

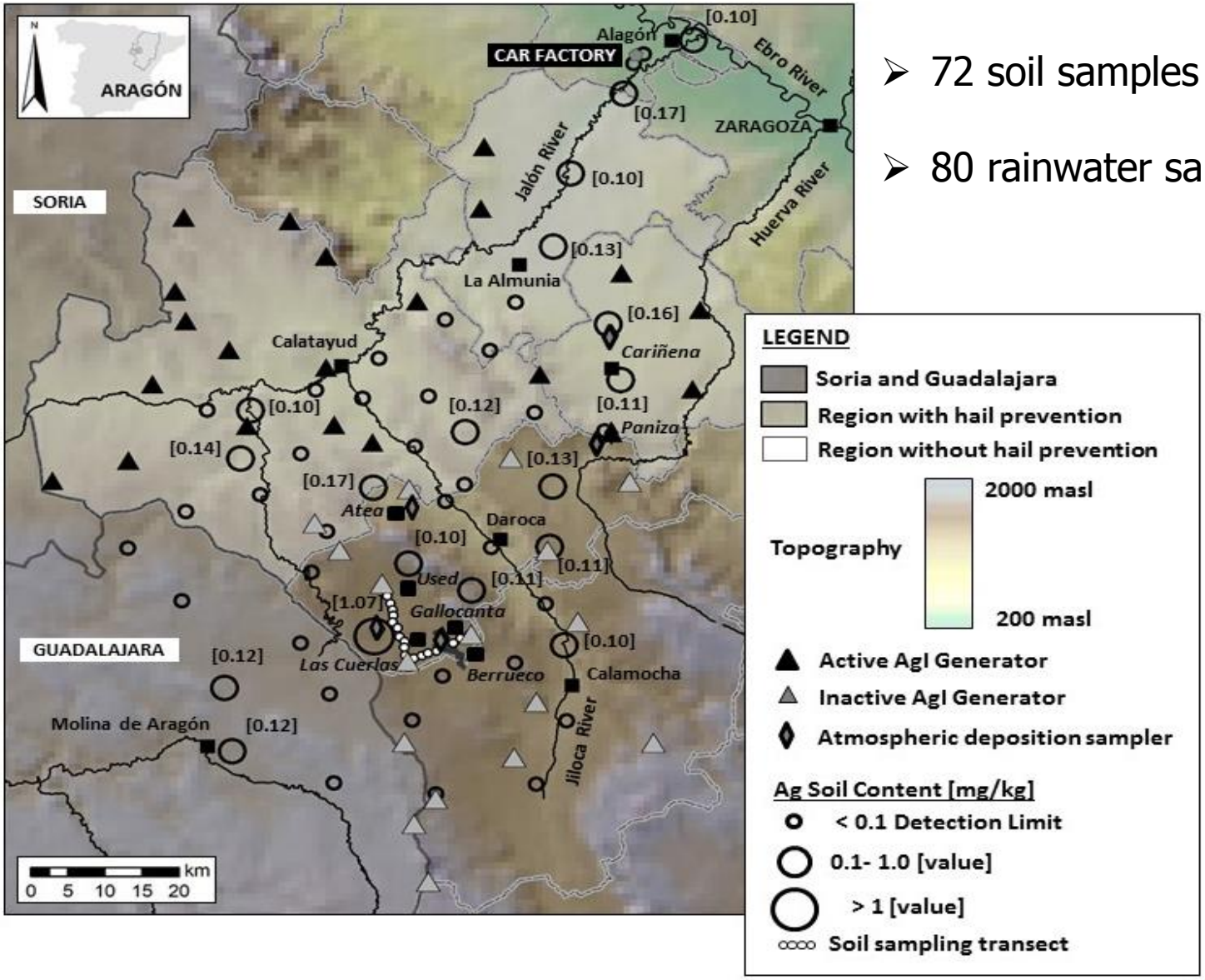
Environmental effects of silver iodide emitted by hail suppression systems in Aragón (Spain)

José M. Orellana-Macías [1], Jesús Causapé [1], Jorge Pey [2], Blas Valero-Garcés[2], Jesús Reyes[1], Iciar Vázquez[1]

[1] Instituto Geológico y Minero de España, Spain
[2] Instituto Pirenaico de Ecología, CSIC, Spain

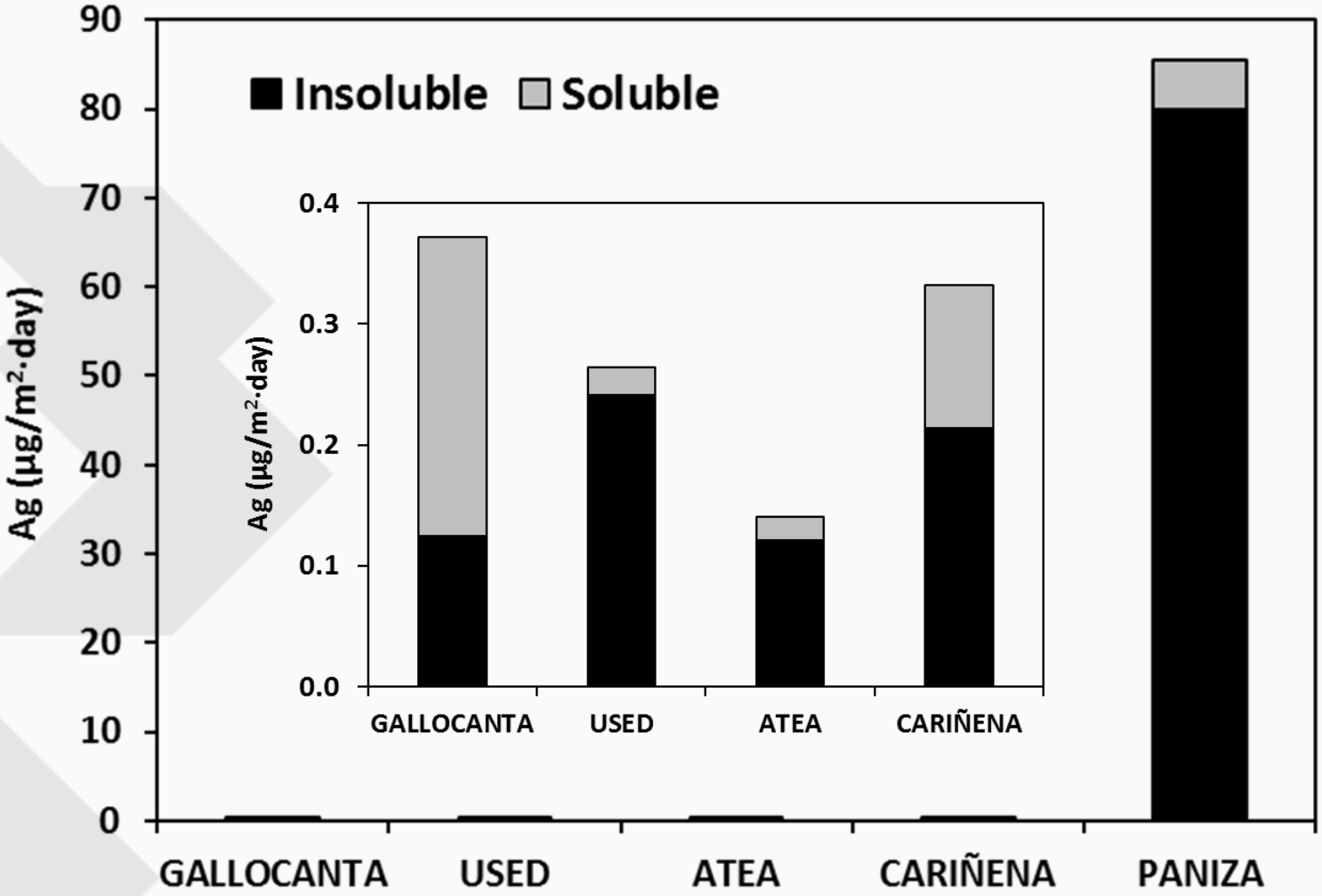
EGU General Assembly 2021

Silver content in soil and rainfall



- 72 soil samples
- 80 rainwater samples (5 gauges)

Silver content in rainfall



Silver content in rainfall

- *Silver content and rainfall in each sampling period*

HAIL SUPPRESION PERIOD

HAIL SUPPRESION PERIOD

From	To	Gallocanta		Used		Atea		Cariñena		Paniza	
Date (dd/mm/yyyy)		Ag (µg/m²·day) | Rainfall (mm/day)									
07/04/2017	10/05/2017	0.01	0.4	0.00	0.4	0.01	0.7	0.02	0.3	14	0.3
10/05/2017	02/06/2017	0.19	1.5	0.00	1.2	0.07	1.4	1.13	0.9	89	1.4
02/06/2017	16/06/2017	0.10	2.0	0.02	2.8	0.00	3.4	0.11	1.9	24	2.1
16/06/2017	10/07/2017	0.45	1.5	0.17	1.2	0.27	1.4	0.18	1.4	63	1.7
10/07/2017	08/08/2017	0.05	0.1	0.01	0.1	0.01	0.0	0.05	0.3	8	0.1
08/08/2017	01/09/2017	0.83	1.4	0.15	2.0	0.17	1.9	0.36	1.3	264	1.2
01/09/2017	28/09/2017	0.83	0.5	0.27	0.4	0.37	0.4	0.04	0.3	109	0.5
28/09/2017	07/11/2017	0.12	0.0	0.03	0.1	0.04	0.0	0.04	0.1	22	0.1
07/11/2017	25/01/2018	0.13	0.4	0.06	0.3	0.12	0.1	1.61	0.4	6	0.7
25/01/2018	26/03/2018	0.12	1.3	0.12	1.2	0.44	1.8	0.02	1.6	192	2.0
26/03/2018	27/04/2018	4.26	2.5	0.08	2.2	0.25	3.3	1.41	4.5	5	3.6
27/04/2018	14/06/2018	0.67	2.8	1.04	3.6	0.47	4.0	0.11	2.6	299	2.3
14/06/2018	13/07/2018	0.29	1.0	1.29	1.7	0.16	2.5	0.02	0.2	167	1.1
13/07/2018	30/08/2018	0.03	0.6	1.44	1.1	0.07	0.6	0.17	0.8	35	0.5
30/08/2018	26/09/2018	0.24	1.0	0.05	1.9	0.07	1.6	0.07	0.7	311	0.9
26/09/2018	02/04/2019	0.01	0.9	0.01	0.9	0.01	1.0	0.03	0.4	31	0.7

- *Multivariate Cluster Analysis. Samples were divided into two groups depending on the hail suppression period (codes 0-1), silver content and rainfall*

Hail-suppression period*	Variable	Gallocanta	Used	Atea	Cariñena	Paniza
GROUP 1 0.9	Ag (µg/m²·day)	0.72	0.44	0.20	0.36	144.89
	Rainfall (mm/day)	1.56	1.89	2.19	1.59	1.68
GROUP 2 0.5	Ag (µg/m²·day)	0.19	0.06	0.09	0.30	31.55
	Rainfall (mm/day)	0.38	0.37	0.37	0.30	0.40

Silver content in soils

Region	Number of samples	Ag > DL[1]	Mean Ag[2]
		%	mg/kg soil
Castilla	7	29	0.07
Jiloca	8	13	0.06
Daroca	9	67	0.20 (0.10)[3]
Cariñena	3	67	0.11
Calatayud	16	19	0.07
Valdejalón	5	60	0.10
High Ebro Banks	3	33	0.07

Region without hail suppression systems

Region with hail suppression systems

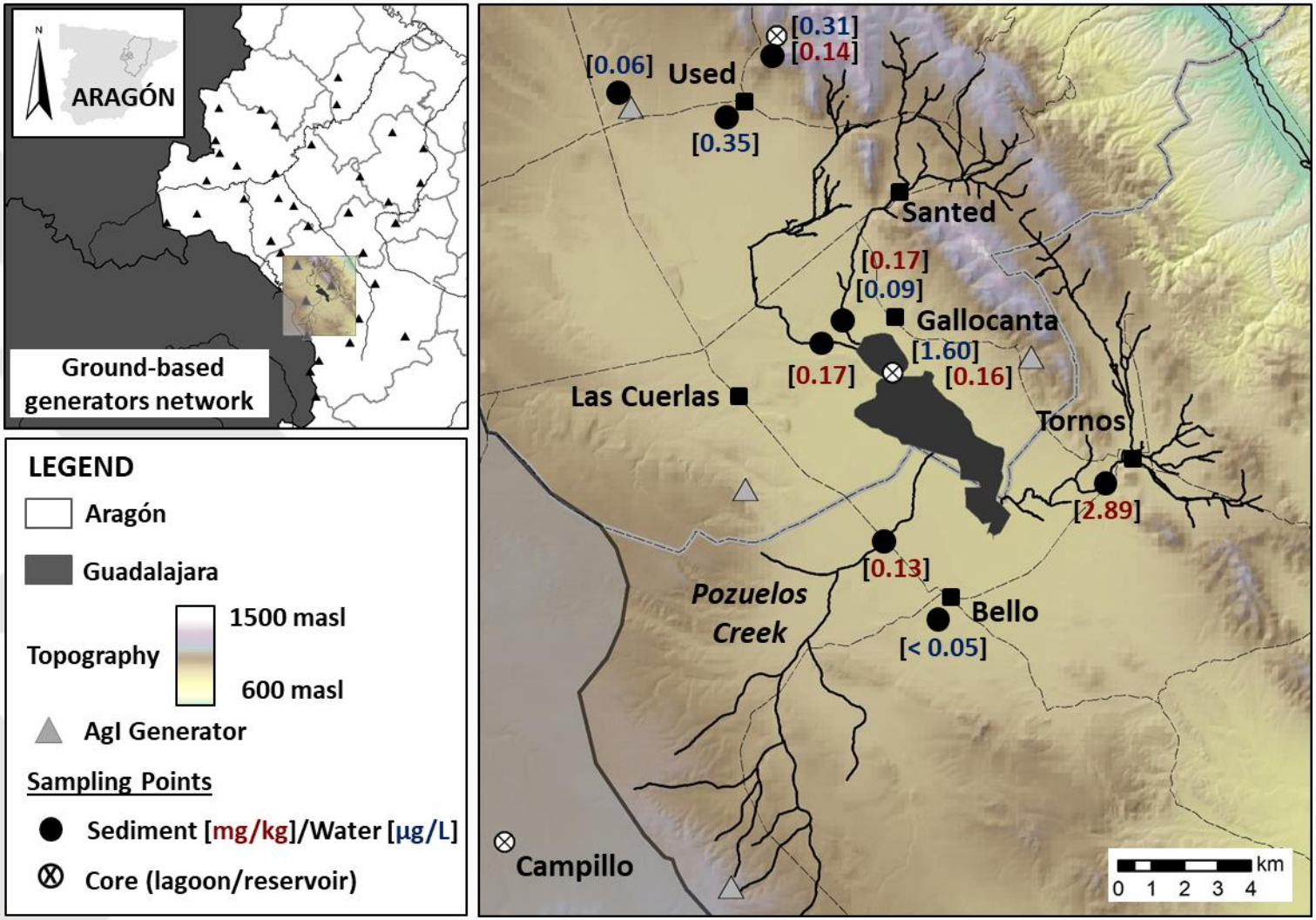
[1] DL: Detection limit Ag = 0.1 mg/kg soil.

[2] When silver content is < DL, silver content is considered as 0.05 mg/kg soil for calculation

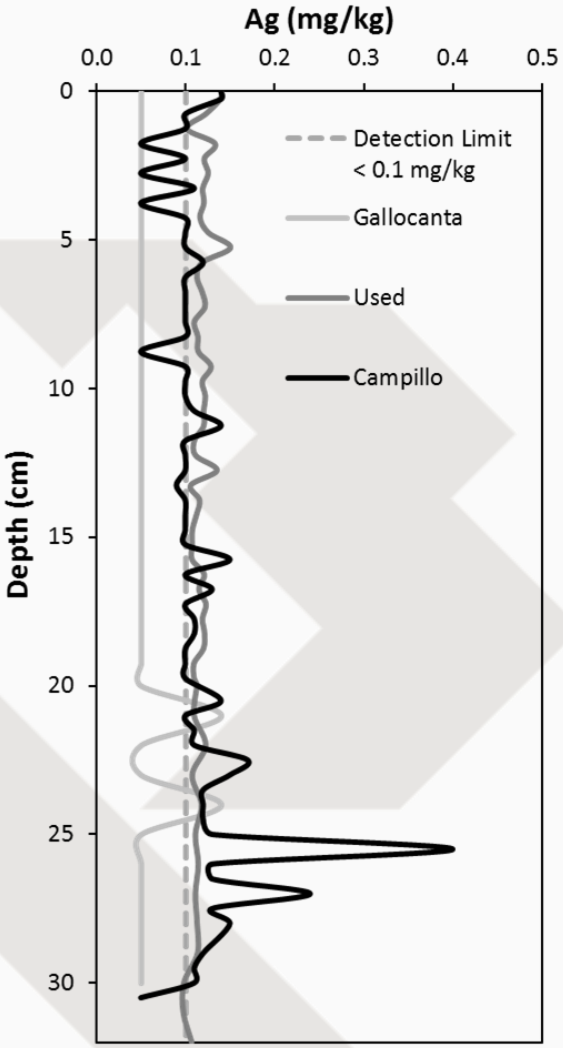
[3] Mean value excluding the sample collected next to a former generator.

- Higher silver concentration in regions with hail suppression systems.
- In Daroca, hail suppression systems were functioning until 2017.

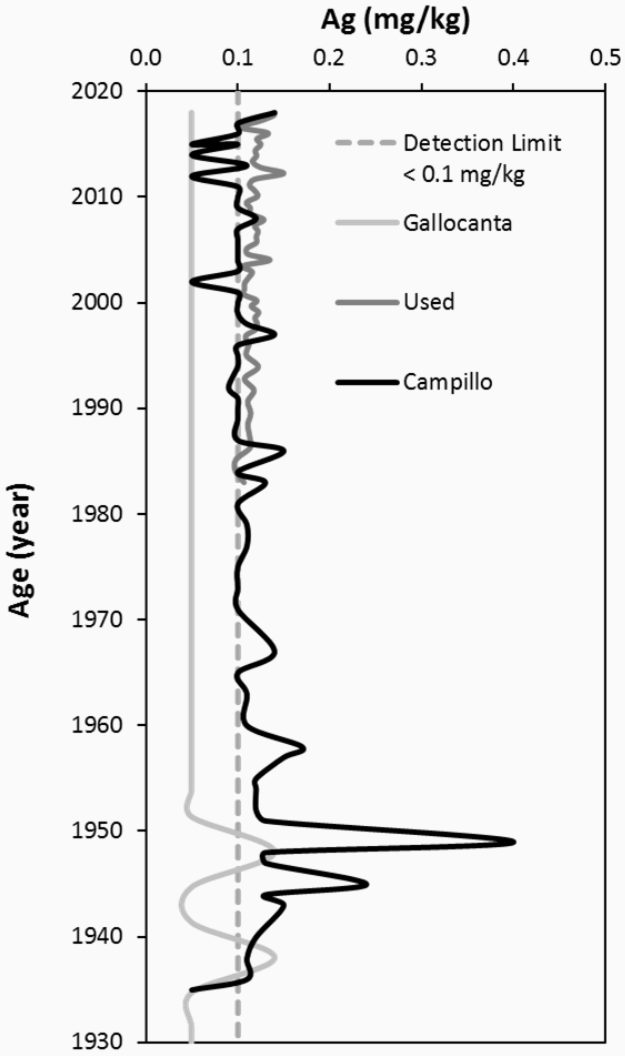
Silver content in sediment and water



Silver accumulation in sediment cores



Depth sequence



Age-Model sequence

- Silver peaks in cores were previous to hail suppression systems.
- No remarkable peaks associated to silver emission from hail suppression.
- Silver content in cores in the same order of magnitude that in soil samples.

Silver accumulation in biota. Essay with wheat.

1 mg/kg soil	6 mg/kg soil	13 mg/kg soil	38 mg/kg soil	64 mg/kg soil
				
				
1,6 mg/kg straw	2,5 mg/kg straw	7,4 mg/kg straw	-	-

- Wheat growth limited when silver content in soil increase.
- The higher silver content in soil, the higher silver concentration in straw, so silver in soils can be absorbed by plants and crops.
- Silver concentration in soils and straws sampled in the study area are lower.

Silver accumulation in biota. Sheep tissues

	Tissue						
	Liver	Kidney	Spleen	Fur	Hoof	Bone	Lean
	----------Ag (mg/kg dried) ----------						
Hail suppression	10.2	2.7	0.3	1.7	1.0	1.7	1.9
No hail suppression	0.5	0.3	< 0.1	< 0.1	0.8	1.6	1.9

- Two sheep grazing during 8 years in areas with and without hail suppression systems.
- Silver content was higher in the tissues of the sheep in the hail suppression area.
- Silver was mostly accumulated in the liver.

Conclussions

- Except for the surroundings of the generators, silver concentration in rainwater and soils are low but detectable. Higher in areas with hail suppression systems.

- Plants and crops can absorb silver from soils.

- Silver concentration in soils and sediments is lower than expected after 50 years of emission. We propose bio-accumulation (i.e. absorption and extraction by plants and crops) as the reason.

More info and contact:

Causapé, J., Pey, J., Orellana-Macías, J. M., Reyes, J. (2021). Influence of hail suppression systems over silver content in the environment in Aragón (Spain). I : Rainfall and soils. *Science of the Total Environment*, 147220. https://doi.org/10.1016/j.scitotenv.2021.147220

Causapé, J., Orellana-Macías, J. M., Valero-Garcés, B., & Vázquez, I. (2021). Influence of hail suppression systems over silver content in the environment in Aragón (Spain). II : Water, sediments and biota. *Science of the Total Environment*, *779*, 146403. https://doi.org/10.1016/j.scitotenv.2021.146403

jm.orellana@igme.es



Instituto Geológico
y Minero de España