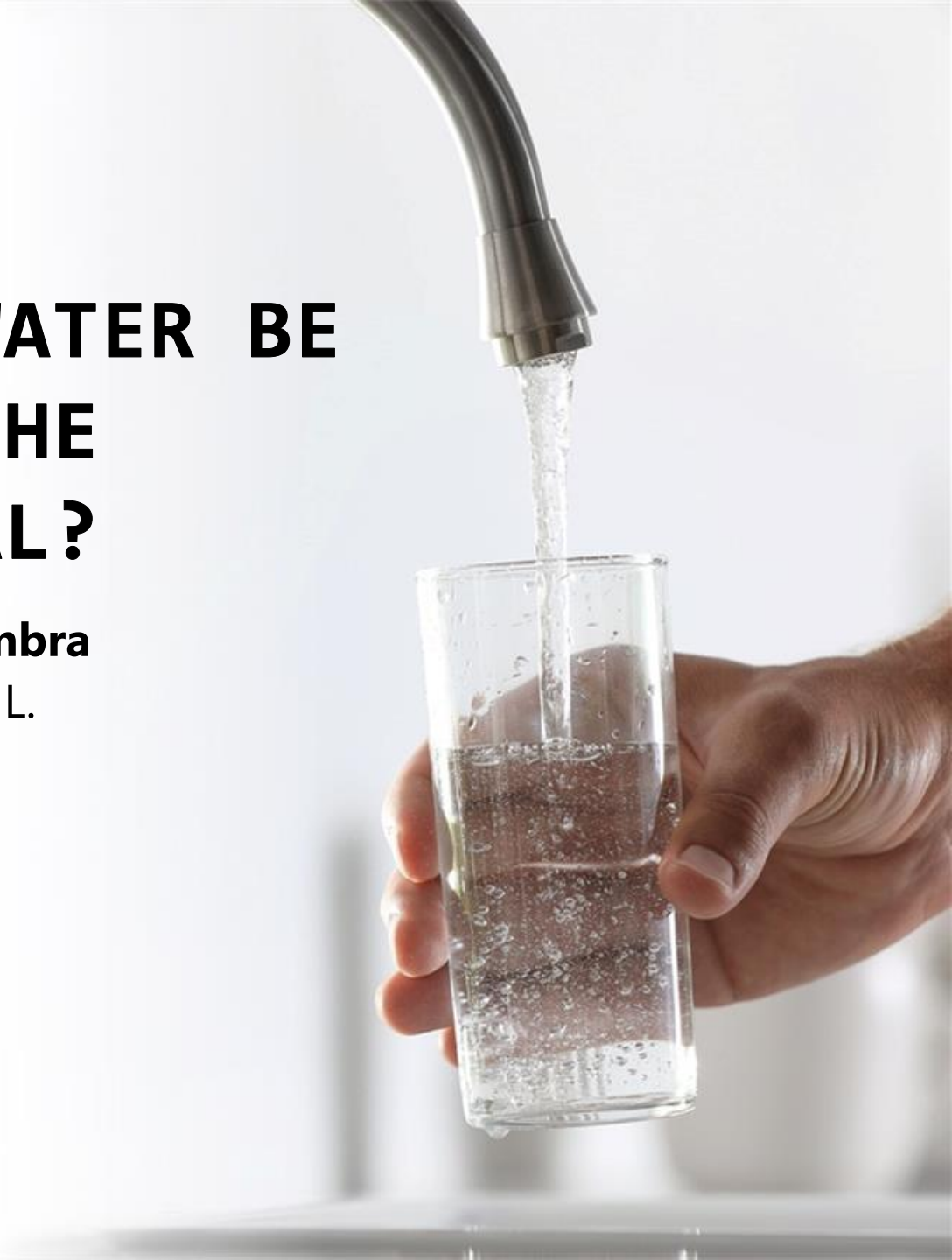
CAN RADON IN DRINKING WATER BE USEFUL FOR PREDICTING THE GEOGENIC RADON POTENTIAL?

Filipa Domingos, PhD student @ University of Coimbra
Pereira, A., Dias, L., Rodrigues, S., Alexandre, C., Simas, L.

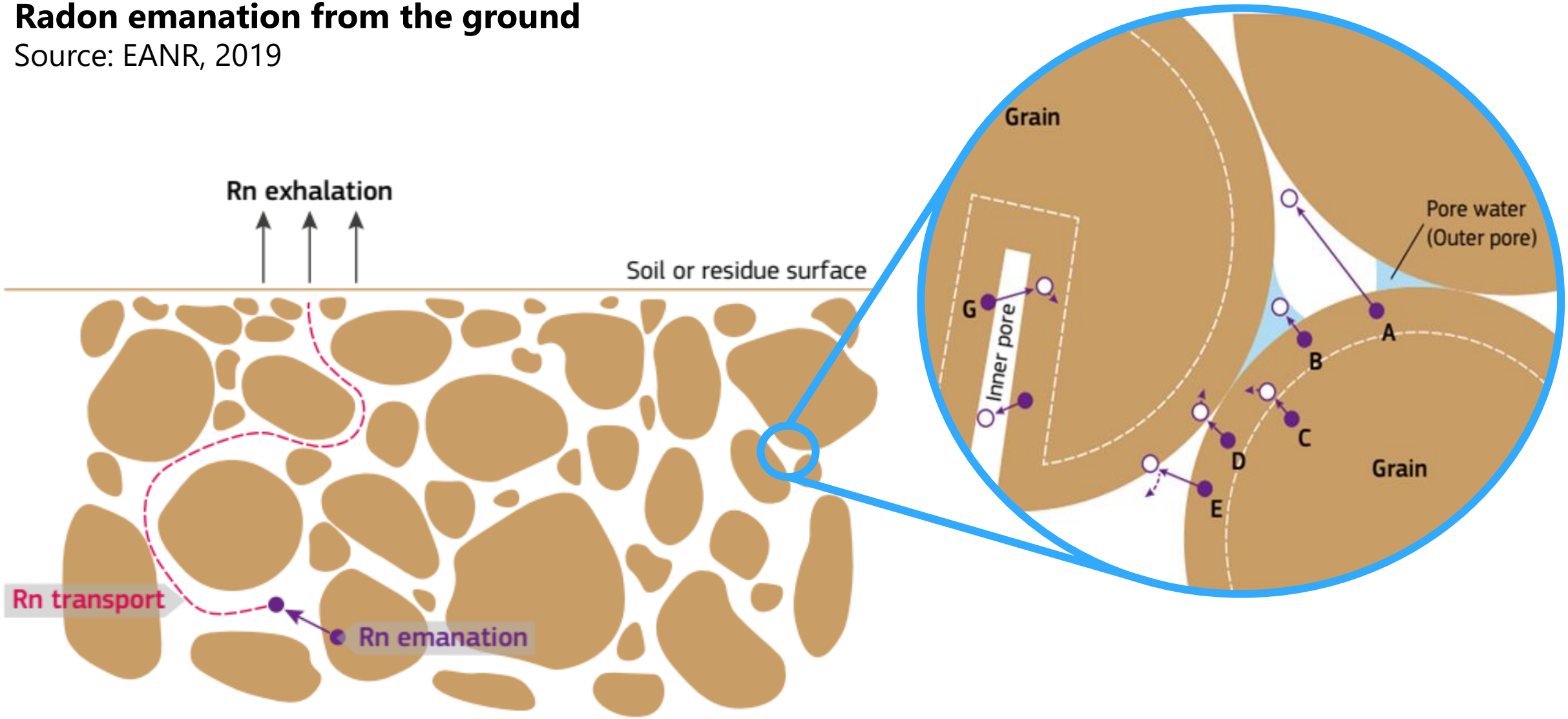


16TH GARRM, SEPTEMBER 19TH-21ST 2023

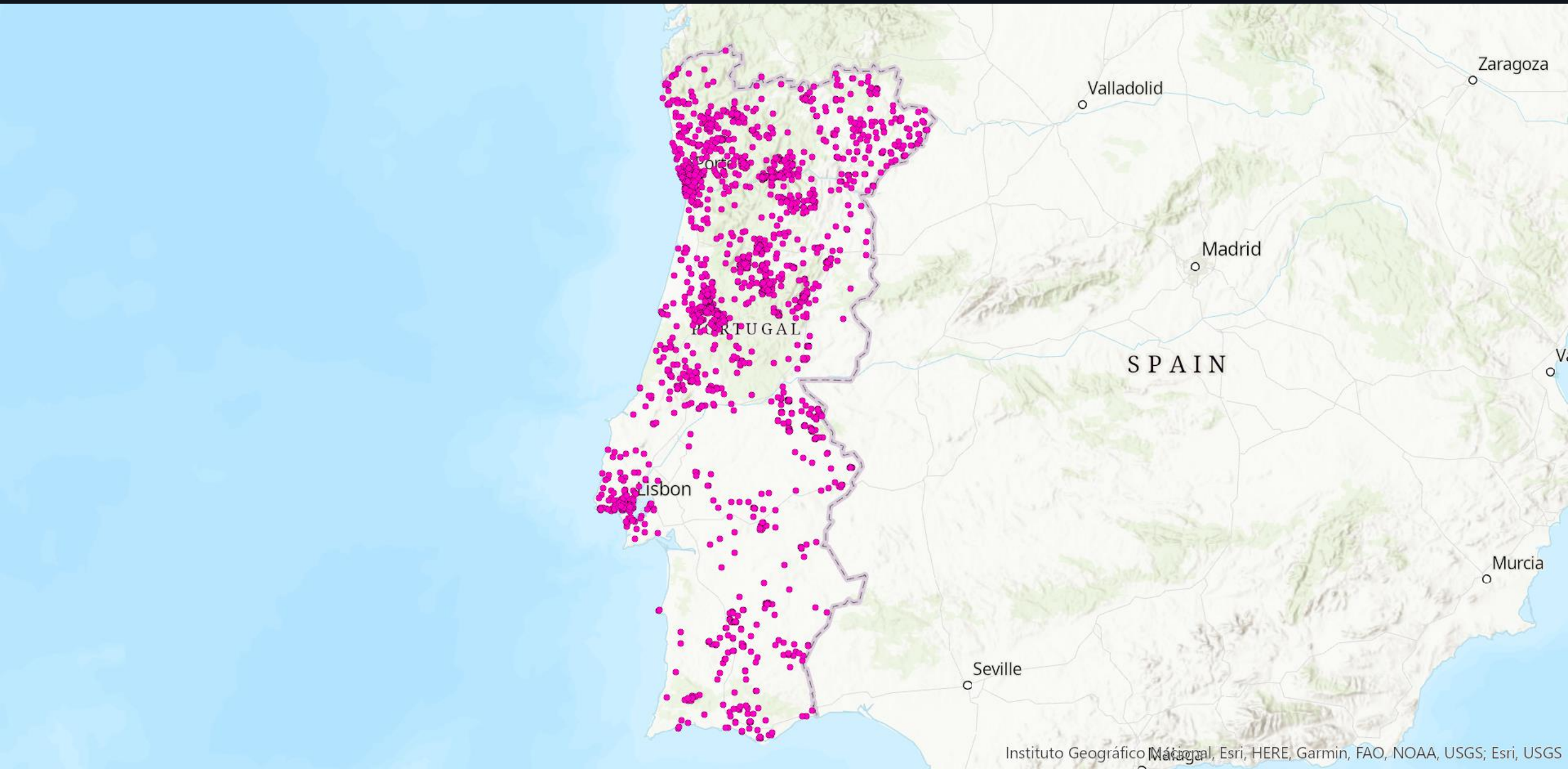
CONTENTS

SOURCE OF RADON IN DRINKING WATER

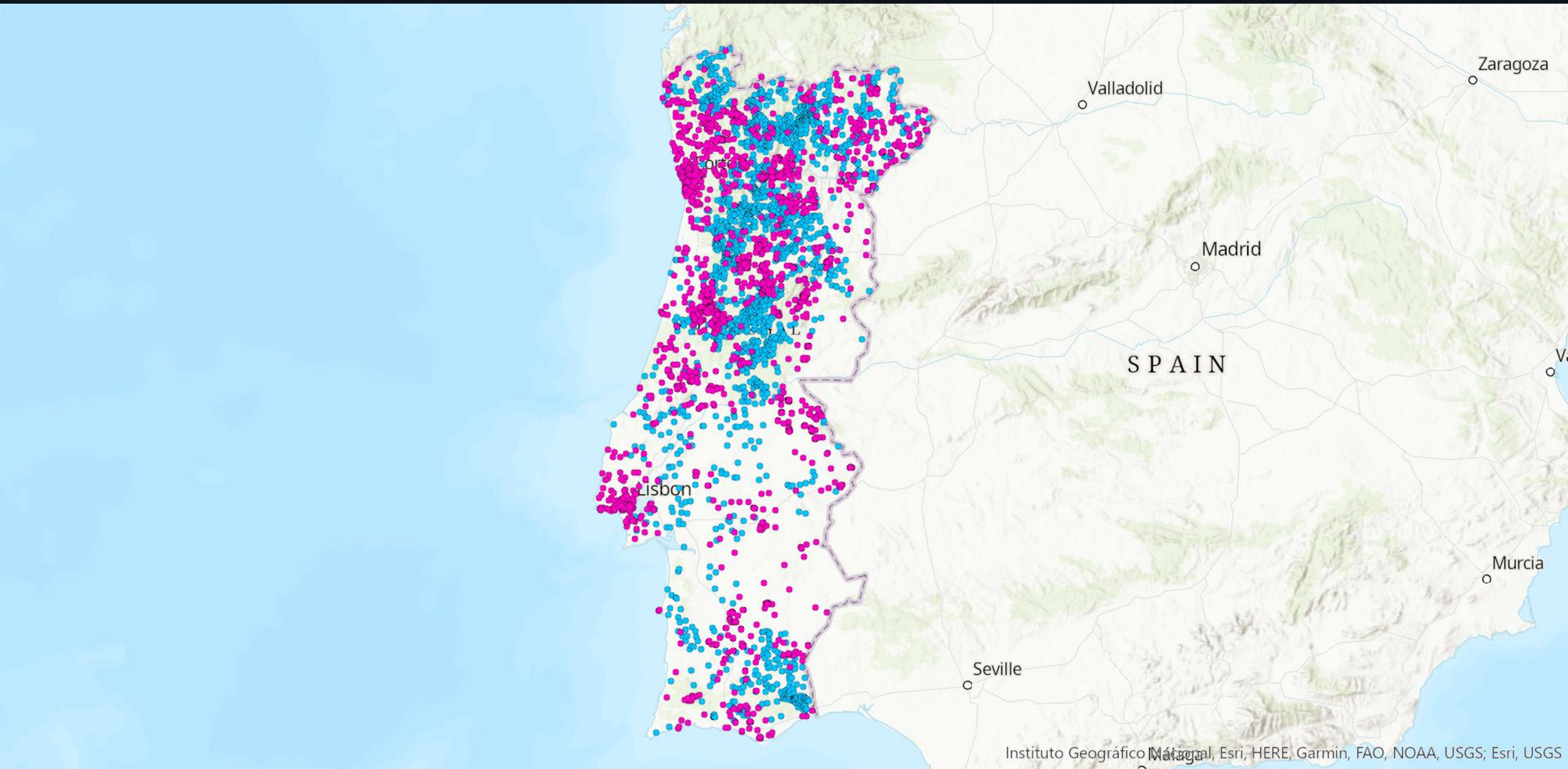
Radon emanation from the ground
Source: EANR, 2019



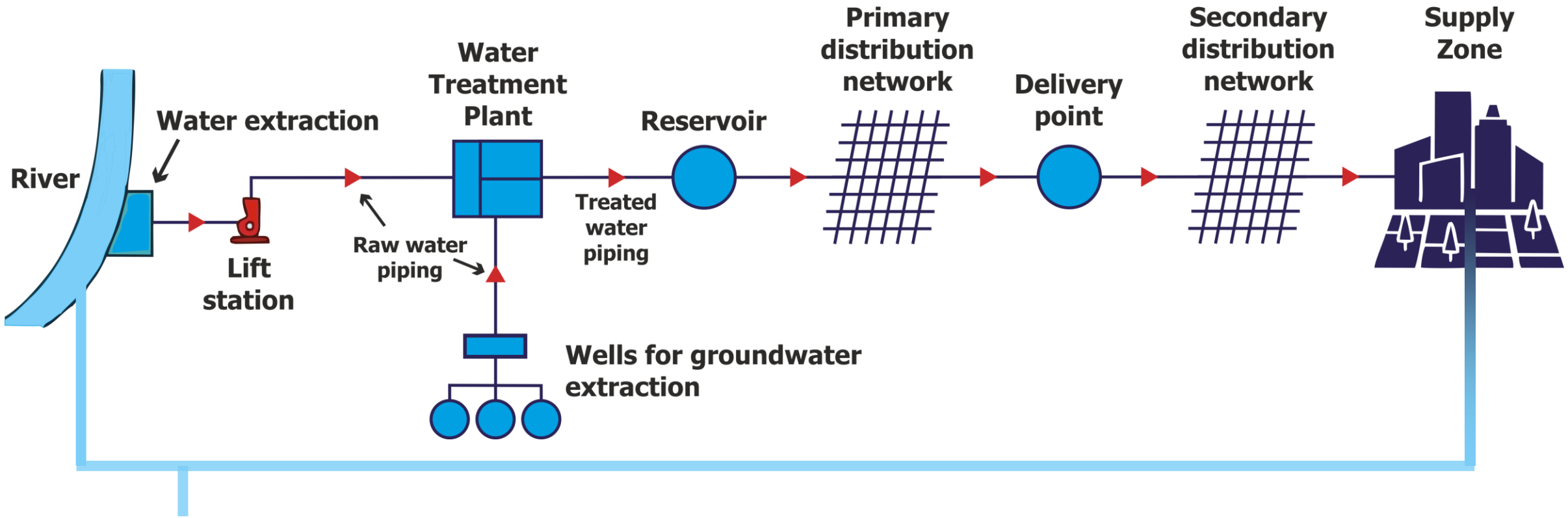
INDOOR RADON DATA



INDOOR RADON + WATER RADON DATA



MANDATORY WATER QUALITY MONITORING



Monitoring requirements:

COUNCIL DIRECTIVE 2013/51/EURATOM
Parametric value: **1000 Bq/L (maximum)**

DECREE-LAW No. 69/2023
Parametric value: **500 Bq/L**

→ **Data**

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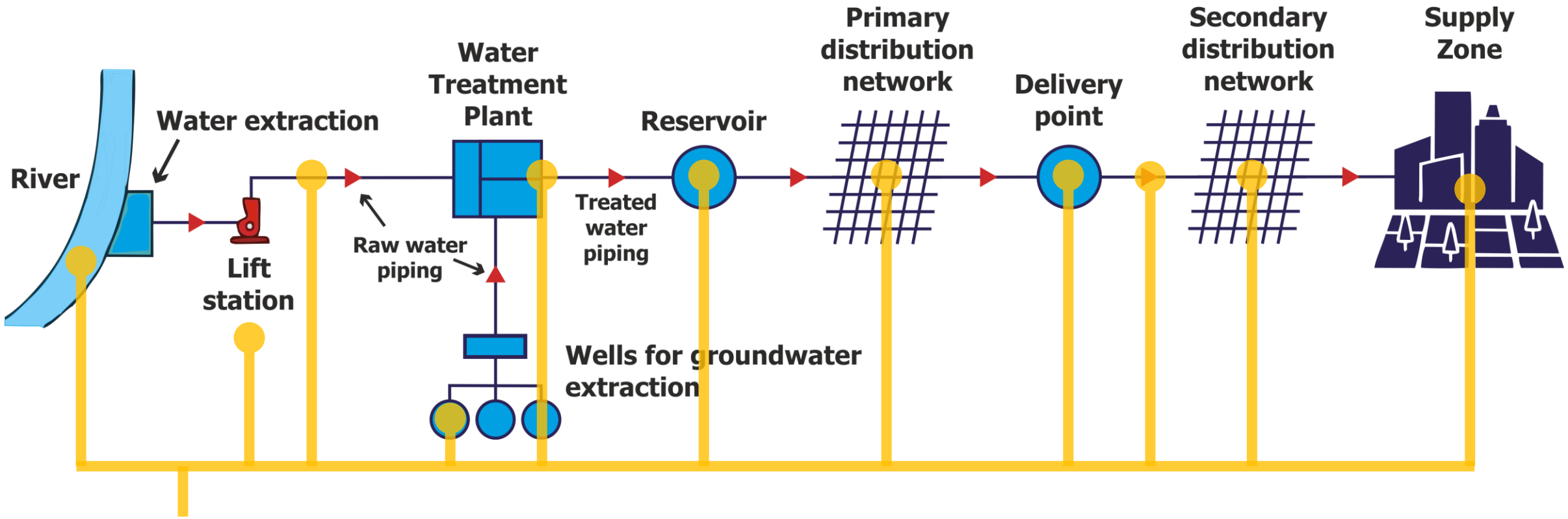

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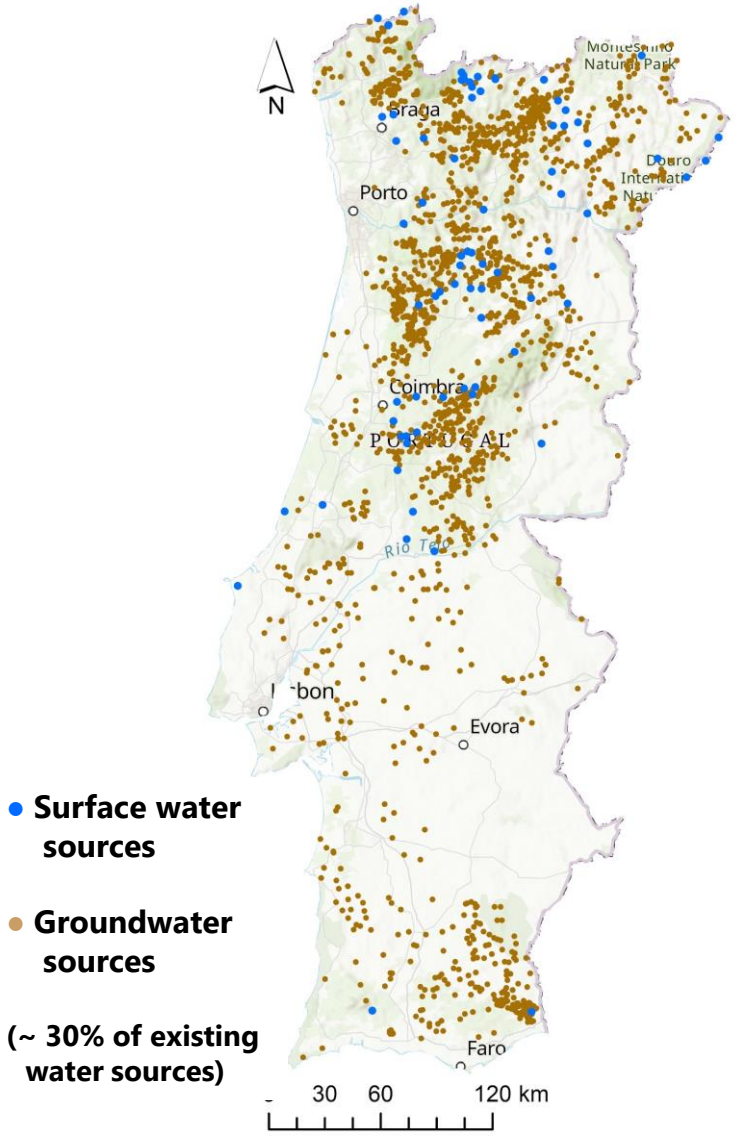
→ **Data**

Traceability to a water source
Water treatment
Sampling/Analytical uncertainty
Spatial and time variability

NUMBER AND TYPE OF DATA

Data Source: ERSAR	2016	2017	2018	2019	Total
Groundwater					
Raw	135	189	127	14	465
Treated	3648	3571	72	8	7299
Surface water					
Raw		8	5		13
Treated	463	449	4		916
Mixed (untraceable to source)					
Treated	426	352	2		780
Total	4672	4569	210	22	**9473**

Groundwater	found below the surface
Surface water	inland water other than groundwater
Raw water	water as found in nature
Treated water	water that undergoes any type of treatment



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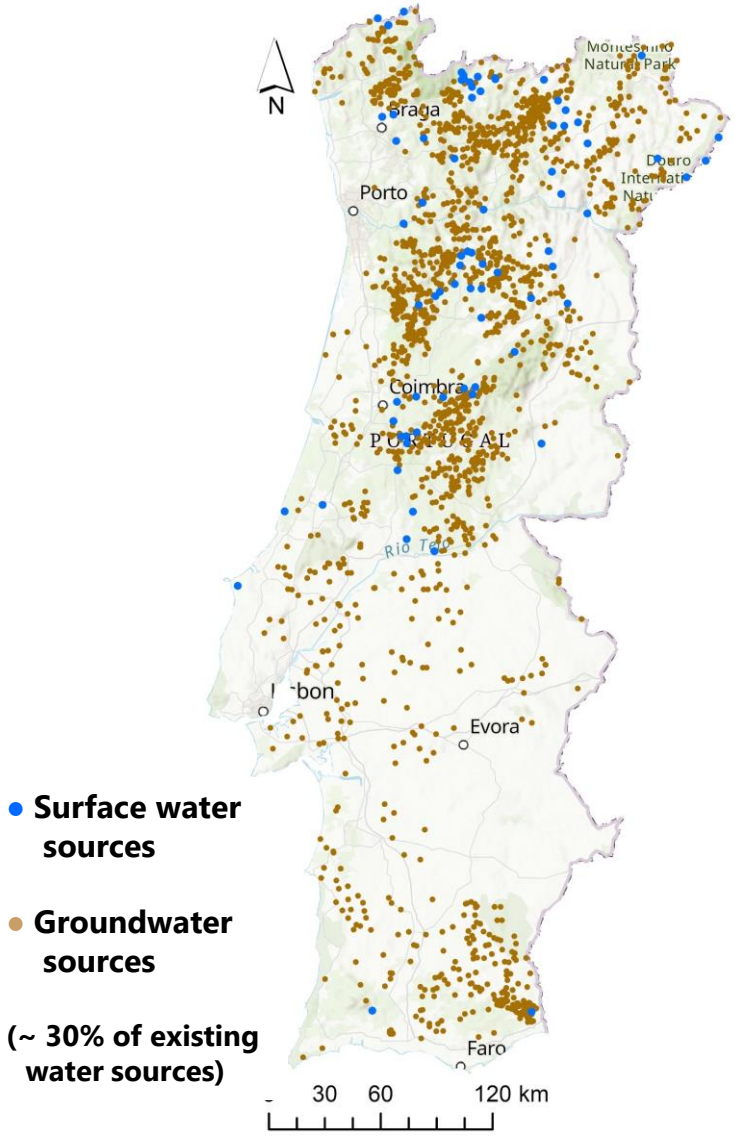
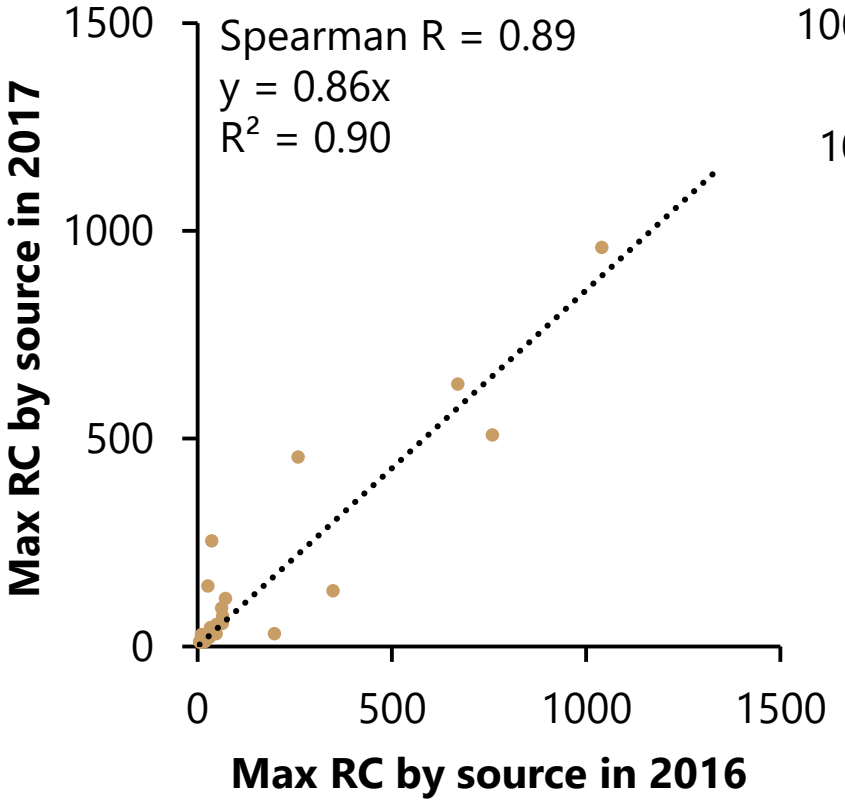
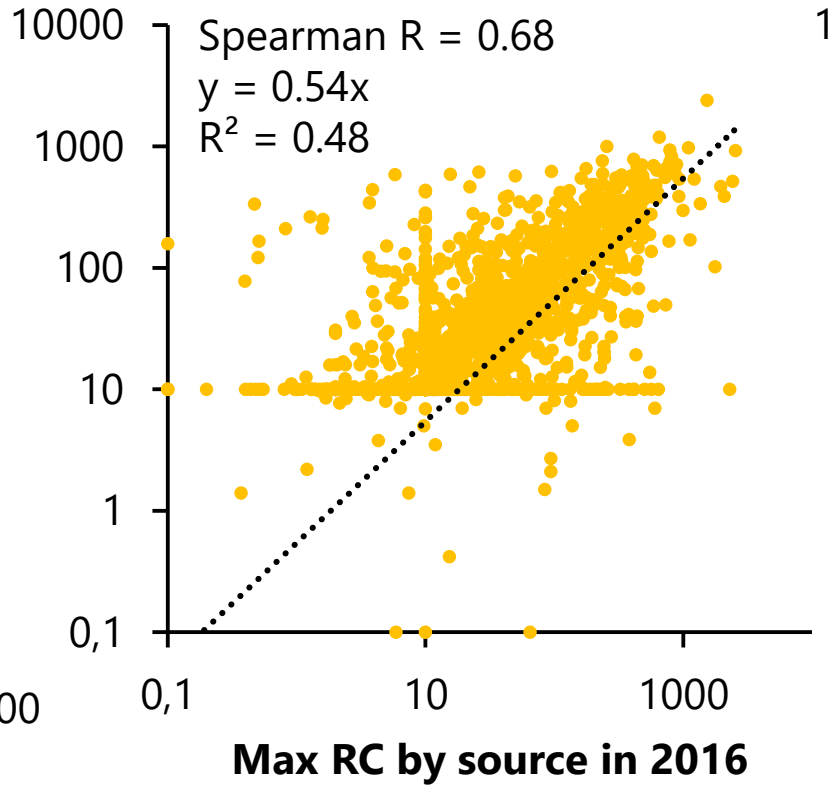


2016 VS. 2017 DATA

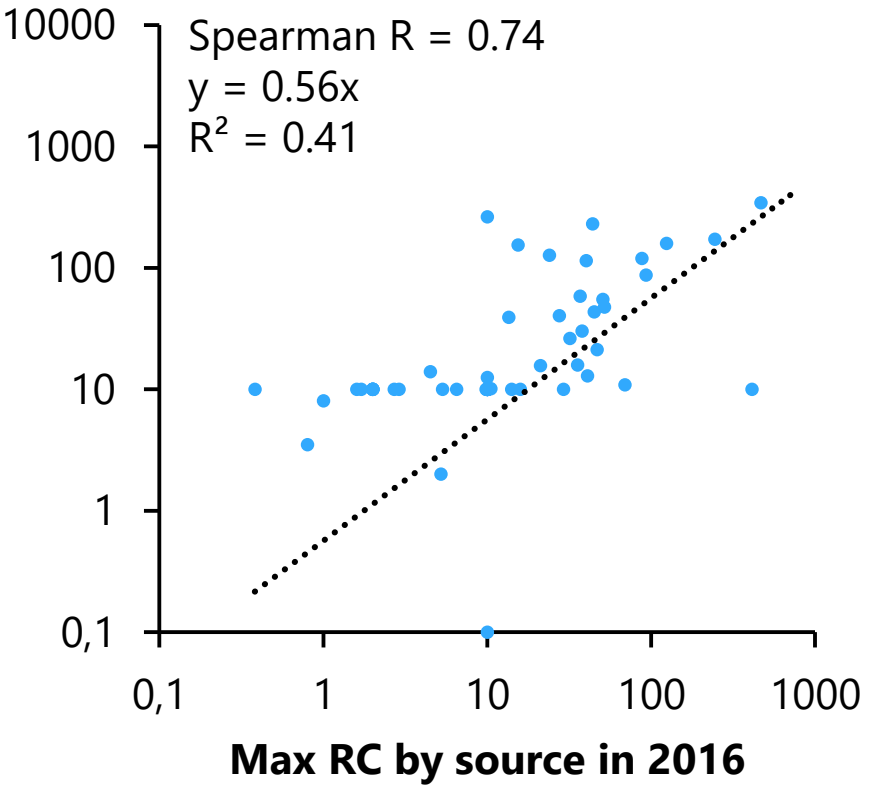
Raw groundwater (N = 47)



Treated groundwater (N = 1804)

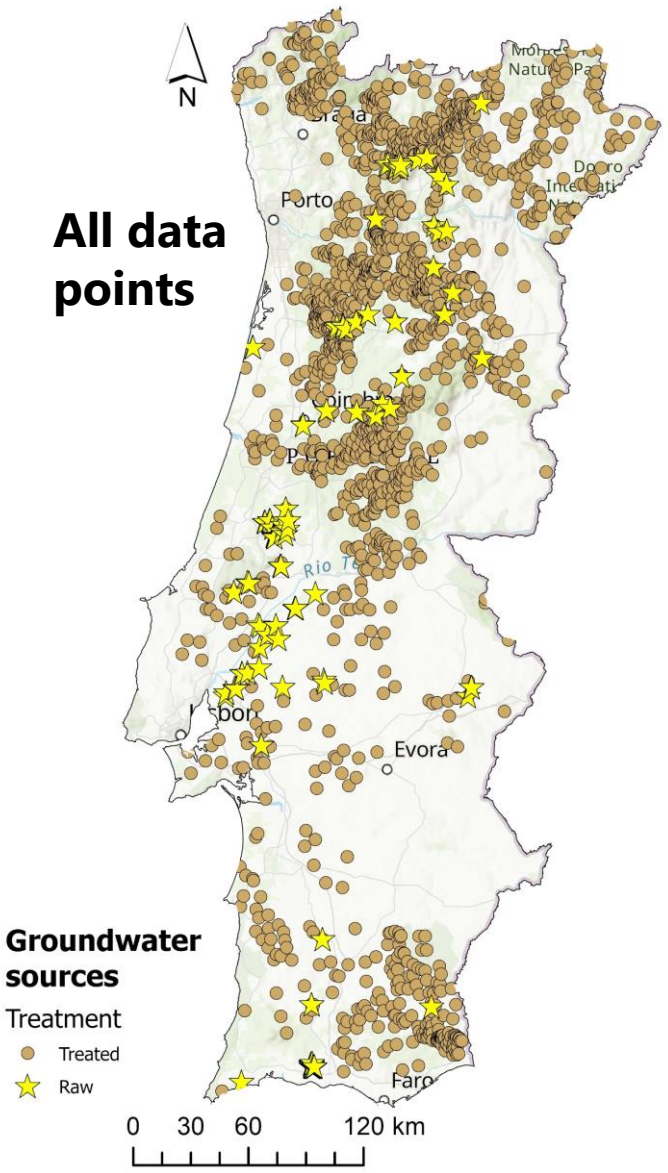


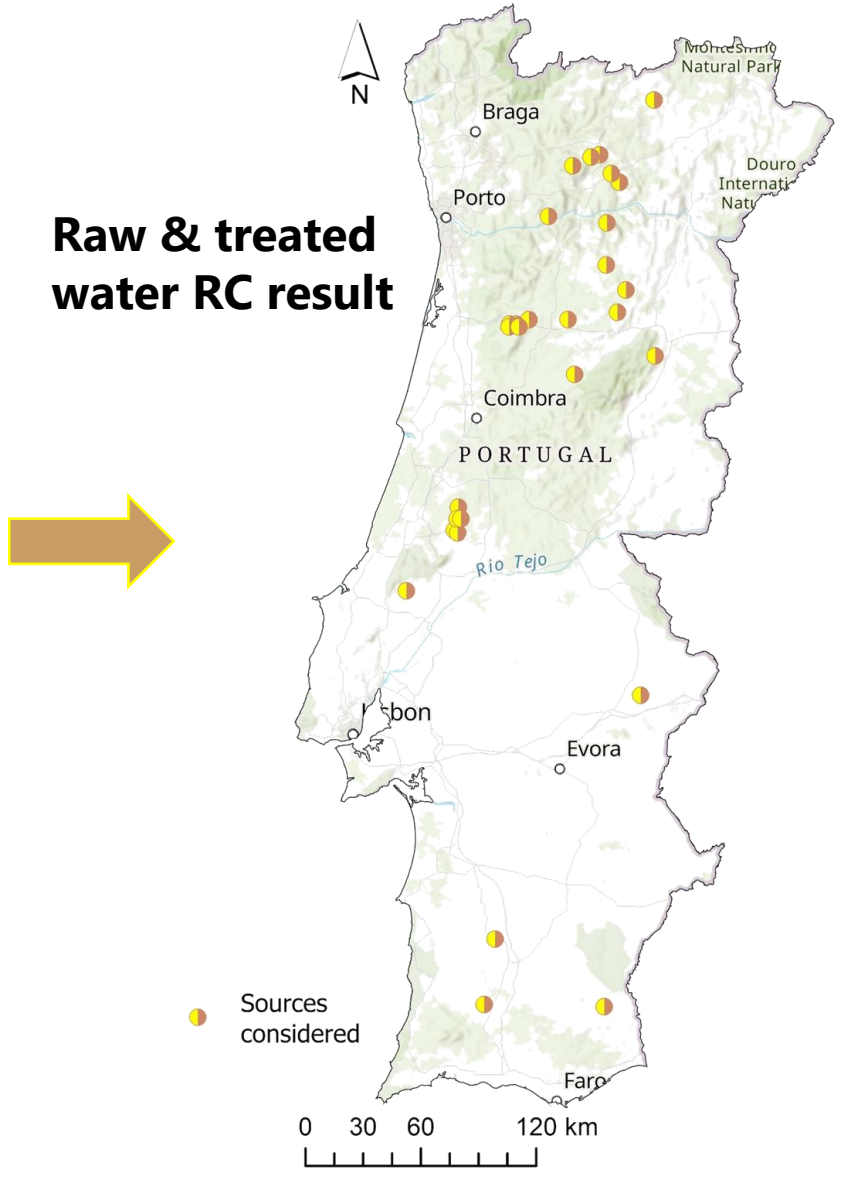
Treated surface water (N = 67)

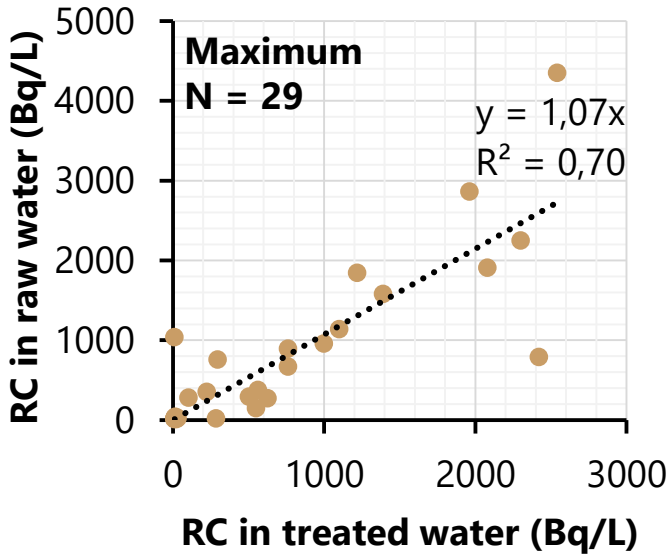


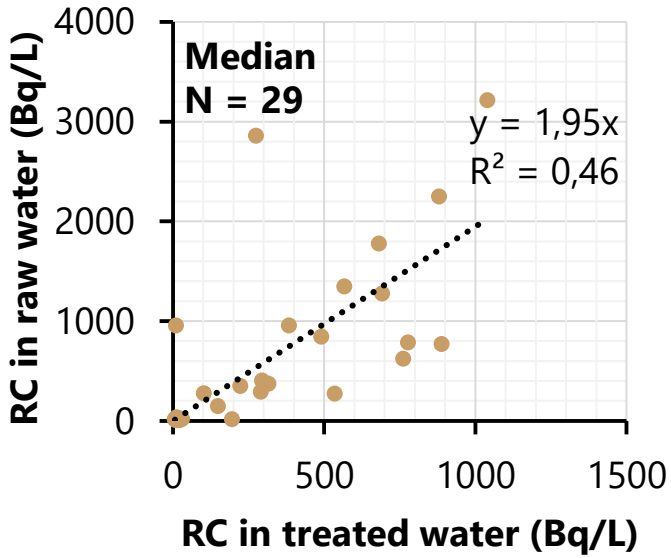
- ✓ Statistically significant correlations between 2016 and 2017 radon concentration by source
- ✓ Correlations are better for raw groundwater > treated groundwater > treated surface water

RAW VS. TREATED WATER







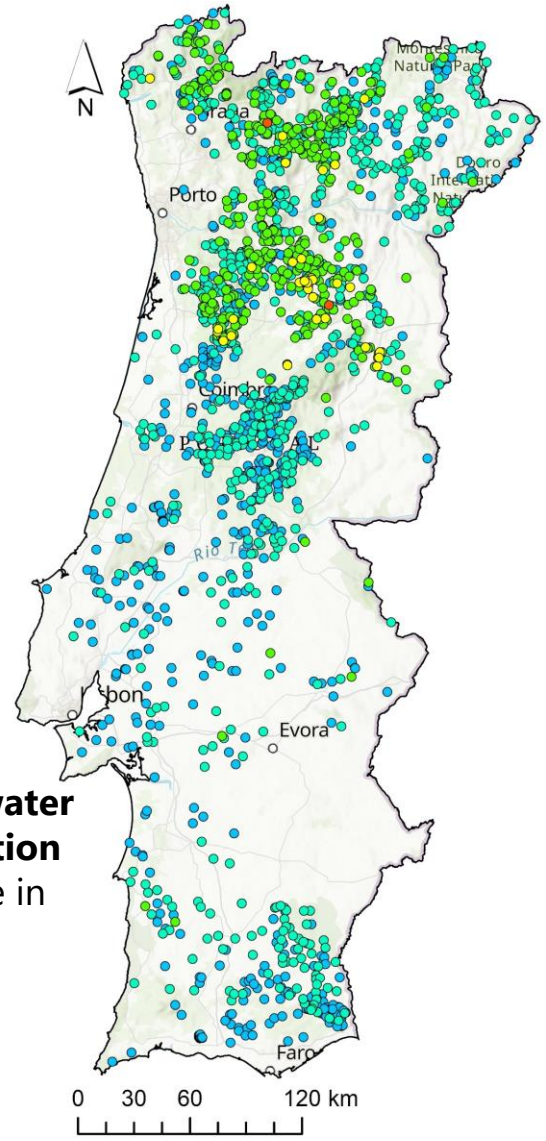


DISTRIBUTION OF RADON CONCENTRATION

Descriptive statistics	Groundwater		Mixed	Surface	
	Raw	Treated	Treated	Raw**	Treated
Number of samples*	465	7299	780	13	916
Mean (Bq/L)	179	85	21	10	15
Standard deviation (Bq/L)	488	180	66	0	38
Median (Bq/L)	14	18	10	10	10
Median absolute deviation (Bq/L)	7	16	0	0	0
Skewness*	4.8	5.8	7.9	-	8.2
Kurtosis*	28	58	75	-	79

Dimensionless; **All values are equal.
Median values are not representative for the country.

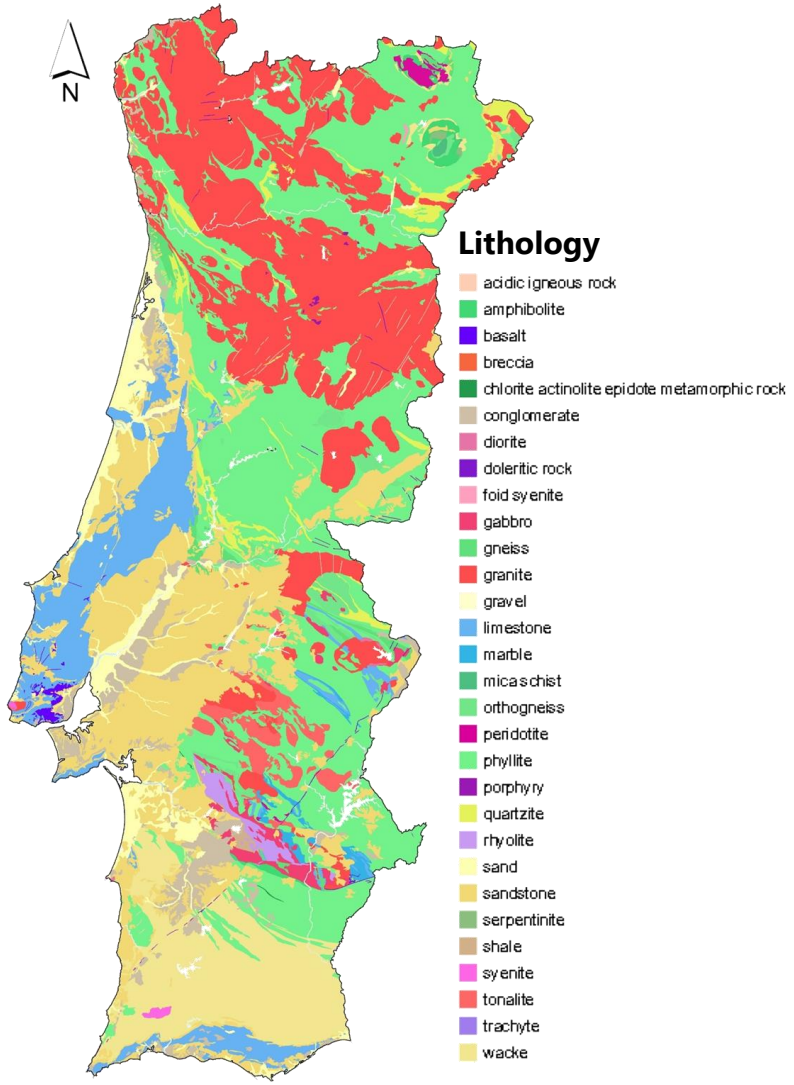
Detection limit required in national legislation



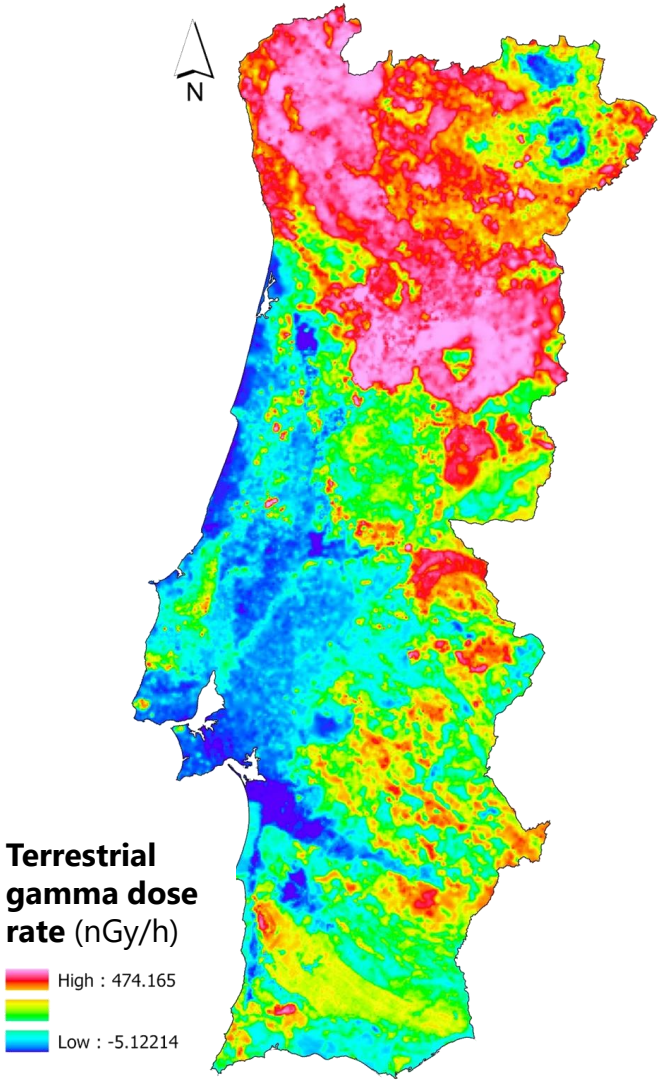
Treated groundwater radon concentration (median by source in Bq/L)

- 0 - 10
- 11 - 100
- 101 - 500
- 501 - 1000
- 1001 - 1805

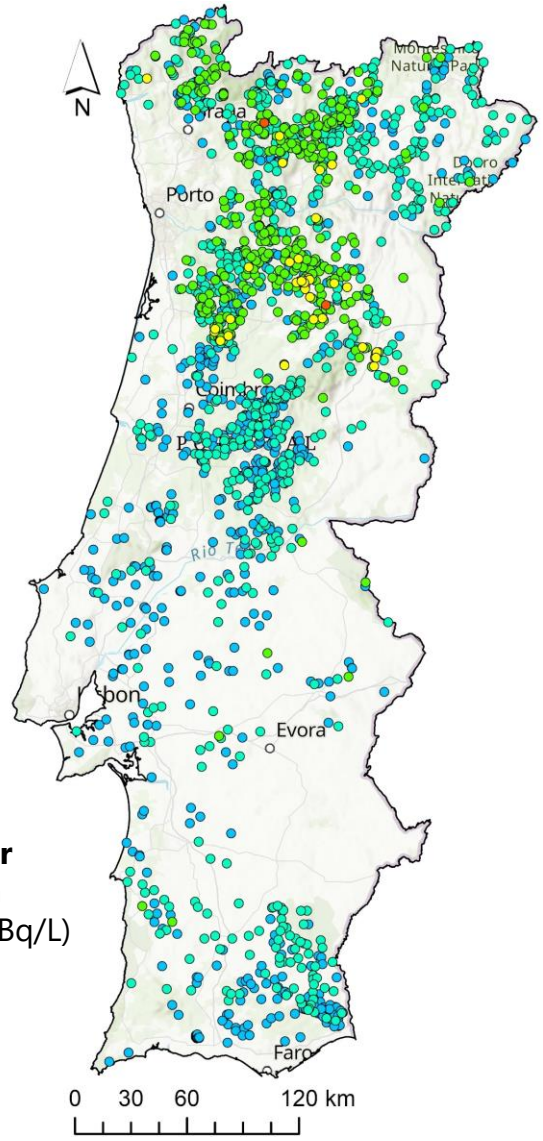
DISTRIBUTION OF RADON CONCENTRATION



Source: LNEG (2023)

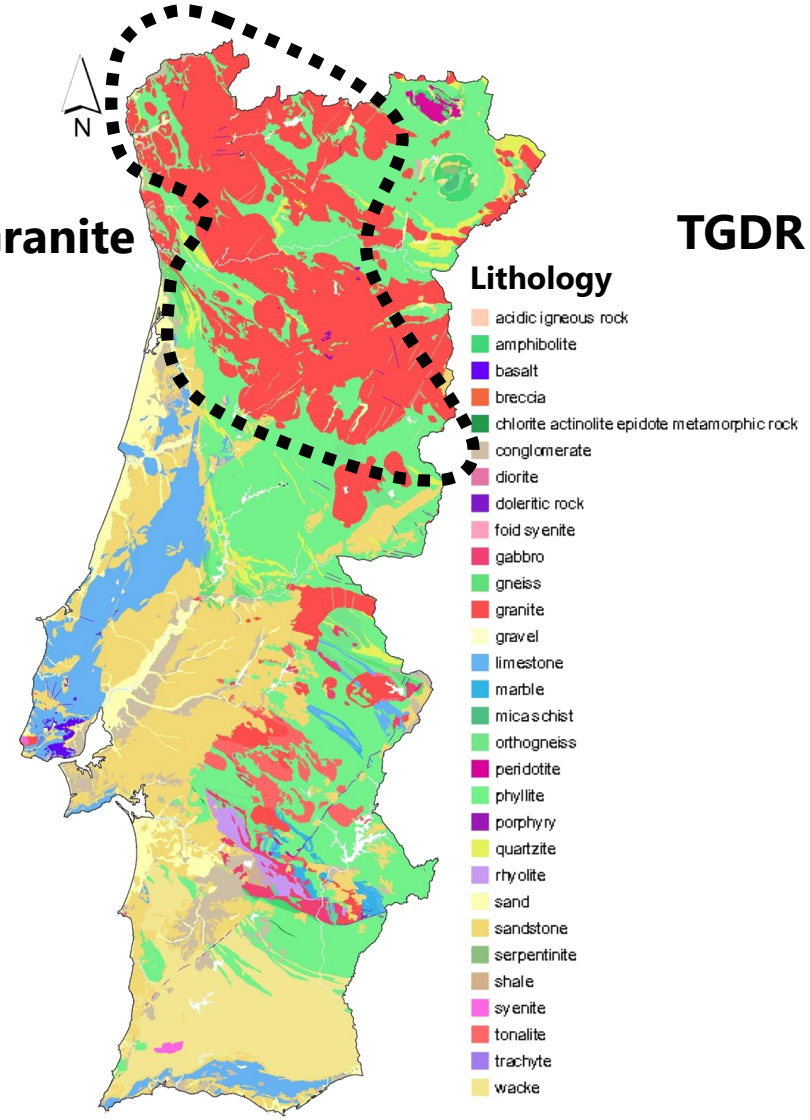


Source: Batista et al. (2013)



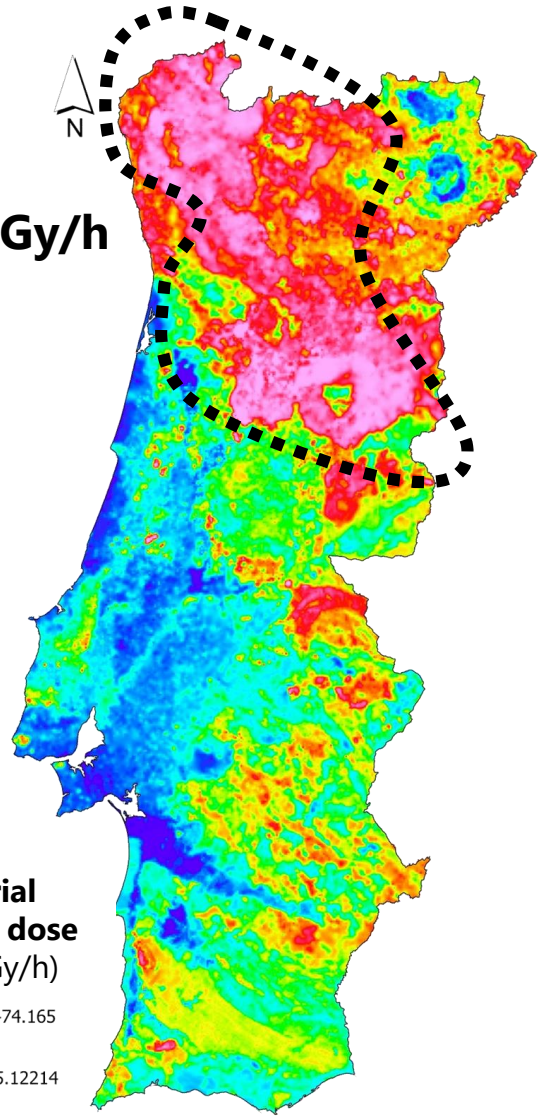
DISTRIBUTION OF RADON CONCENTRATION

Granite



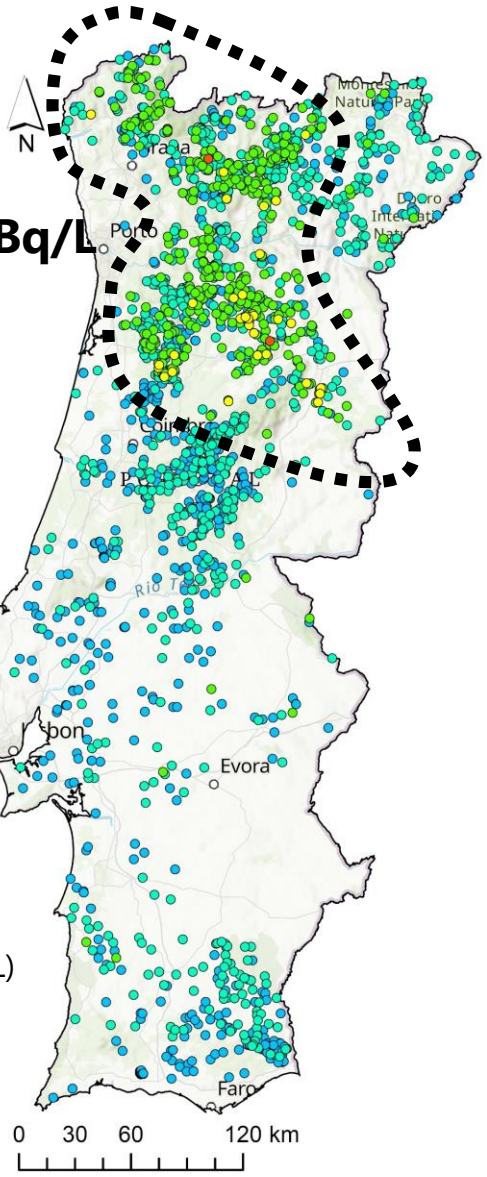
Source: LNEG (2023)

TGDR > 160 nGy/h



Source: Batista et al. (2013)

^{222}Rn > 100 Bq/L



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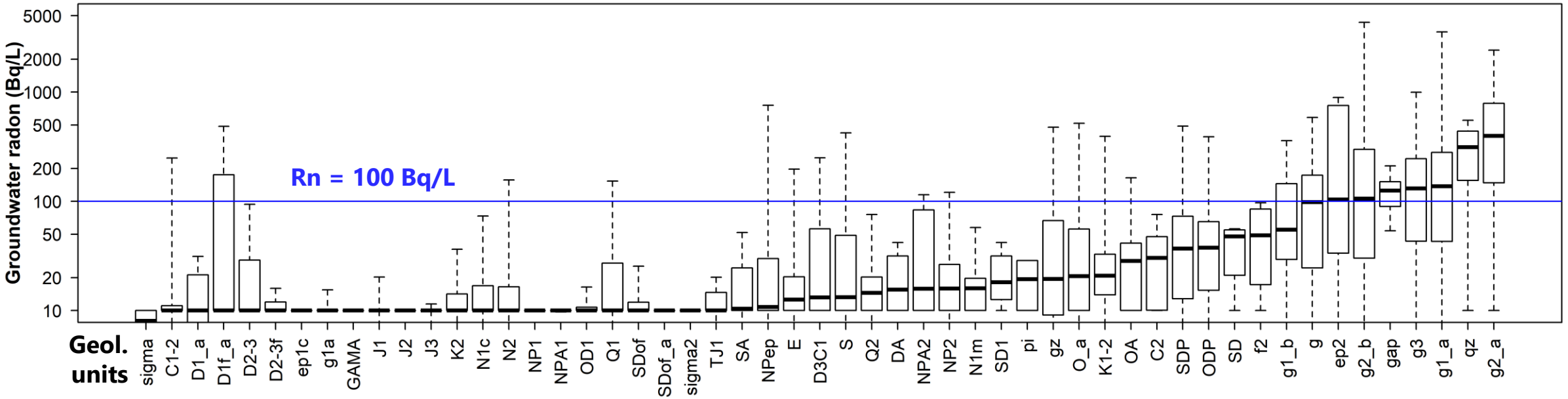
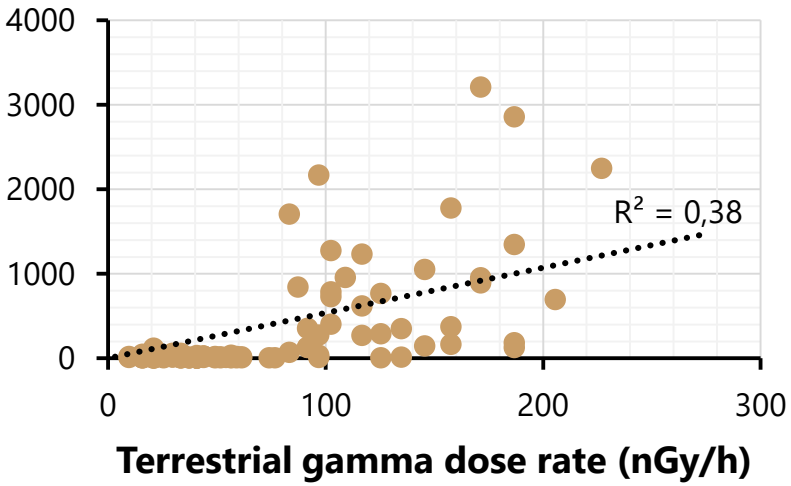
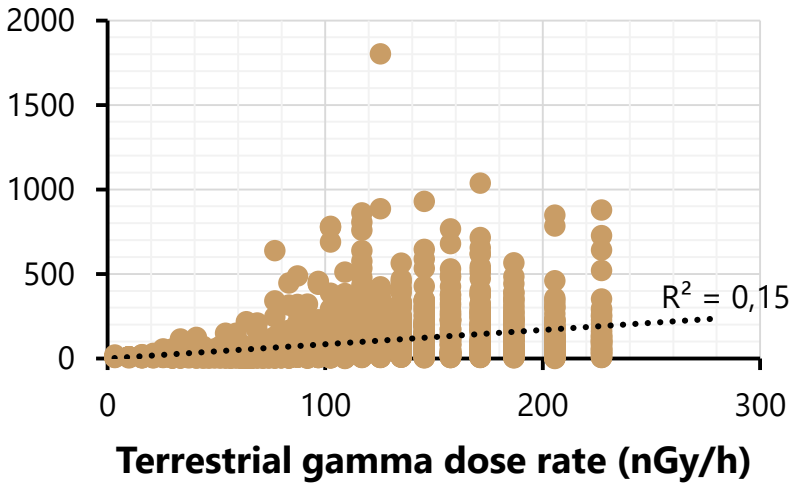


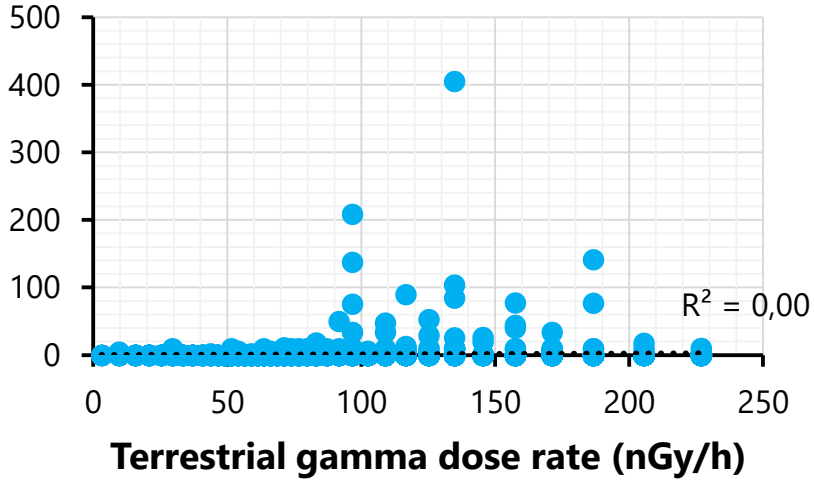
Raw groundwater RC (Bq/L)



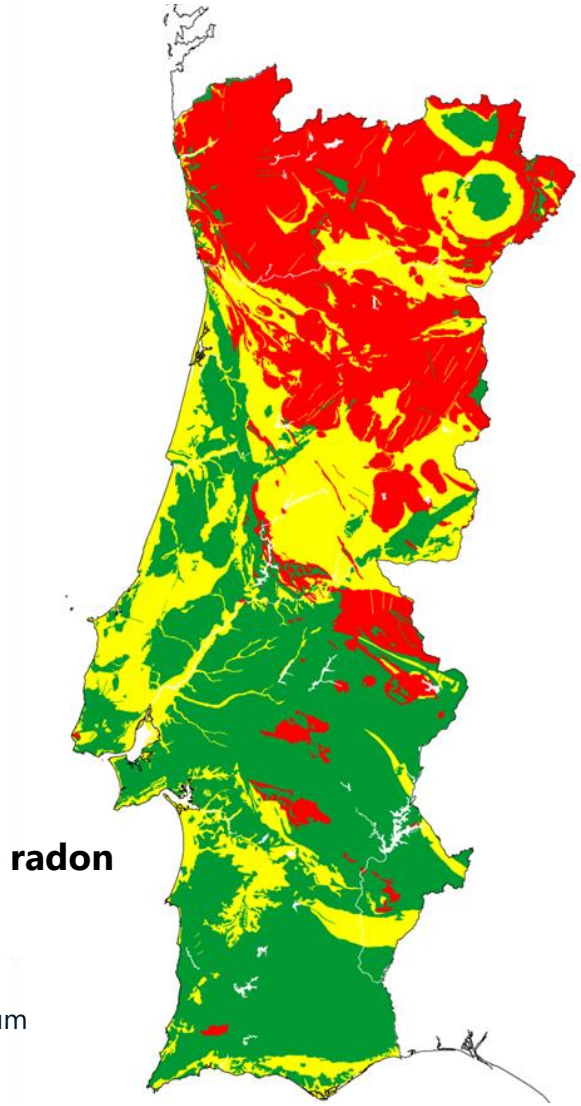
Treated groundwater RC (Bq/L)



Treated surface water RC (Bq/L)



GRP PREDICTION USING WATER RADON DATA

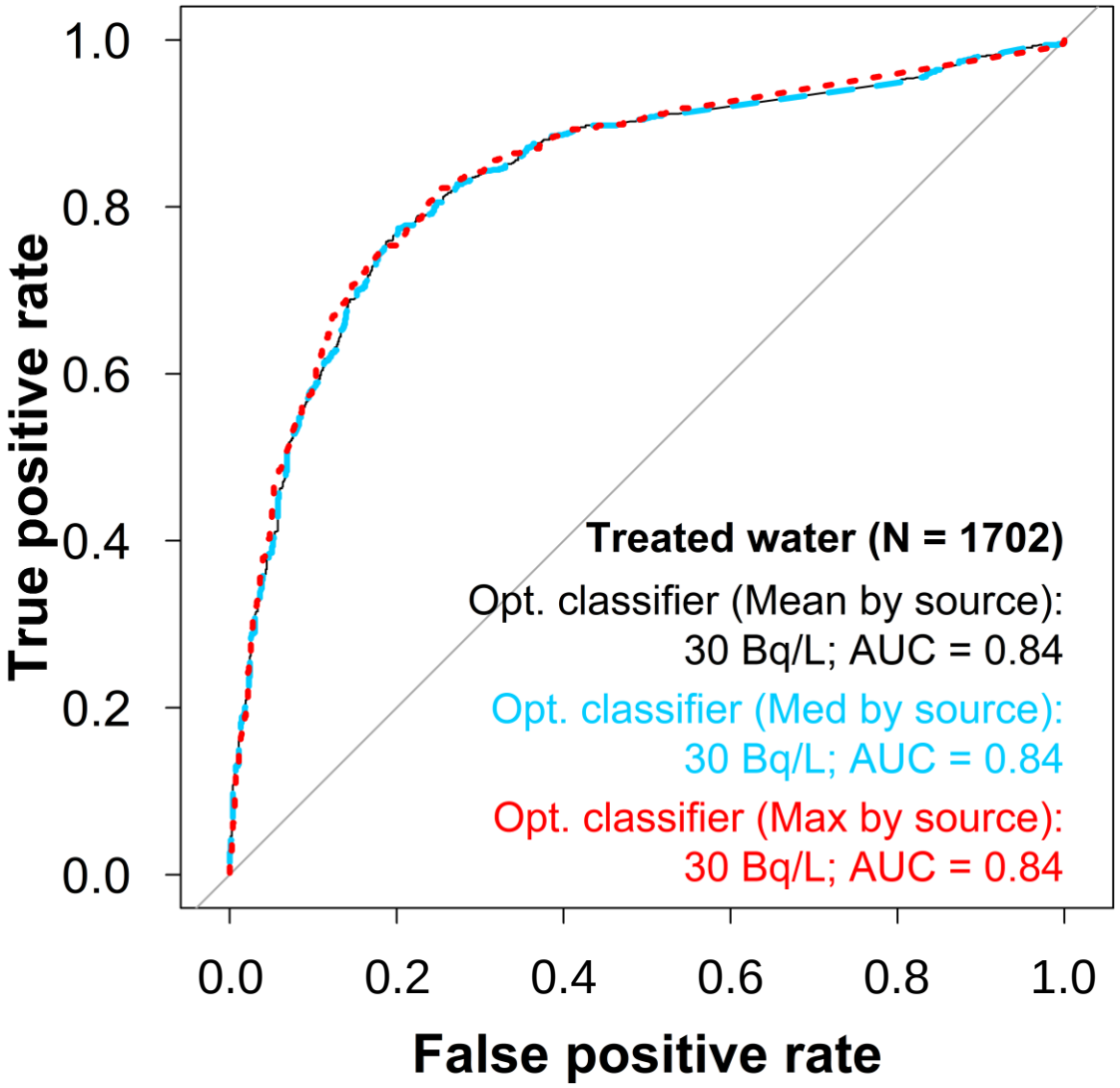


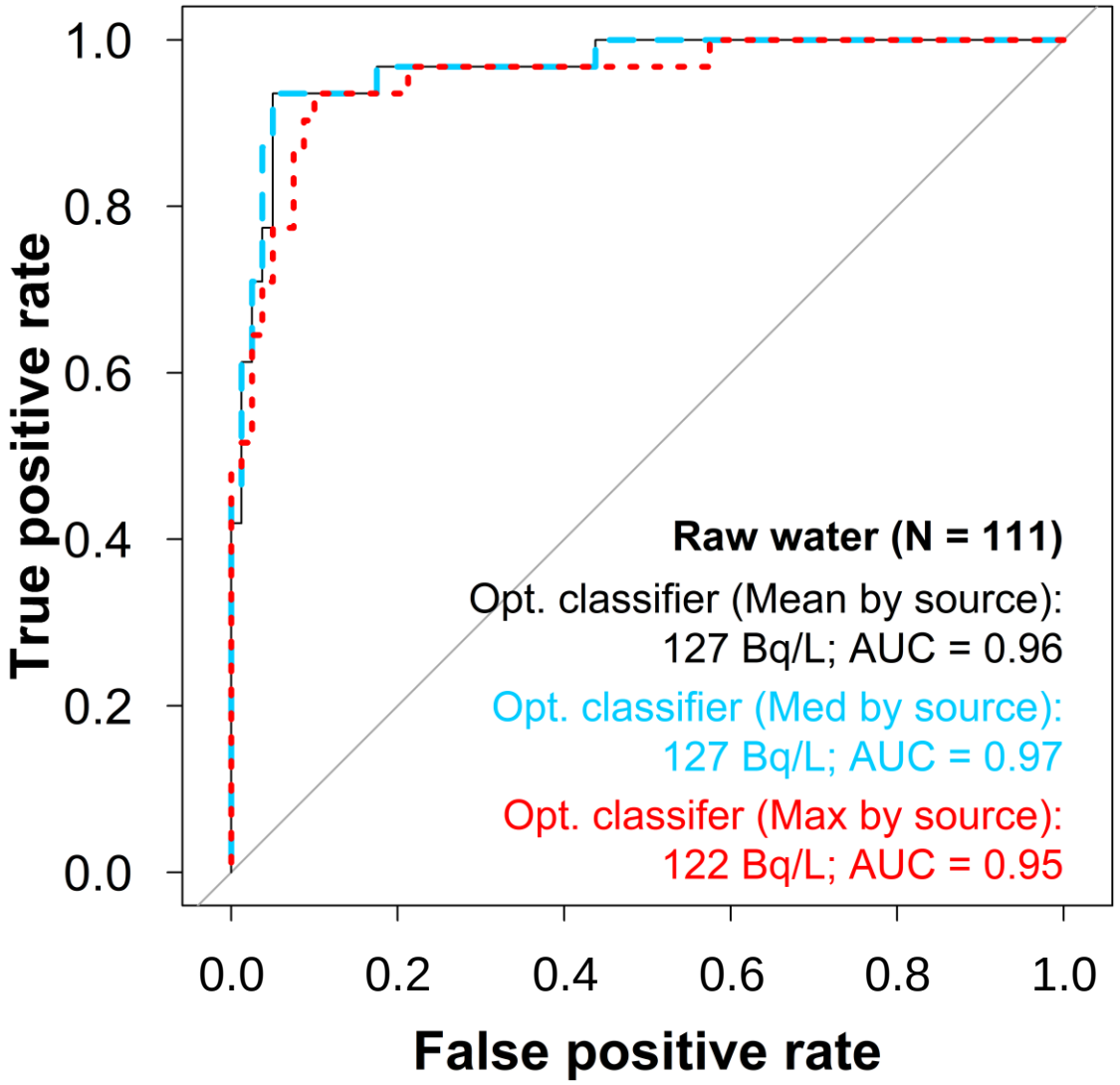
Source: Pereira et al., (2022)

Multiclass Receiver Operating Characteristic (ROC) curve analysis using the One vs. Rest strategy			
Confusion matrix:		**Groundwater radon concentration (Bq/L)**	
		RC ≥ Threshold (1)	RC < Threshold (0)
Geogenic radon potential	High (1)	True positive	False negative (type II error)
	Other than high (0)	False positive (type I error)	True negative

Metrics (Bossew, 2014; Robin et al., 2011)	**Selection of optimal classifier**	**Classification power**
	Youden Index	Area under the curve (AUC)

GRP PREDICTION USING WATER RADON DATA





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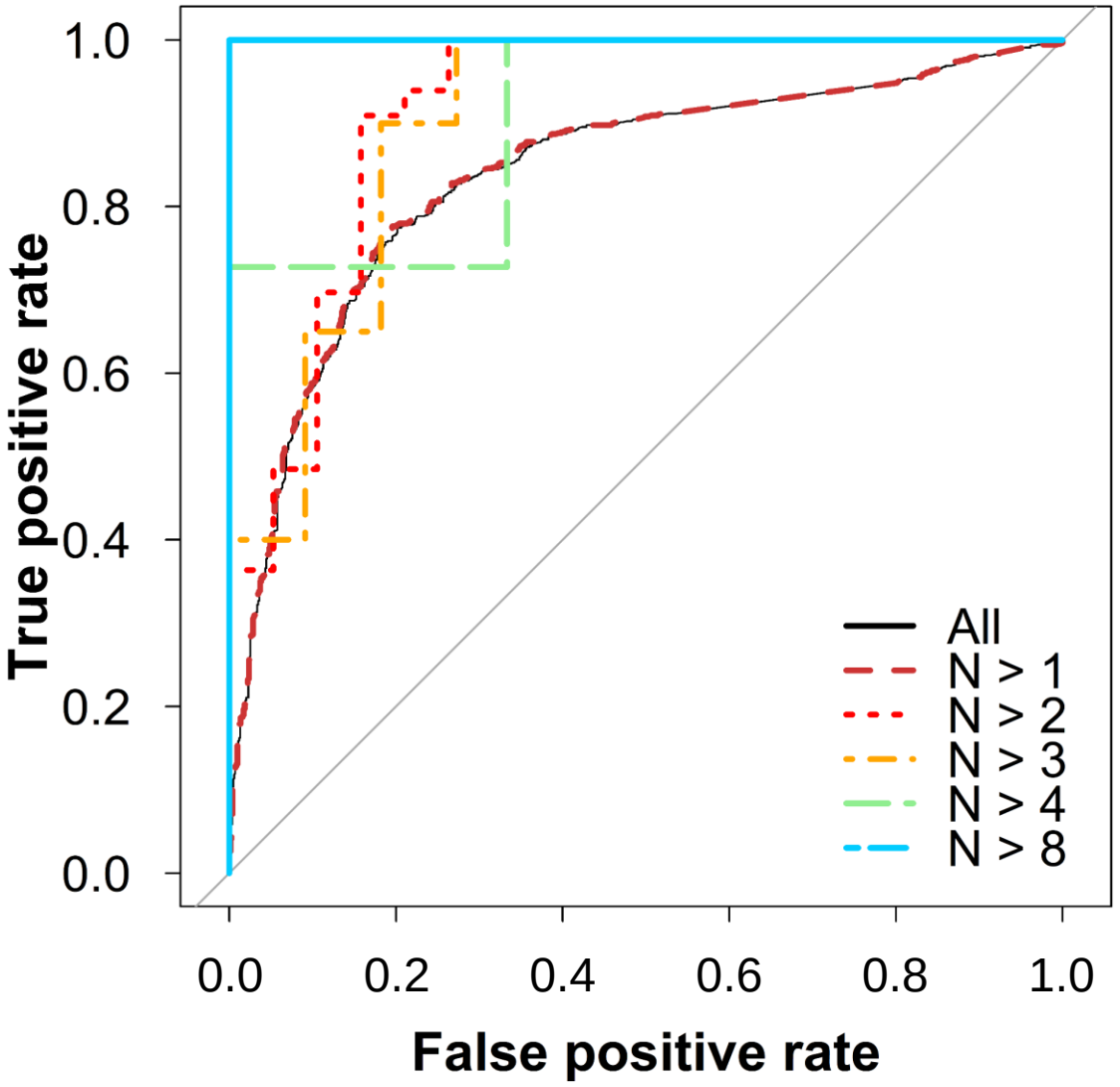

Data points *per* source	AUC	Optimal classifier (Bq/L)	No. of water sources considered
All included	0.84	30	1702
>1	0.84	30	1663
>2	0.92	71	52
>3	0.90	21	31
>4	0.91	336	14
>5	1.00	46	11
>6	1.00	46	10
>7	1.00	115	7
>8	1.00	115	6
>9	1.00	115	6
>10	Unfeasible computation (1 response level)		

FINAL REMARKS

- **Distribution of Radon Concentration in mainland Portugal:**
  - ✓ Higher in Groundwater and Raw water (compared to Surface / Treated water)
  - ✓ High spatial variability (related to geology), as well as temporal
- **Correlation between variables:**
  - ✓ 2016 and 2017 maximum RC by source
  - ✓ Raw water and Treated water RC (N = 29!)
  - ✓ RC and TGDR
- **Groundwater Radon Concentration for Geogenic Radon Potential Prediction:**
  - ✓ Classification power is good (AUC > 0.84);
  - ✓ Higher classification power using raw water data and with higher N *per* water source
  - ✓ RC threshold inconsistency (strong data dependency!)

ACKNOWLEDGEMENTS

Water and Waste Services Regulation Authority (ERSAR)

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THANK YOU FOR YOUR ATTENTION!

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