CHEIKH ANTA DIOP UNIVERSITY
FACULTY OF SCIENCES AND TECHNOLOGIES
PHYSICS DEPARTMENT

The Joint virtual event of the African Light Source AfLS-2023 (6 th) and the African Physical Society AfPS-2023

Instrumentation Neutron Activation Analysis & Proton Induced X-RAY Emission techniques supported with Robust Statistics analysis for rare earth/macro/micro elements correlation from O. glaberrima Rice varieties in Senegal River valley

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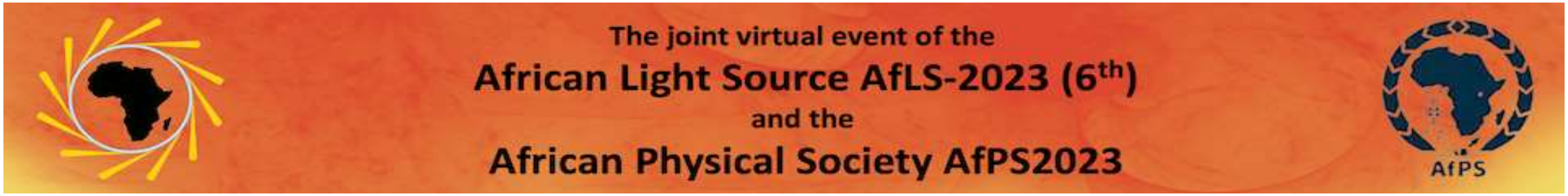
From 13-17 November 2023



Motivation

This study aims:

- To understand the **bioaccumulation and transport mechanisms** of both micro- and macronutrients in the leaves and roots of African rice *Oryza glaberrima* (O.G.) rice plants at vegetative stage of growth
- To determine the **translocation factors** from roots to leaves
- To evaluate the suitability of O.G. rice plants for **Salt Tolerance from water and the use of fertilizer**

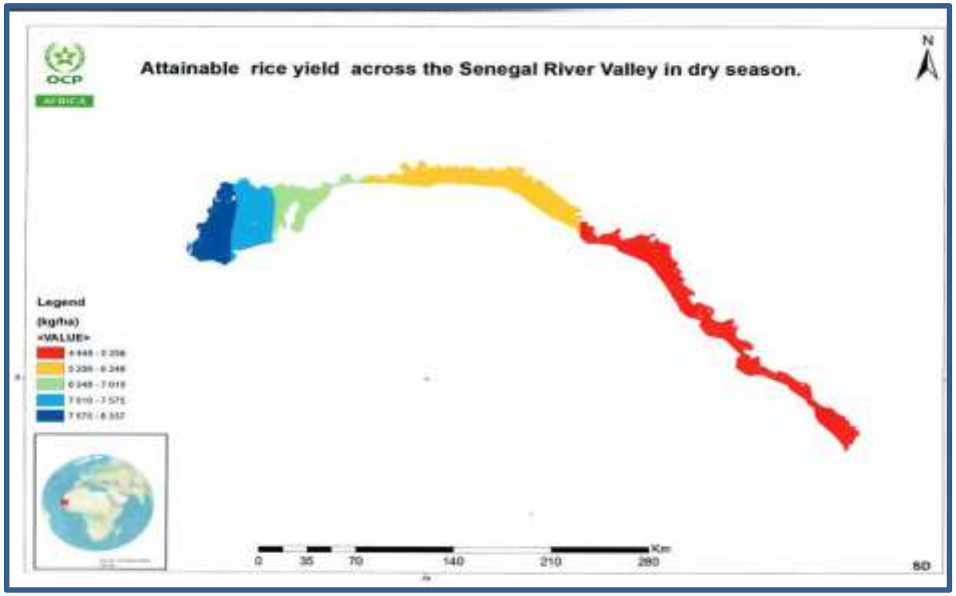
Current Research & Motivation

Oriza Glaberrima is widely used for household consumption and rarely sold on the market. It is a very important food security crop, as short cycle varieties can be harvested during the 'hunger period' thus provide food when other crops and Asian rice varieties still mature.

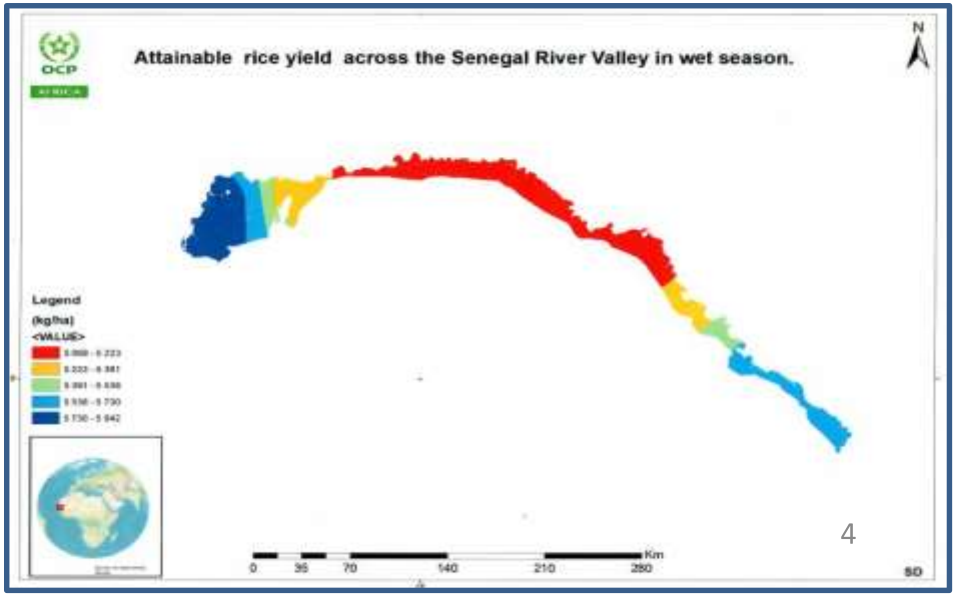
O. Glaberrima varieties show tolerance to drought and flood, pest and diseases, and exhibit the ability to grow in acid and phosphorus-deficient, alkaline soils, and thrive without the application of chemical fertilizer. Many of these environments and conditions are not suitable for high-yielding Asian rice varieties (O. sativa) that came to dominate rice production in West Africa.

Assessing attainable rice yields

As irrigated rice in the River valley of Senegal is grown in the dry-season from March to May and in the Wet season from July to November, maps produced were developed for each of these two periods to take into account effect of the season to crop growth conditions and yields.



Attainable yields are different for these seasons (maps) amounting to more than 2t/ha in favor of dry season, which result in different rice nutrient requirements. Consequently, fertilizers formulations needs to be considered separately for each of these seasons with the possibility to find rationale to come to one fertilization scheme for practical reason and logistic considerations

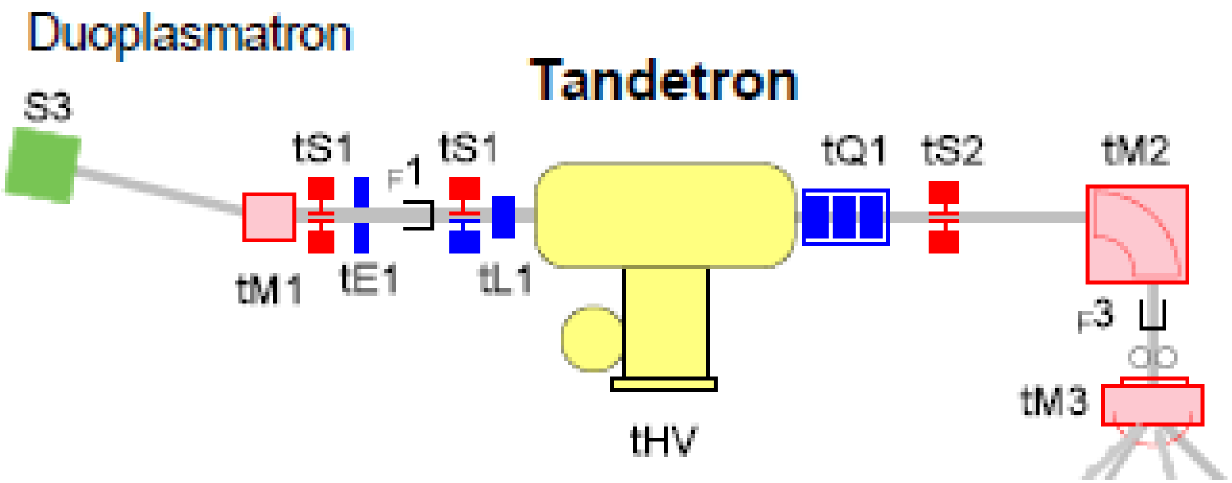


PLANT MATERIALS

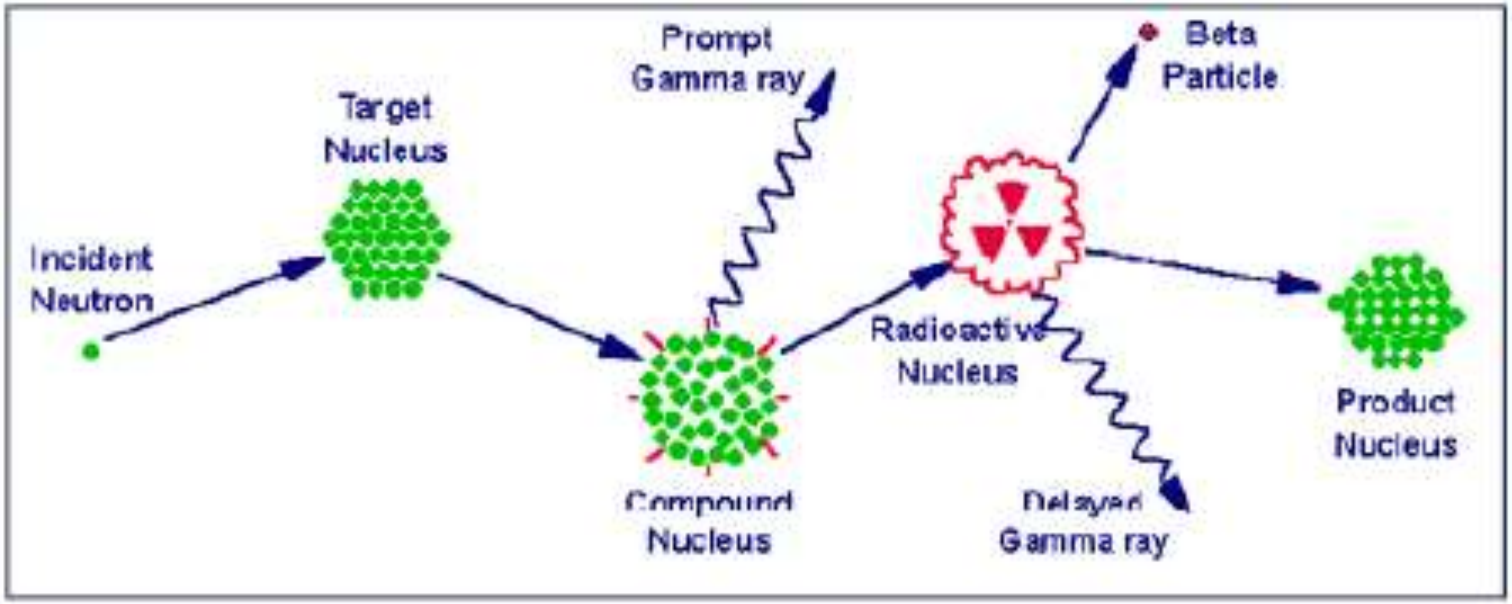
Plant materials were collected from trials conducted using two different sets of germplasm. One set comprised of a diversity panel of **317 accessions** of *O. Glaberrima* received from Africa Rice Genetic Resources Unit and checks: FL478 (salt tolerance), IR 29 (salt sensitive), Sahel 210 and Sahel 134. The second is comprised of an indica diversity panel of **330 genotypes** received from IRRI. Both sets were evaluated under control conditions where they were grown under irrigated lowland conditions using non-saline river water (EC <1 dSm^{-1}) and also under saline conditions in a concrete-lined field where salinity was maintained at 4 dSm^{-1}.

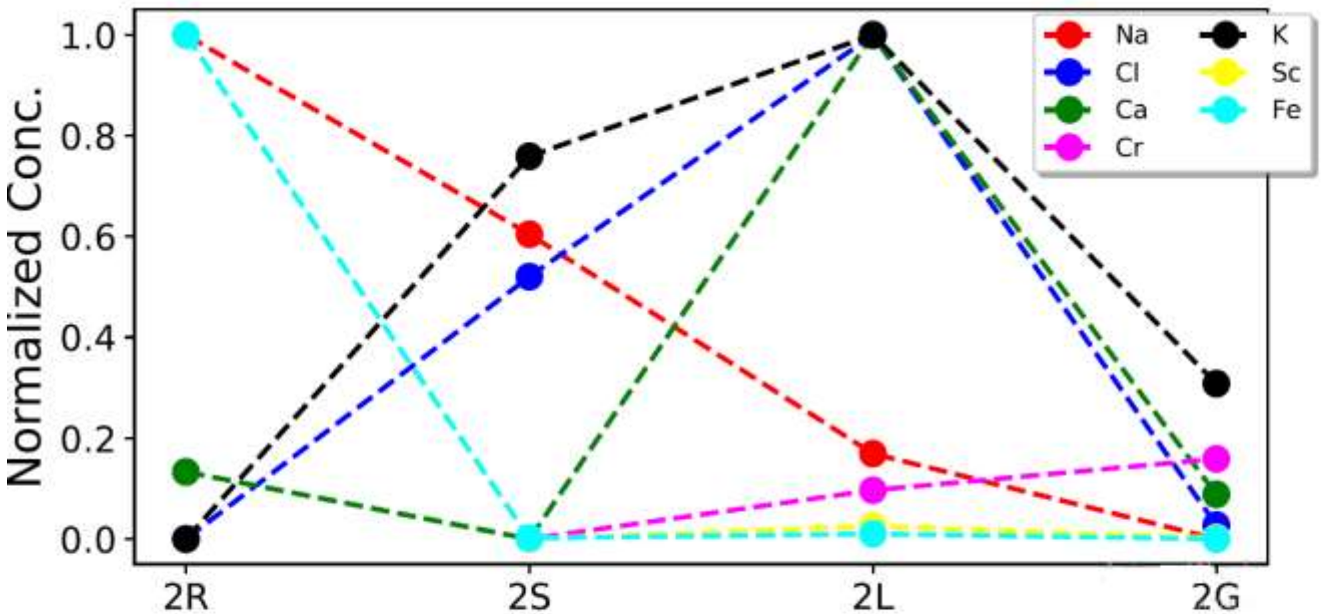
The **check varieties** used for the salinity stress were FL478 (IR 66946-3R-178-1-1), called the **salt tolerant check**; IR 29, the **salt sensitive check**; Sahel 134 (IR 31851-96-2-3-2-1) characterised by a high yield potential (between 11 and 12 tonnes of paddy per hectare), the long grain type and moderate tolerance to salinity; and Sahel 210 (ECIA 31-6066) medium duration and characterised by a potential yield of 12 tonnes of paddy per hectare with long grain and soft cooking traits.

TECHNIQUES DES FAISCEAUX D'IONS CHARGES: PIXE



ANALYSE PAR ACTIVATION NEUTRONIQUE: INAA




Na
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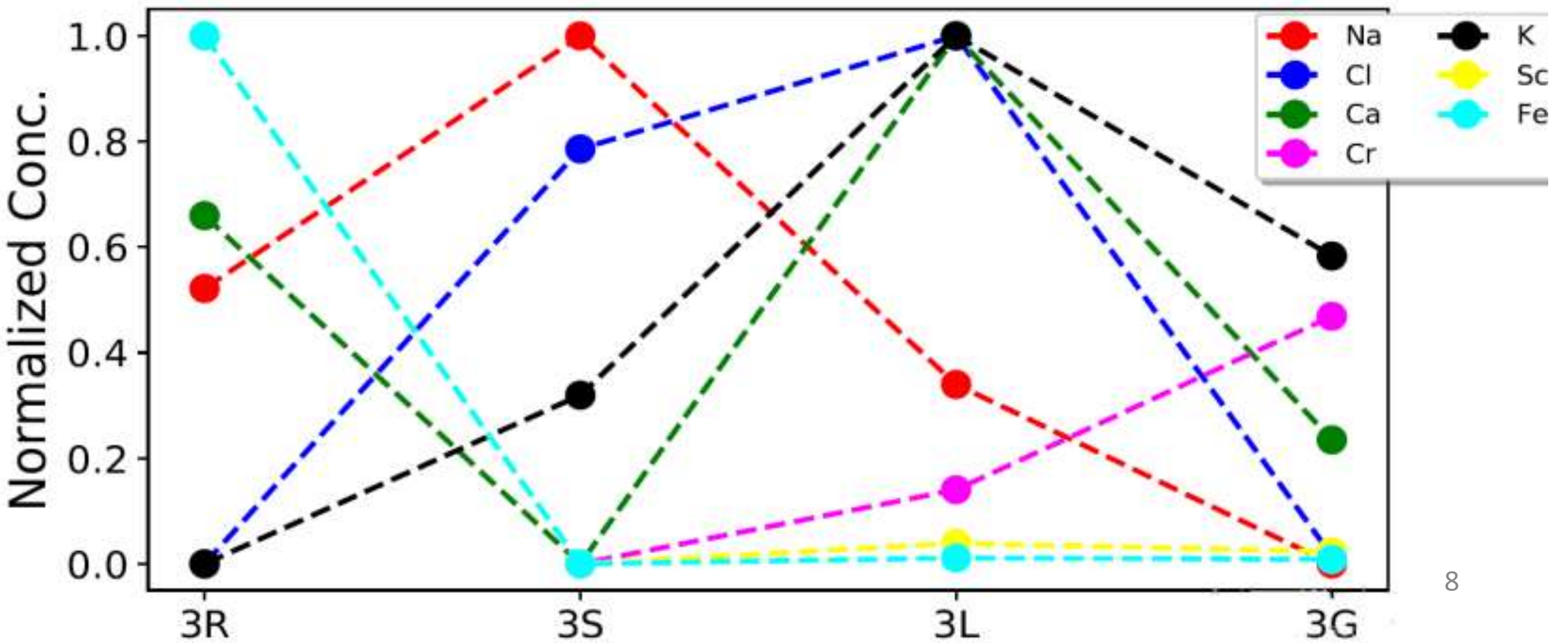
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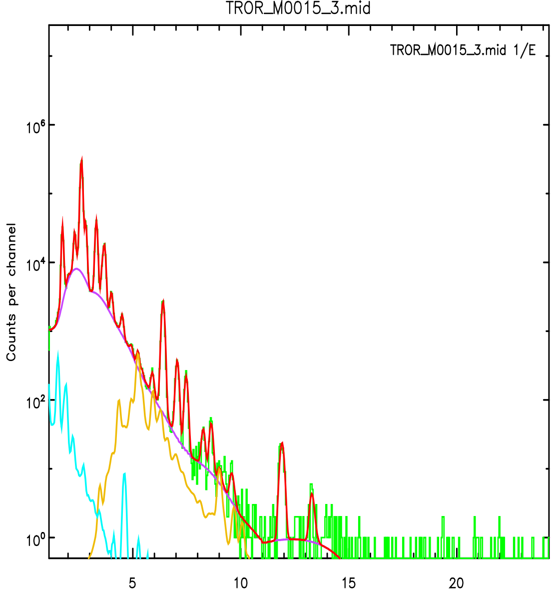
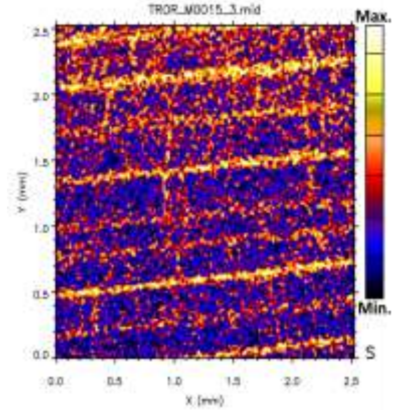
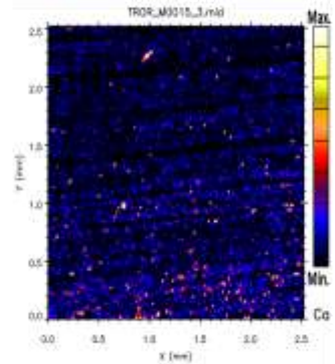
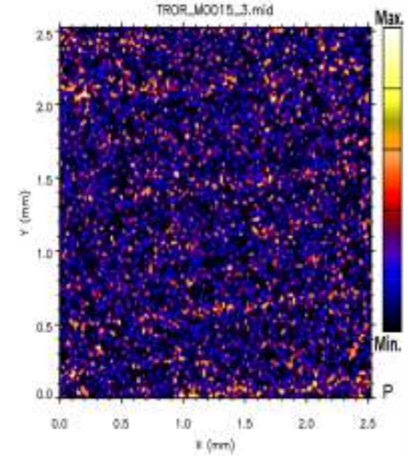
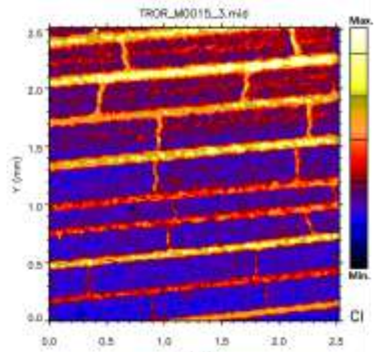
IR29(4)-inside_Trao_Leave_3

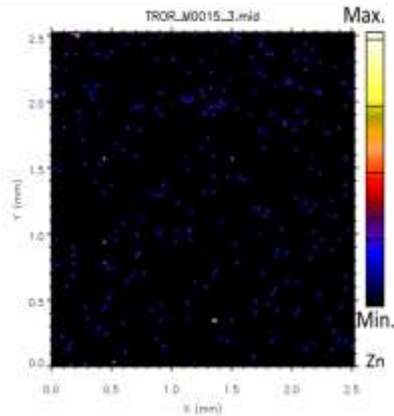


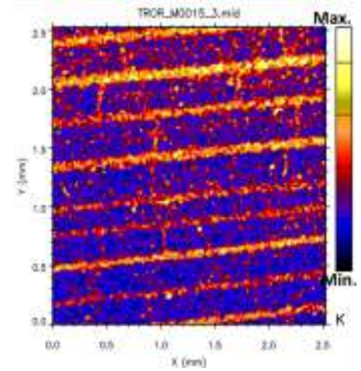


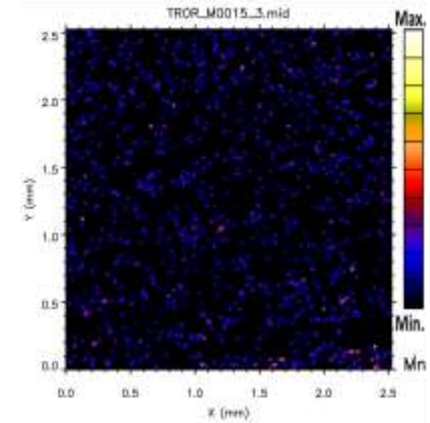


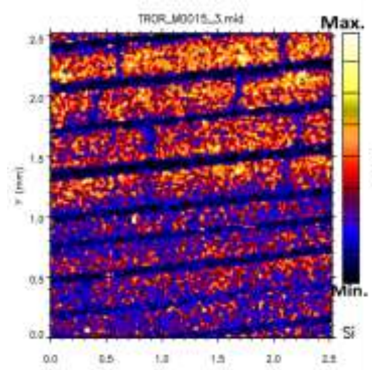


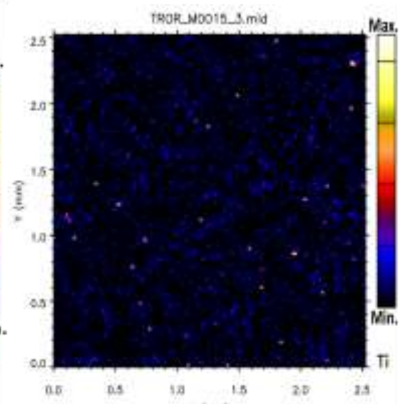


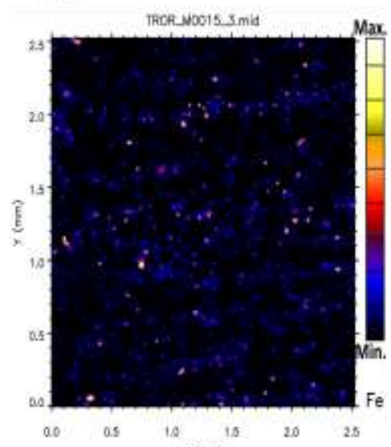


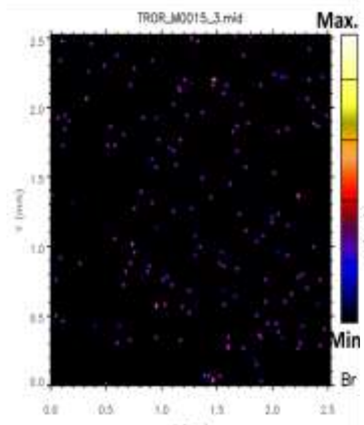


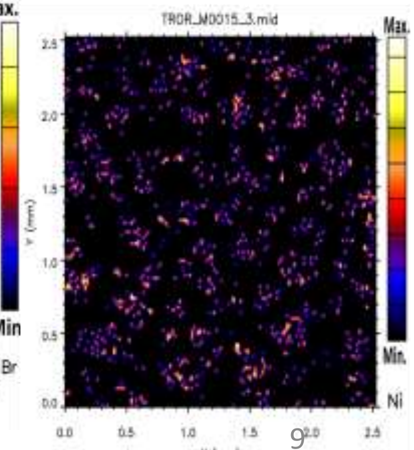


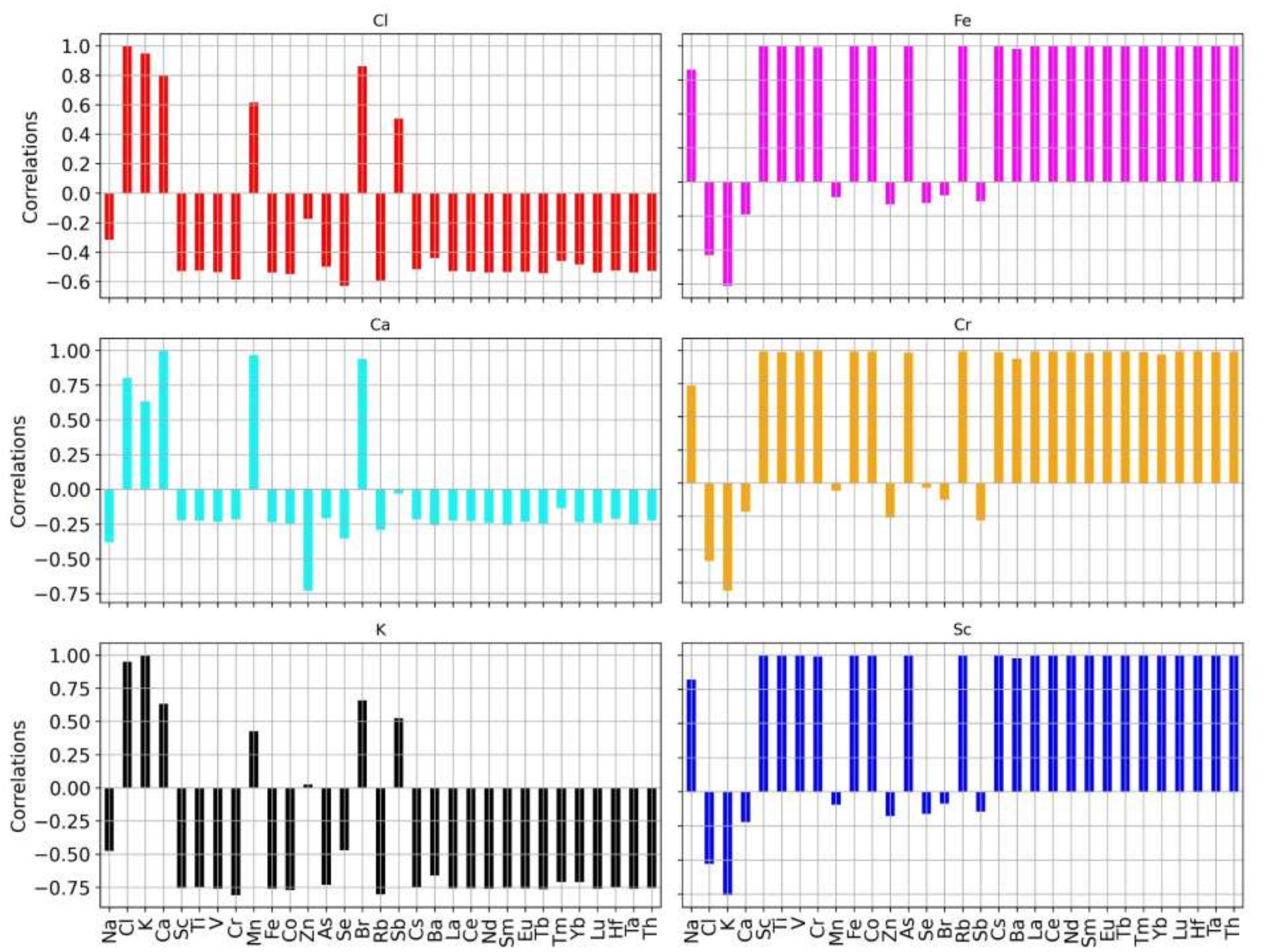












Cl
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Correlations
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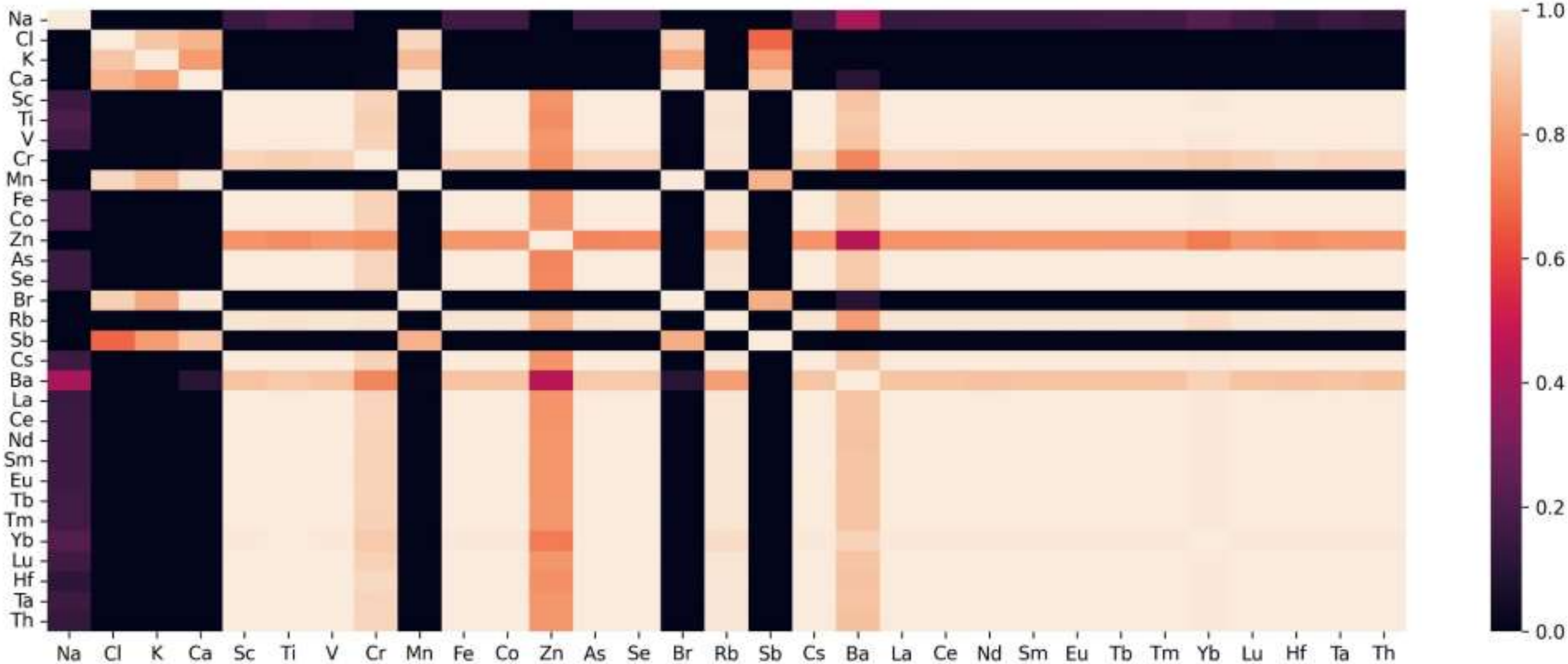
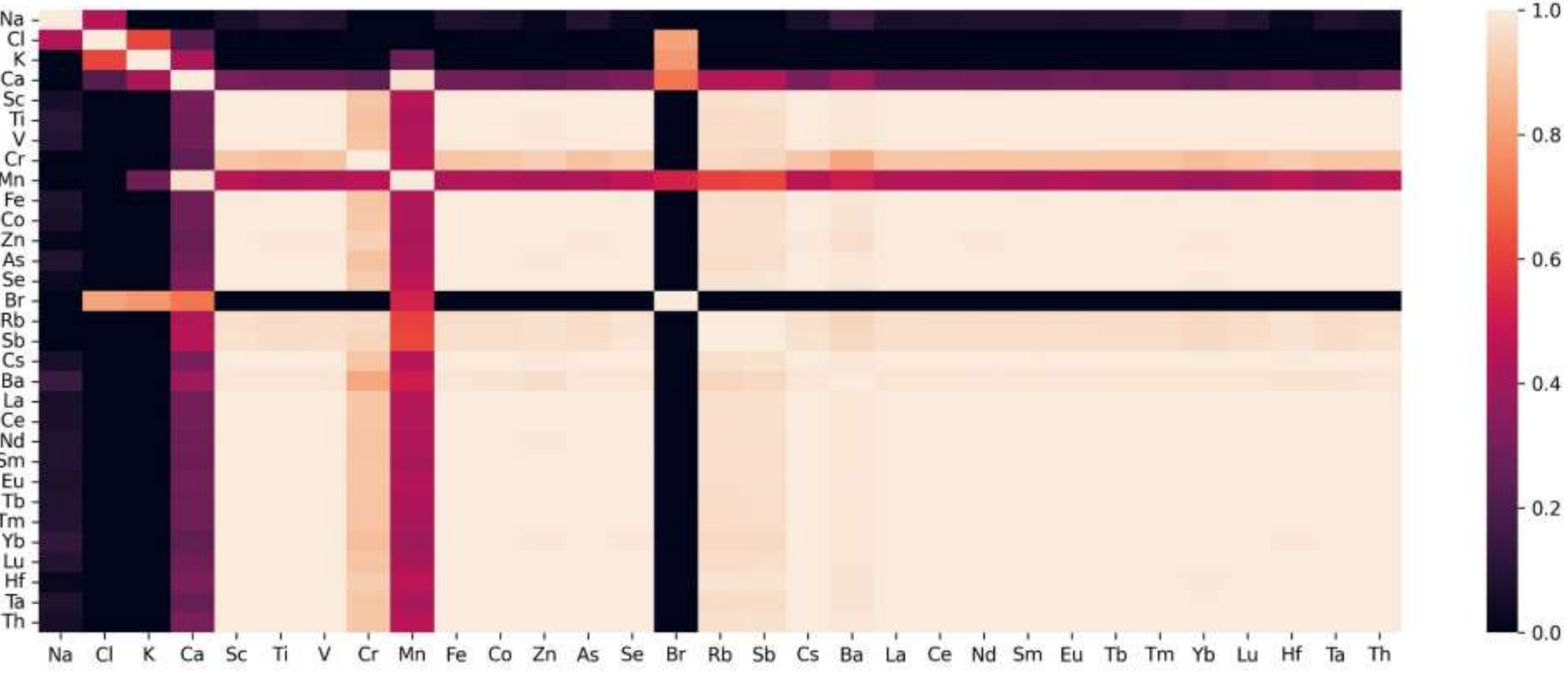
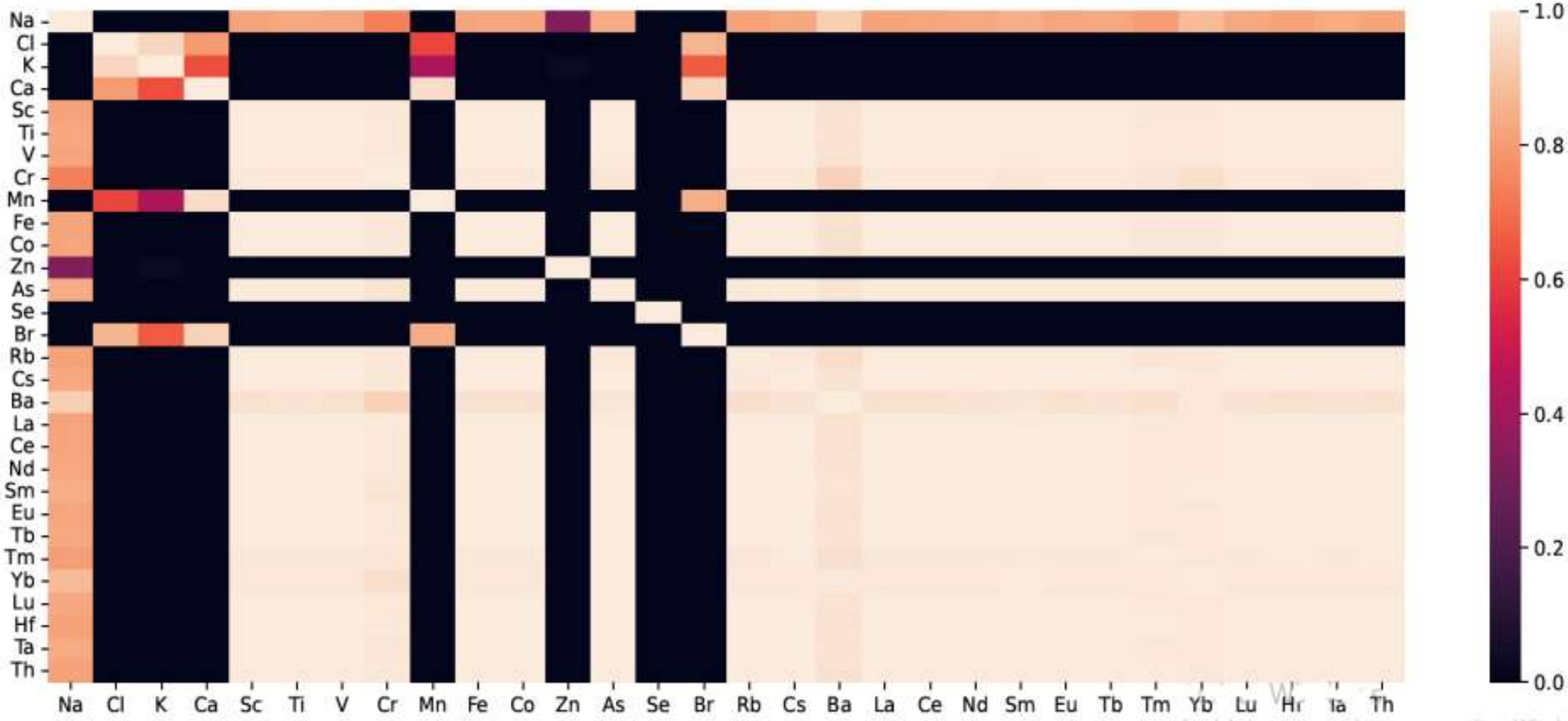
Heatmap correlation root_Grain sample#4



Heatmap correlation root_Grain sample#3



Heatmap correlation root_Grain sample#2



- **Accumulation** and **Distribution** within plant tissues
- **Mechanisms** underlying metal decommissioning
- **Compartmentalization** on the cellular, tissue and organ levels in case of contaminated area or hazardous genetic effect of the rice plant

Spatial investigation of essential and Toxic Metals

↓

Micro analytical imaging techniques

- **Metabolic processes explaining**
- **Influence of different soils composition on plant uptake of nutrients and fertilizer types depending on seasons**
- **Genotypes response**

+++PIGE & RBS

	Sufficiency* [24,43,44]	Toxicity ** [24,43]	This study - OG rice leaves				This study - OG rice roots				TF
			PIGE		RBS	PIXE	PIGE		RBS	PIXE	
Elemental concentration (% mass)											
C	-	-	39.56 ± 0.47 (0.19)	1	38.23 ± 0.77	-	47.05 ± 0.51 (0.20)	1	47.42 ± 0.95	-	-
H	–	–	–	–	5.438	–	–	–	6.194	–	–
O	–	–	41.93 ± 0.95 (2.59)	7	44.92 ± 0.45	–	40.32 ± 0.94 (2.05)	3	42.50 ± 0.43	–	–
	–	–	43.15 ± 6.48 (11.7) &	7	–	–	42.25 ± 2.38 (6.34) &	3	–	–	–
N	1.5 – 4.0	–	**0.843 ± 0.078 (0.081)**	11	**0.841**	–	**0.951 ± 0.098 (0.076)**	5	**0.955**	–	0.9
P	0.2 – 0.5	> 1	0.735 ± 0.163 (0.026)	11	0.734	0.700 ± 0.015 (0.030)	0.117 ± 0.026 (0.012)	5	0.116	0.099 ± 0.003 (0.001)	7.1
K	0.5 – 4	> 5	3.134 ± 0.176 (0.495)	7	3.127	3.977 ± 0.023 (0.001)	0.770 ± 0.117 (0.366)	3	0.775	0.763 ± 0.004 (0.001)	5.2
Ca	0.05 – 1	> 10	–	–	–	0.362 ± 0.084 (0.001)	–	–	–	0.156 ± 0.002 (0.001)	2.3
Mg	0.15 – 0.35	> 1.5	0.225 ± 0.030 (0.050)	11	0.224	–	0.086 ± 0.010 (0.025)	5	0.085	–	2.6
S	0.1 – 0.5	–	–	–	0.189	0.257 ± 0.006 (0.002)	–	–	0.179	0.184 ± 0.002 (0.001)	1.4
Si	–	–	5.736 ± 0.412 (0.013)	11	5.722	4.681 ± 0.045 (0.002)	0.811 ± 0.068 (0.010)	5	0.815	0.505 ± 0.004 (0.002)	9.3
Elemental concentration (mg kg^{-1} or ppm)											
Cl	100 – 6000	4000 – 7000	**5716 ± 592 (1131)**	6	**5690**	**5535 ± 55 (14)**	(< 1131)	5	–	835 ± 13 (8.1)	6.6
Zn	15 – 150	100 – 400	–	–	–	37 ± 1.7 (1.2)	–	–	–	26 ± 1.6 (0.97)	1.4
B	5 – 100	50 – 1000	(< 1867)	–	–	–	(< 1867)	5	–	–	–
Mo	0.1 – 5	10 – 1000	–	–	–	8 ± 1.7 (2.9)	–	–	–	< 6 (3)	> 1.3
Cu	0.1 – 30	15 – 100	–	–	–	5 ± 1.2 (1.2)	–	–	–	25 ± 1.5 (0.9)	0.2
Fe	50 – 150	> 500	–	–	–	235 ± 6 (2.0)	–	–	–	337 ± 5 (1.4)	0.7
Mn	10 – 300	200 – 5300	–	–	–	110 ± 8.8 (3.0)	–	–	–	15 ± 3.0 (1.8)	7.3
Ni	0.1 – 5	10 – 100	–	–	–	15 ± 1 (1.4)	–	–	–	4.6 ± 0.9 (1.1)	3.3
Na	–	2000 – 5000	66 ± 16 (4)	11	–	–	55 ± 18 (3)	5	–	–	1.2
Al	–	40 – 200	**222 ± 37 (89)**	7	–	**202 ± 35 (20)**	**846 ± 60 (56)**	5	–	**829 ± 19 (15)**	0.2
V	0.2 – 1.5	0.1 – 10	–	–	–	< 28 (9.4)	–	–	–	< 19 (9.4)	–
Se	0.01 – 2	5 – 100	–	–	–	< 1.9 (1.0)	–	–	–	< 1.1 (0.6)	–
Co	0.02 – 1	10 – 50	–	–	–	(< 1.0)	–	–	–	(< 1.0)	–
F	5 – 30	50 – 500	**340 ± 137 (3)**	11	–	–	**109 ± 25 (2)**	5	–	–	3.1
Ti	–	50 – 200	–	–	–	< 90 (45)	–	–	–	98 ± 24 (45)	< 0.9
Cr	0.1 – 0.5	0.1 – 30	–	–	–	**32 ± 7 (6)**	–	–	–	9.3 ± 5.2 (4.0)	3.4
Rb	–	–	–	–	–	21 ± 1.7 (1.2)	–	–	–	8.2 ± 1.7 (1.1)	2.6
Br	–	–	–	–	–	15 ± 1.7 (1.0)	–	–	–	4.3 ± 1.2 (0.7)	3.5
Sr	–	–	–	–	–	12 ± 2.5 (1.5)	–	–	–	6.5 ± 1.6 (1.3)	1.9
Zr	–	15	–	–	–	< 4 (2.0)	–	–	–	8.7 ± 2.5 (1.9)	< 0.5
Ba	–	500	–	–	–	< 133 (66)	–	–	–	< 131 (65)	–
As	1 – 1.7	0.1 – 20	–	–	–	< 1.7 (1.0)	–	–	–	< 1.1 (0.6)	–

Acknowledgments

- CANAM project with the ministry of High education and research in Czech Republic. Code 397 Title: Micro-PIXE for quantitative mapping of metal concentration in O. glaberrima and O. sativa rice plants 2019
- CANAM project with the ministry of High education and research in Czech Republic. Code 428 Title: Multi elemental analysis of nutrients and pollutants in cultivated O. glaberrima and O. sativa rice plants based on instrumental neutron activation analysis 2019
- CRP from the IAEA Vienna Austria, code G42008 entitled 'Facilitating Experiments with Ion Beam Accelerators' has been approved from 13 June 2019 to 12 June 2024 at IThemba LABS in South Africa

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24 August 2023

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Cheikh Anta Diop University
Dakar, Senegal
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Dear Dr. Traore,

Thanks for your attention