

**Combination of
NAA, TXRF, and
ED-XRF to detect
elements
deposition in the
moss**

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Combination of NAA, TXRF, and ED-XRF to detect elements deposition in the moss

- **1. Introduction**
- **2. Methods and Result**
 - 2.1 . Sampling areas
 - 2.2. Sample collection
 - 2.3 . Method detection
 - 2.4. Results
- **3. Conclusions**



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Introduction

- Mosses are effective and widely-used biomonitors of atmospheric pollution because of their bio-accumulative properties.
- They lack a cuticle and roots, and readily absorb contaminants from the atmosphere. Mosses are widespread, easy to collect and handle, and provide an inexpensive method of detecting atmospheric contaminants.
- The moss method was developed in the late 1960s by Rühling and Tyler (1968, 1969, 1970) and has been used extensively in Europe and elsewhere.

Introduction

Several nuclear-related analytical techniques have been applied to measure trace element concentrations in mosses.

- Neutron Activation Analysis (NAA) :France, India, Portugal, Ghana, Jamaica, Romania, and Russia.
- Atomic Absorption Spectrometry (AAS) : n India, Jamaica, Ghana,
- Inductively Coupled Plasma Mass Spectrometry (ICP-MS):France, India, Israel, and Norway.
- Total Reflection X-ray Fluorescence (TXRF) :n India, Jamaica, Ghana,...
- Proton Induced X-ray Emission (PIXE) :n India, Jamaica, Ghana, ...

Introduction

Three methods:

- NAA (Neutron activation analysis),
- TXRF (Total Reflection X-Ray Fluorescence)
- EDXRF (Energy-dispersive X-ray Fluorescence)

are used in the present investigation.

- These three techniques are general non-destructive, multi-element techniques with high sensitivity and short analysis time.
- The research focused on the qualitative detection and quantitative measurement of trace elements in *Barbula indica* moss from Bao Loc, Vietnam.



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Methods and Result

2.1. Sampling areas

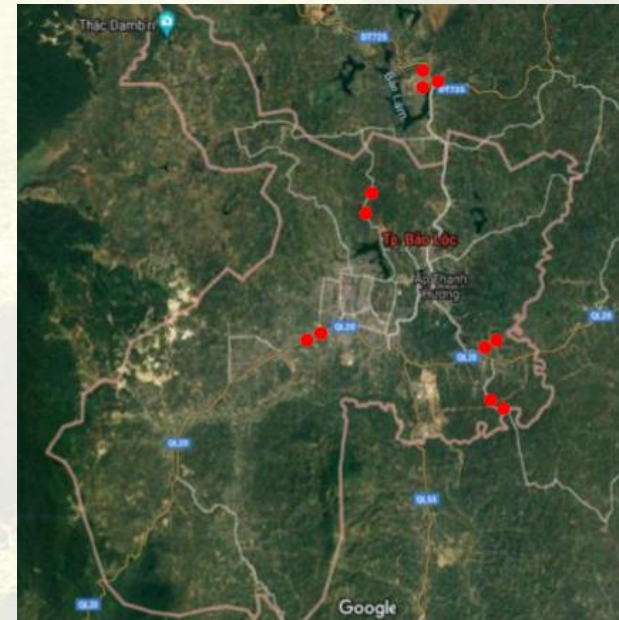
- ✓ Bao Loc is a city in Lam Dong Province (Vietnam) in the Central Highlands of Vietnam.
- ✓ Bao Loc's climate is classified as tropical with an average temperature of 21.2°C.
- ✓ The average rainfall is about 2480 mm per year.
- ✓ Bao Loc normally has two seasons of six months each.
- ✓ The dry season begins in November and ends in May, and the rainy season lasts the rest of the year.



2. Methods and Result

2.1. Sampling areas

- ✓ *Barbula indica* moss collection was carried out once per half month from the end of the rainy season in November 2019 to March 2020.
- ✓ Sample sites were chosen where the moss was likely to have been affected by traffic, farms, or industry
- ✓ Picture shows the locations of the 11 moss sample sites in Bao



Loc

2. Methods and Result

2.2 Sample collection

- ✓ The *Barbula indica* moss morphology and a moss powder sample are shown in the picture. To minimize the influence of the substrate, the moss was collected from trees at least 1.5 m above the ground and only the top, green part was used for analysis.



2. Methods and Result

2.3 Method detection

➤ *TXRF technique*

- A Bruker S2 PICOFOX™ spectrometer was used to collect the characteristic X-ray spectrum for each moss sample.
- It was operated at 50 kV high voltage with a maximum tube rating of 50 W.
- The S2 PICOFOX spectrometer can detect 25 elements with K-line energy (from Al to Y), and 47 elements with L-line energy (from Ru to U).



2. Methods and Result

2.3 Method detection

➤ *NAA technique*

- NAA was carried out at the 500 kW Dalat research reactor (DRR) of Vietnam.
- Previous work established that NAA at DRR has met the requirements of multielement analysis for 42 elements from Al to U.



2. Methods and Result

2.3 Method detection

- *ED-XRF*
 - In this research, we used the SPECTRO XEPOS spectrometer represents ED-XDF technology.
 - It leads SPECTRO's newest generation of ED-XRF instruments.
 - Ensures optimum excitation using polarization and secondary targets, an autosampler for up to 12 items and intelligent software modules which delivers higher sensitivity and accuracy for the entire element range from Na-U.



2. Methods and Result

2.4 Results

No.	Element concentration in mg/kg			
	El.	NAA	TXRF	ED-XRF
1	Na	304	--	306
2	Mg	684	--	681
3	Al	--	3,236	3,197
4	Si	--	--	6,412
5	P	--	662	654
6	S	--	1,683	1,678
7	Cl	696	682	673
8	K	914	925	918
9	Ca	--	854	856
10	Sc	1.89	--	

2. Methods and Result

2.4 Results

No.	Element concentration in mg/kg			
	El.	NAA	TXRF	ED-XRF
11	Ti	--	337	328
12	V	4.91	5.51	5.40
13	Cr	6.61	6.32	6.45
14	Mn	118	102	109
15	Fe	2,887	3,105	3,147
16	Co	2.01	1.97	1.82
17	Ni	--	3.24	3.15
18	Cu	--	16.59	16.41
19	Zn	371	413	426
20	As	5.67	--	--

2. Methods and Result

2.4 Results

No.	Element concentration in mg/kg			
	El.	NAA	TXRF	ED-XRF
21	Se	0.28	--	--
22	Br	5.14	3.43	--
23	Rb	3.27	2.91	
24	Sr	--	46	48
25	Y	--	8.24	
26	Zr	21		
27	Ag	--	61	
28	Sn	--	92	
29	Sb	43.36	46.63	
30	I	7.41	--	--

2. Methods and Result

2.4 Results

No.	Element concentration in mg/kg			
	El.	NAA	TXRF	ED-XRF
31	Cs	1.13	--	1.62
32	Ba	--	45.44	46.32
33	La	6.89	--	6.78
34	Ce	14.23	--	
35	Sm	1.43	--	
36	Eu	0.24	--	
37	Tb	0.26	--	
38	Dy	1.24	--	
39	Yb	0.63	--	
40	Hf	0.69		

2. Methods and Result

2.4 Results

No.	Element concentration in mg/kg			
	El.	NAA	TXRF	ED-XRF
41	Ta	0.22	--	
42	Pb	--	4.14	4.57
43	Th	2.29	--	3.01
44	U	3.08	--	3.11

2. Methods and Result

2.4 Results

The three techniques detected 44 elements in the moss samples.

- The NAA method detected 29 elements: Na, Mg, Cl, K, Sc, V, Cr, Mn, Fe, Co, Zn, As, Se, Br, Rb, Sb, I, Cs, La, Ce, Sm, Eu, Tb, Dy, Yb, Hf, Ta, Th, and U.
- The TXRF method detected 24 elements: Al, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Br, Rb, Sr, Y, Ag, Sn, Sb, Ba, and Pb.
- ED-ERF method detected 26 elements: Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Sr, Zr, Cs, Ba, La, Pb, Th, and U.
- Seven elements (Cl, K, Cr, Mn, Fe, Co, Zn) were detected by three methods.
- The results are consistent between the techniques

3. Conclusions

This investigation combined NAA, TXRF, and EDXRF techniques to identify 44 chemical elements in *Barbula indica* moss.

- ✓ 29 elements identified with the NAA technique
- ✓ 24 elements detected by TXRF,
- ✓ 26 elements detected by the ED-XRF method.
- ✓ 7 elements: Cl, K, V, Cr, Mn, Fe, Co, Zn, Br, Rb, and Sb were detected by three techniques.

The NAA, TXRF, and ED-XRF techniques complement each other well, increasing the number of trace elements detected in moss samples and providing more information from biomonitoring surveys.

Combined, the three techniques provide a reliable method of determining atmospheric deposition in moss samples.



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