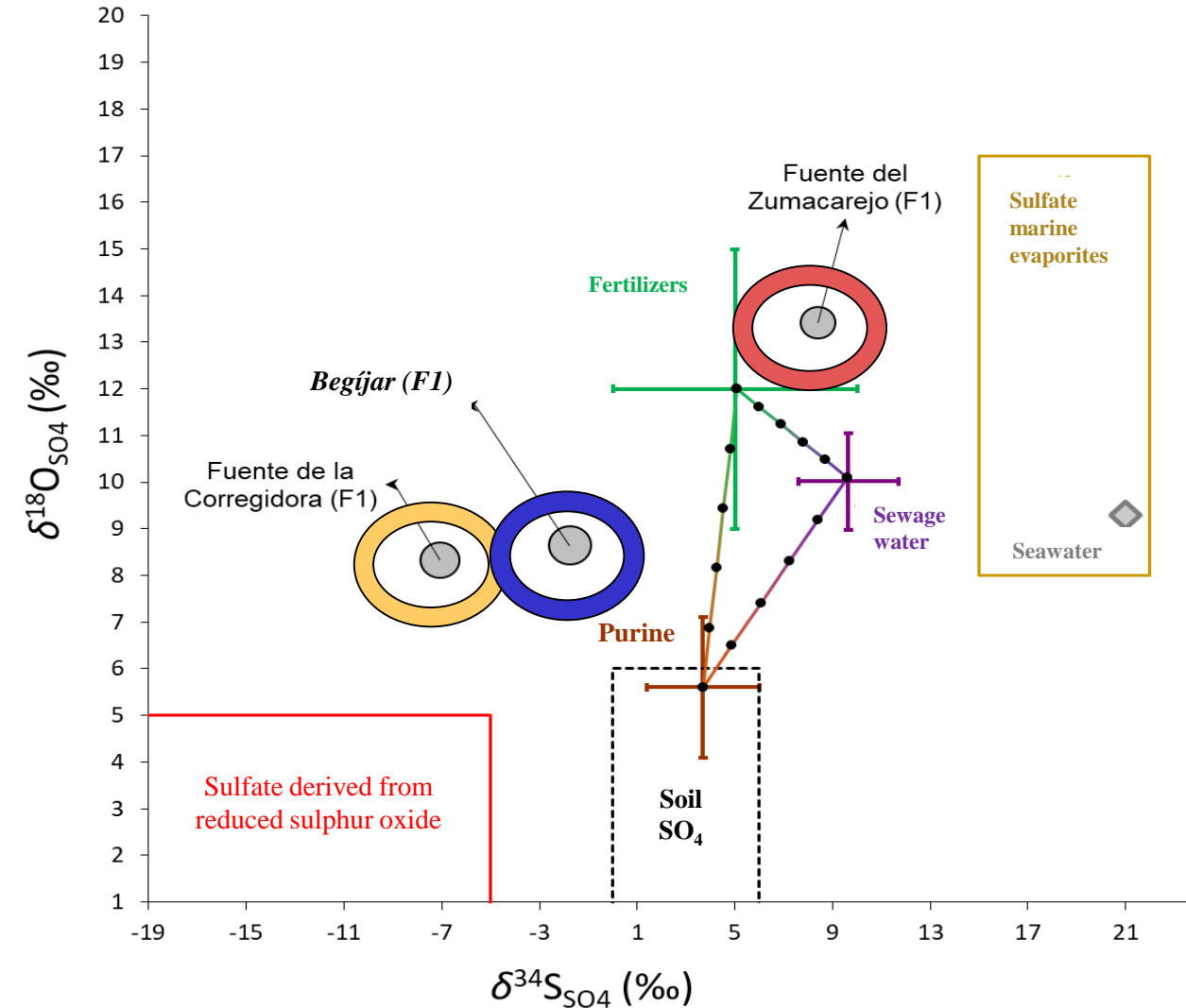
May-June 2021

Fertilizers + oxidation-derived sulfates

BEGÍJAR:**Period** $\delta^{34}\text{S}-\delta^{18}\text{O}-\text{SO}_4^{2-}$

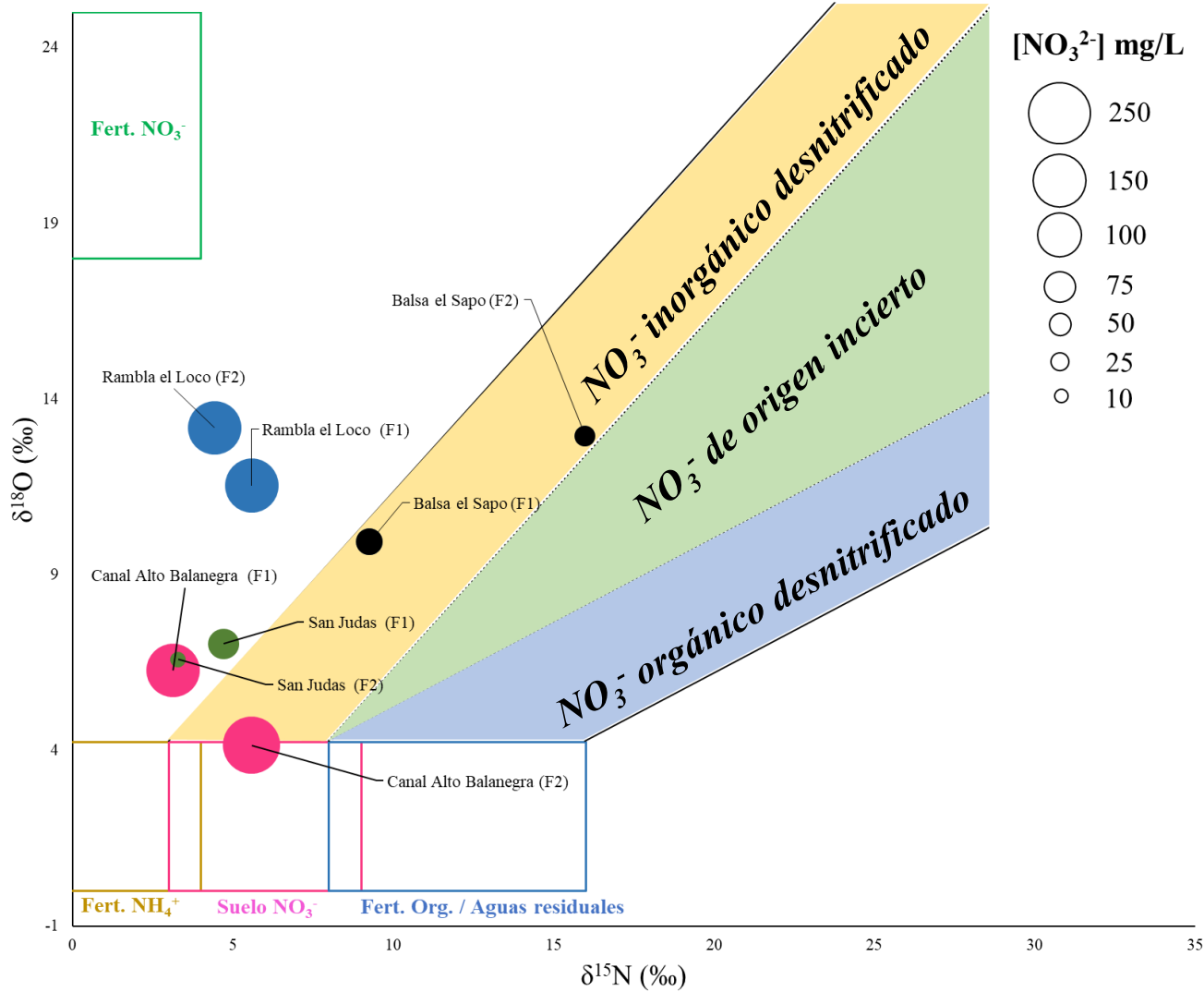
May-June 2021

Fertilizers + oxidation-derived sulfates



Campo de Dalías (Almería)

Zone name	Waters	2021		2022	
		May-Jun	Oct-Nov	May-Jun	Oct-Nov
Balsa el sapo	Surface	44	18	20	20
R. Loco	Surface	157	166	190	204
Punta Entinas	Surface	28	20	4	14
El Corsario	Groundwater	11	13	8	13
Balanegra	Groundwater	155	204	-	297
San Judas	Groundwater	51	10	65	80
Olivos	Groundwater	-	131	142	124
R. Bernal	Groundwater	4	8	9	9



RAMBLA EL LOCO:
 Inorganic denitrified NO₃⁻ (2021)

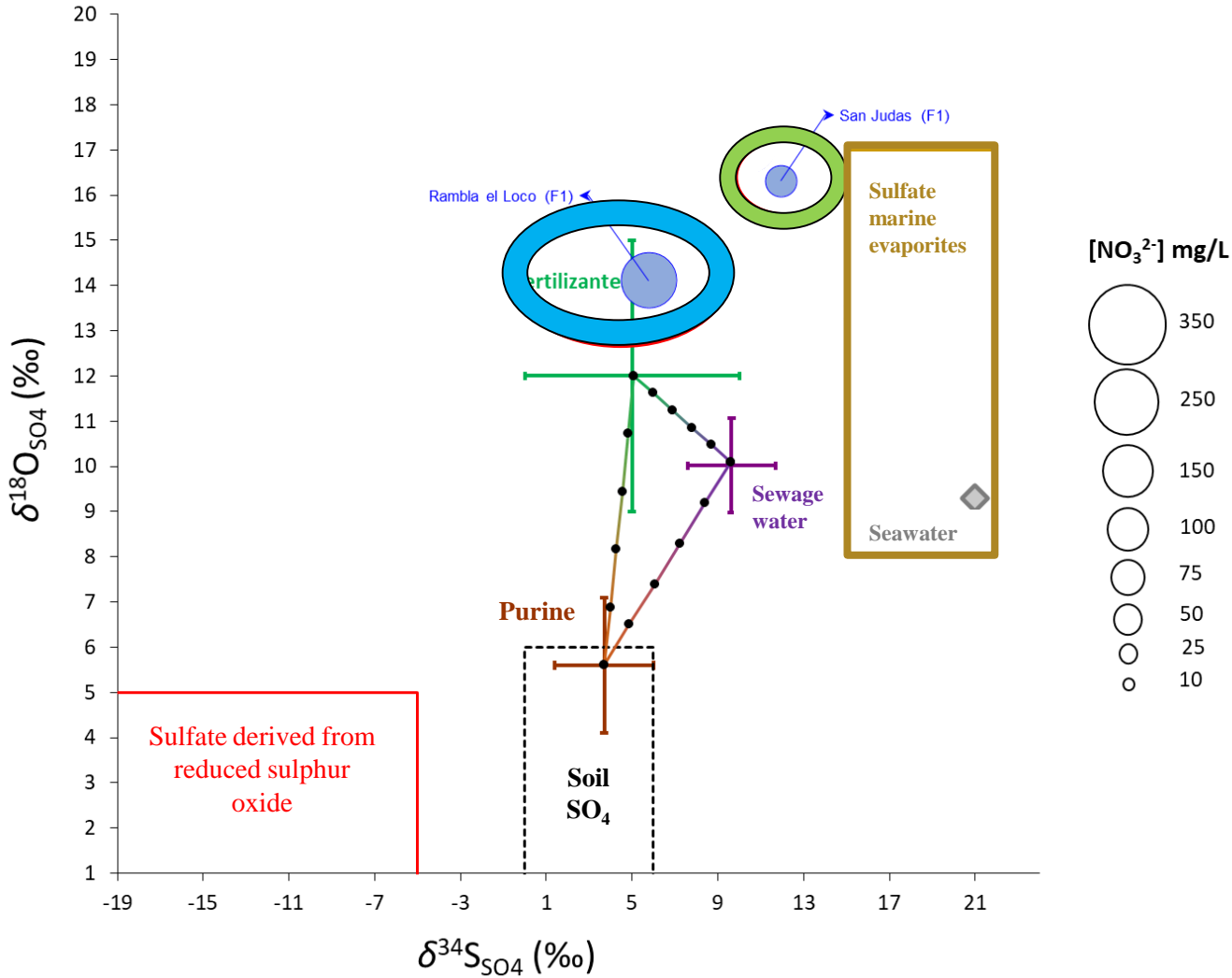
↓

Sulphates

SAN JUDAS:
 Inorganic denitrified NO₃⁻ (2021)

↓

Sulphates



RAMBLA EL LOCO:

Period	$\delta^{34}\text{S}-\delta^{18}\text{O}-\text{SO}_4^{2-}$
May-June 2021	Synthetic fertilizers

SAN JUDAS:

Period	$\delta^{34}\text{S}-\delta^{18}\text{O}-\text{SO}_4^{2-}$
May-June 2021	Fertilizers + geogenic

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Research

Application

Andalusian Institute of
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Fisheries Research and
Training (IFAPA)

RESULTS

1. Scientific & Technical

Research

Application

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RESULTS

2. Transfer & Communication

Training

Dissemination

IFAPA
&
Regional Gov. Agriculture,
Fisheries, Water, and Rural
Development

RESULTS

+

1. Scientific & Technical

Research

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RESULTS

2. Transfer & Communication

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Dissemination

IFAPA
&
Regional Gov. Agriculture,
Fisheries, Water, and Rural
Development

RESULTS

3. Governance

Legislation

Control

Incorporation of the
measures to the new action
program for vulnerable
areas

=



Thank you for your attention

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