JOINT INSTITUTE FOR NUCLEAR RESEARCH IN DUBNA
FRANK LABORATORY OF NEUTRON PHYSICS (FLNP)

Neutron activation analysis and Inductively coupled plasma-optical emission spectroscopy

By:

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Introduction

- Neutron Activation Analysis (NAA) and Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) are analytical techniques used for elemental determination in environmental and materials research.
- NAA excels in non-destructive trace metal analysis, particularly for environmental biomonitoring, while ICP-OES offers high-throughput element quantification, rare earth elements (REEs) in solutions.

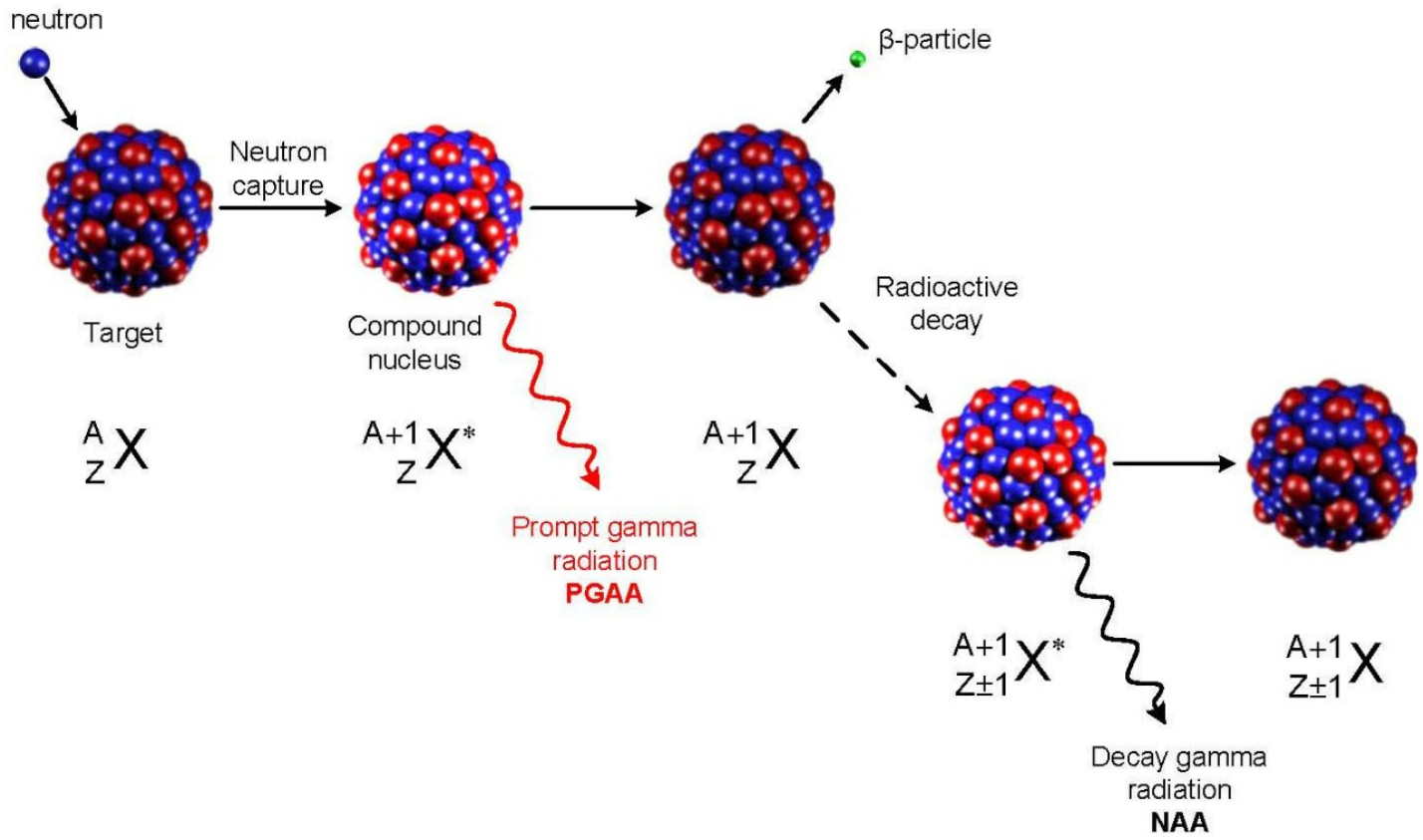
Aims

- The aim of this study is to monitor and quantify metal accumulation in moss using Neutron Activation Analysis (NAA)
- Investigate and optimize the adsorption of rare earth elements (La and Ce) from aqueous solutions using titanosilicate ETS-10 as a sorbent, with ICP-OES employed to measure removal efficiency.

Neutron Activation Analysis

•Advantages
•-High sensitivity and precision
•Accurate quantification
•Multi-element analysis
•Minimal sample preparation

•Disadvantages
•Longer analysis time
•Radioactive waste safety concerns



Biomonitoring

Plant bio-monitors: lichens, moss, and higher plants

Pleurozium schreberi

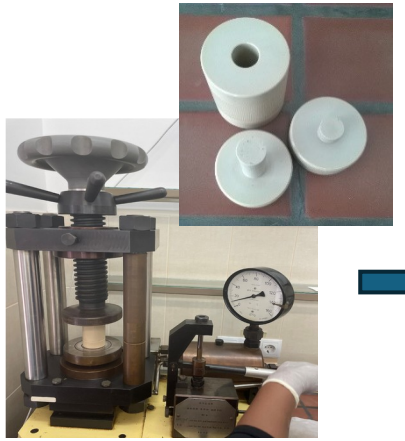
Hypnum cupressiforme

Hylocomium splendens

Methodology: NAA sample preparation

Weighing

Pelletization

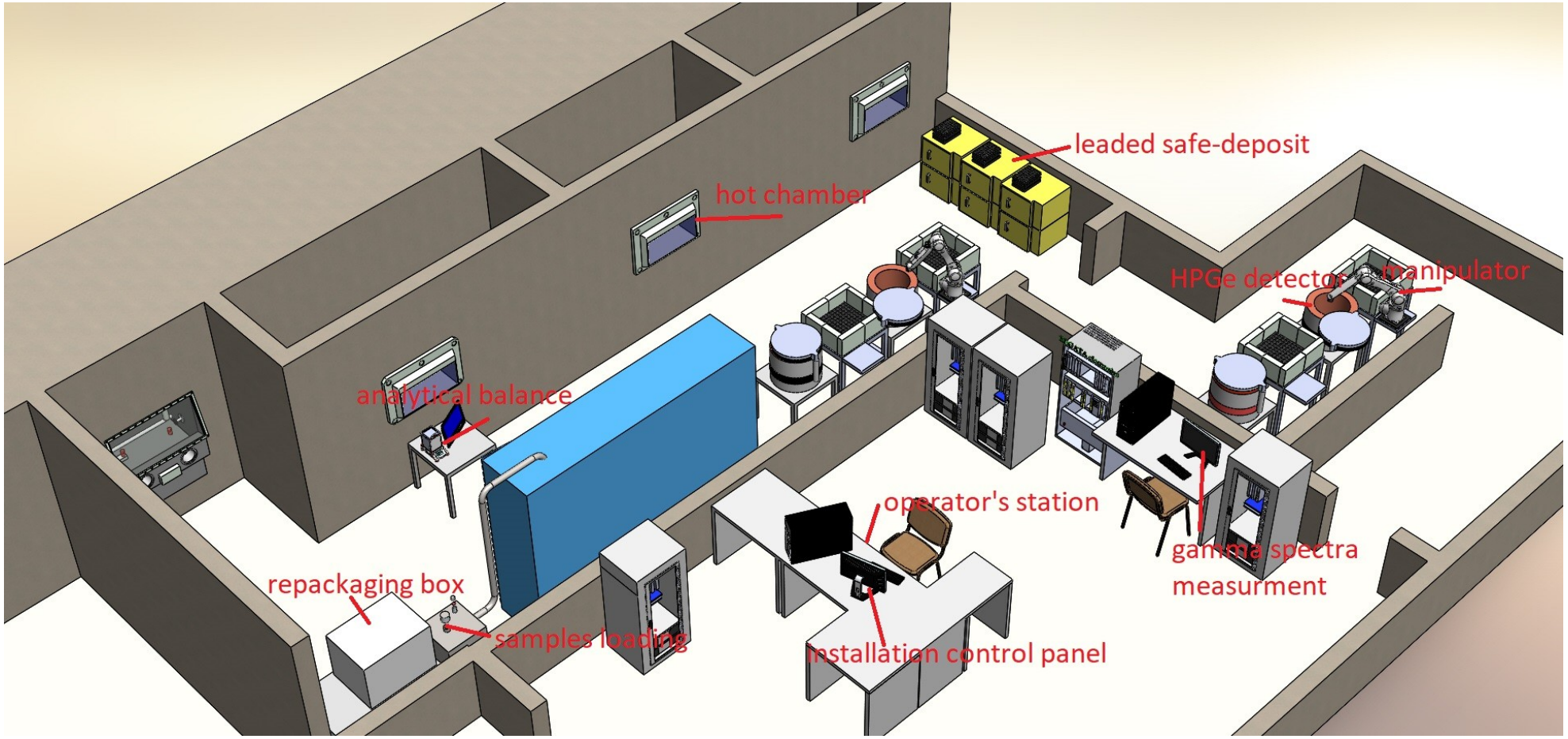


Sample packaging

Long irradiation

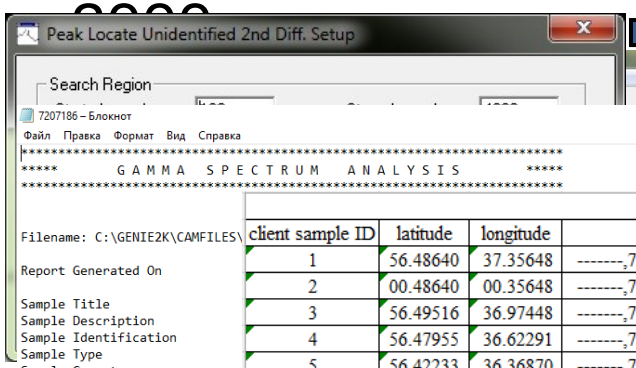
Short irradiation

Radioanalytical complex REGATA



CALIBRATION AND DATA PROCESSING

For calibration and data processing we used GENIE 2000



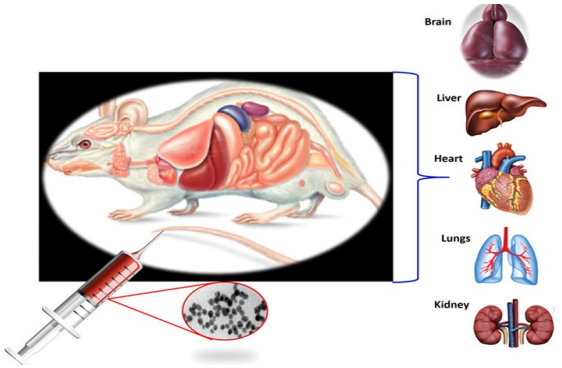
					Na			Mg			Al		
client sample ID	latitude	longitude	files spectrum	processed by	Conc, µg/g	Err, %	MDC, µg/g	Conc, µg/g	Err, %	MDC, µg/g	Conc, µg/g	Err, %	MDC, µg/g
1	56.48640	37.35648	-------,7006162,5107869,1207174	Vergel K.N.	148	5	3.34	1160	8	88	733	5	12.5
2	00.48640	00.35648	-------,7006163,5107870,1207175	Vergel K.N.	120	5	3.34	1560	6	54	604	5	3.1
3	56.49516	36.97448	-------,7006164,5107871,1207176	Vergel K.N.	187	5	2.84	2050	6	91	1030	5	10.3
4	56.47955	36.62291	-------,7006165,5107872,1207177	Vergel K.N.	207	5	4	2620	7	152	1590	5	15
5	56.42233	36.36870	-------,7006166,5107873,1207178	Vergel K.N.	128	5	2.15	1920	6	75	728	5	5
6	56.31978	36.58859	-------,7006167,5107874,1207179	Vergel K.N.	152	5	3.64	2140	6	75	728	5	9.4
7	56.17867	36.70945	-------,7006168,5107879,1207184	Vergel K.N.	136	5	3.1	1570	7	116	819	5	10.3
8	56.09420	36.93874	-------,7006169,5107880,1207185	Vergel K.N.	258	5	0.135	2060	6	84	943	5	9.4
9	56.27766	37.04482	-------,7006170,5107881,1207186	Vergel K.N.	195	5	0.14	2730	6	83	1480	5	8.8
10	56.35086	37.02940	-------,7006171,5107882,1207187	Vergel K.N.	100	5	2.6	2000	7	114	872	5	13.8
11	56.30688	37.17604	-------,7006172,5107883,1207188	Vergel K.N.	160	5	4	2450	6	83	1180	5	8.4
12	56.27251	37.27000	-------,7006173,5107884,1207189	Vergel K.N.	227	5	6.7	1220	7	49	428	5	4.3
13	56.11076	37.21316	-------,7006174,5107836,5207174	Vergel K.N.	300	5	2.25	2970	6	106	1470	5	12
14	56.02591	37.34071	-------,7006175,5107837,5207175	Vergel K.N.	269	5	2	2230	6	94	1130	5	9
15	55.91447	37.29930	-------,7006176,5107838,5207176	Vergel K.N.	178	5	1.26	1980	7	123	1560	5	31
16	56.00069	37.02524	-------,7006177,5107839,5207177	Vergel K.N.	213	5	2.2	1640	8	232	690	5	26
17	55.98817	36.78065	-------,7006178,5107840,5207178	Vergel K.N.	256	5	2.05	1770	7	106	1100	5	16.6
18	55.92567	36.49663	-------,7006179,5107841,5207179	Vergel K.N.	201	5	2.77	2440	6	66	1070	5	9.9
19	56.11272	36.43994	-------,7006180,5107846,5207184	Vergel K.N.	140	5	1.57	1550	7	88	521	5	12.5
20	56.29473	36.25623	-------,7006181,5107847,5207185	Vergel K.N.	112	5	2	1550	7	92	479	5	15.2
21	56.20428	36.06174	-------,7006182,5107848,5207186	Vergel K.N.	96	5	2	1550	7	80	684	5	13
22	56.26700	35.85368	-------,7006183,5107849,5207187	Vergel K.N.	96	5	2.47	2200	6	38	555	5	4.8
23	56.31548	35.73023	-------,7006184,5107850,5207188	Vergel K.N.	85	5	0.071	1340	6	38.6	449	5	3.8
24	56.43142	35.51060	-------,7006185,5107851,5207189	Vergel K.N.	99	5	1.8	1860	6	71	527	5	8.6
25	56.27983	35.62173	-------,7006187,5107852,5207190	Vergel K.N.	116	5	1.77	549	8	36	167	5	5.2
26	56.18440	35.39246	-------,7006188,7107836,7207174	Vergel K.N.	138	5	1.24	2000	6	88	559	5	13.3
27	56.07407	35.64335	-------,7006189,7107837,7207175	Vergel K.N.	165	5	2.85	2040	6	72	619	5	7.8
28	56.10370	35.91751	-------,7006190,7107838,7207176	Vergel K.N.	182	5	2.73	1670	6	74	1340	5	9
29	56.02998	36.32241	-------,7006191,7107839,7207177	Vergel K.N.	98	5	1.73	1990	6	97	634	5	34
30	56.05653	36.12456	-------,7006186,7107840,7207178	Vergel K.N.	135	5	1.73	1790	8	117	715	5	75
31	56.02789	35.81024	-------,7006192,7107841,7207179	Vergel K.N.	811	5	4.4	2070	6	88	1460	5	11.5
32	55.91761	36.05112	-------,7006193,7107846,7207184	Vergel K.N.	411	5	3.84	2860	6	85	2390	5	9.3
33	55.81934	35.79718	-------,7006194,7107847,7207185	Vergel K.N.	158	5	2.5	1940	6	91	868	5	12.6

NAA applications

Bio-monitoring

Food

Archeology



Nano-toxicity

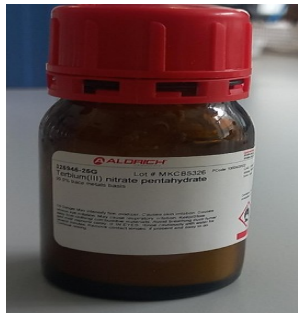
Adsorption studies for wastes water treatment- METHODOLOGY

Titanosilicate ETS-10

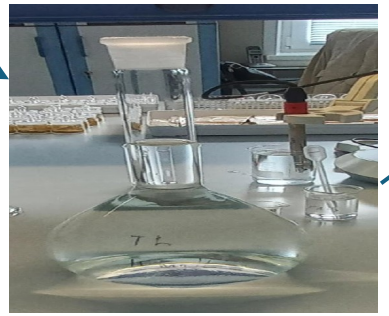
Analytical weighing balance

Sorbent

Sorbent with salt solution



La and Ce

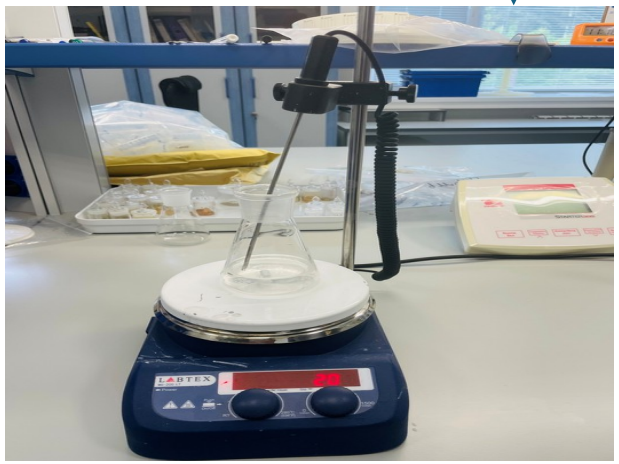


Salt solution

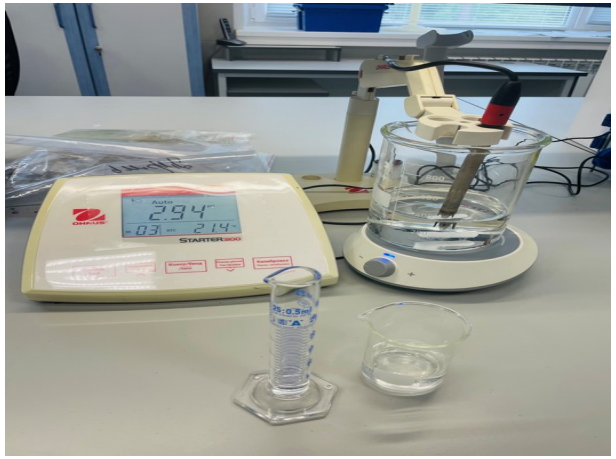
Optimization

Time

Temperature



pH



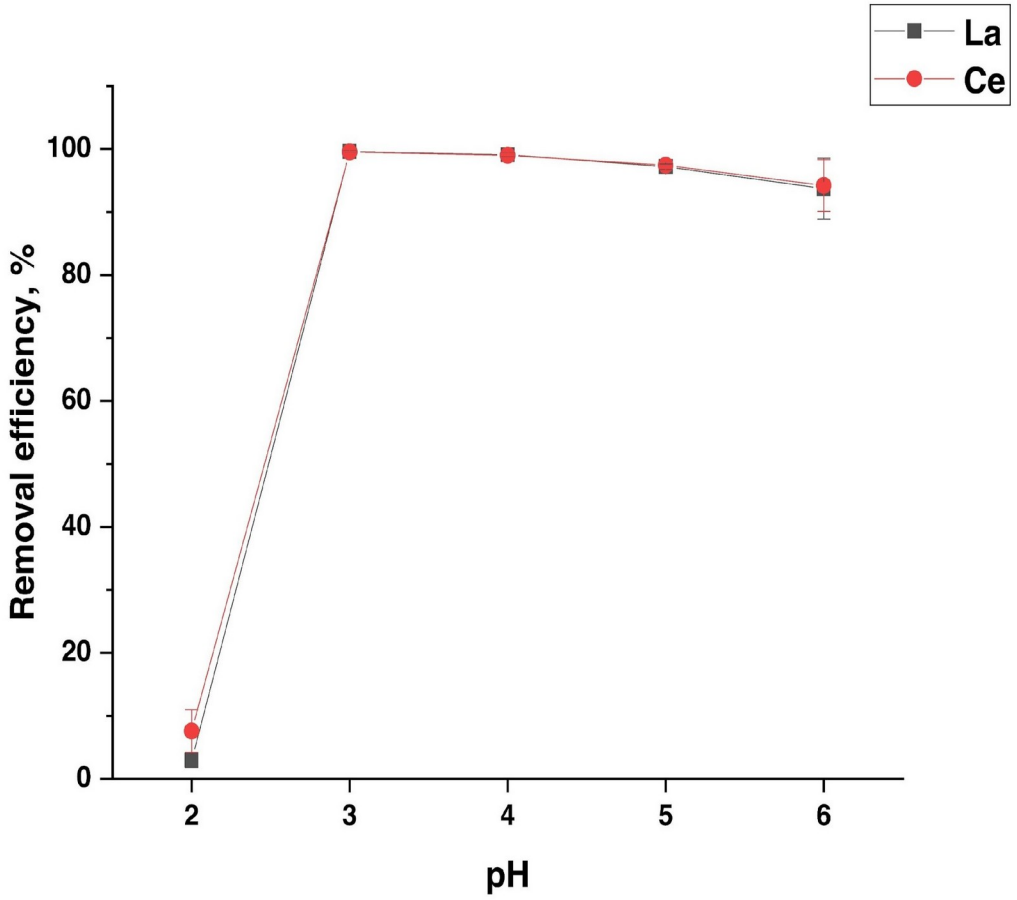
Concentration

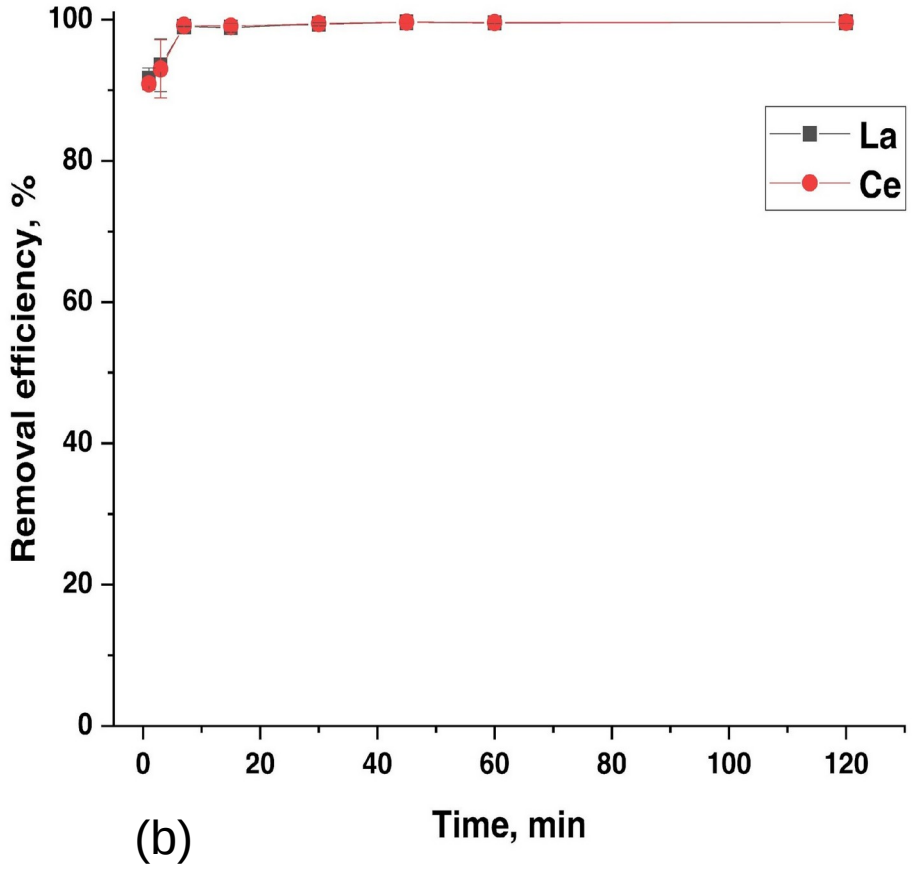
ICP-OES

Results

Effect of pH, time and on La and Ce removal from wastewater

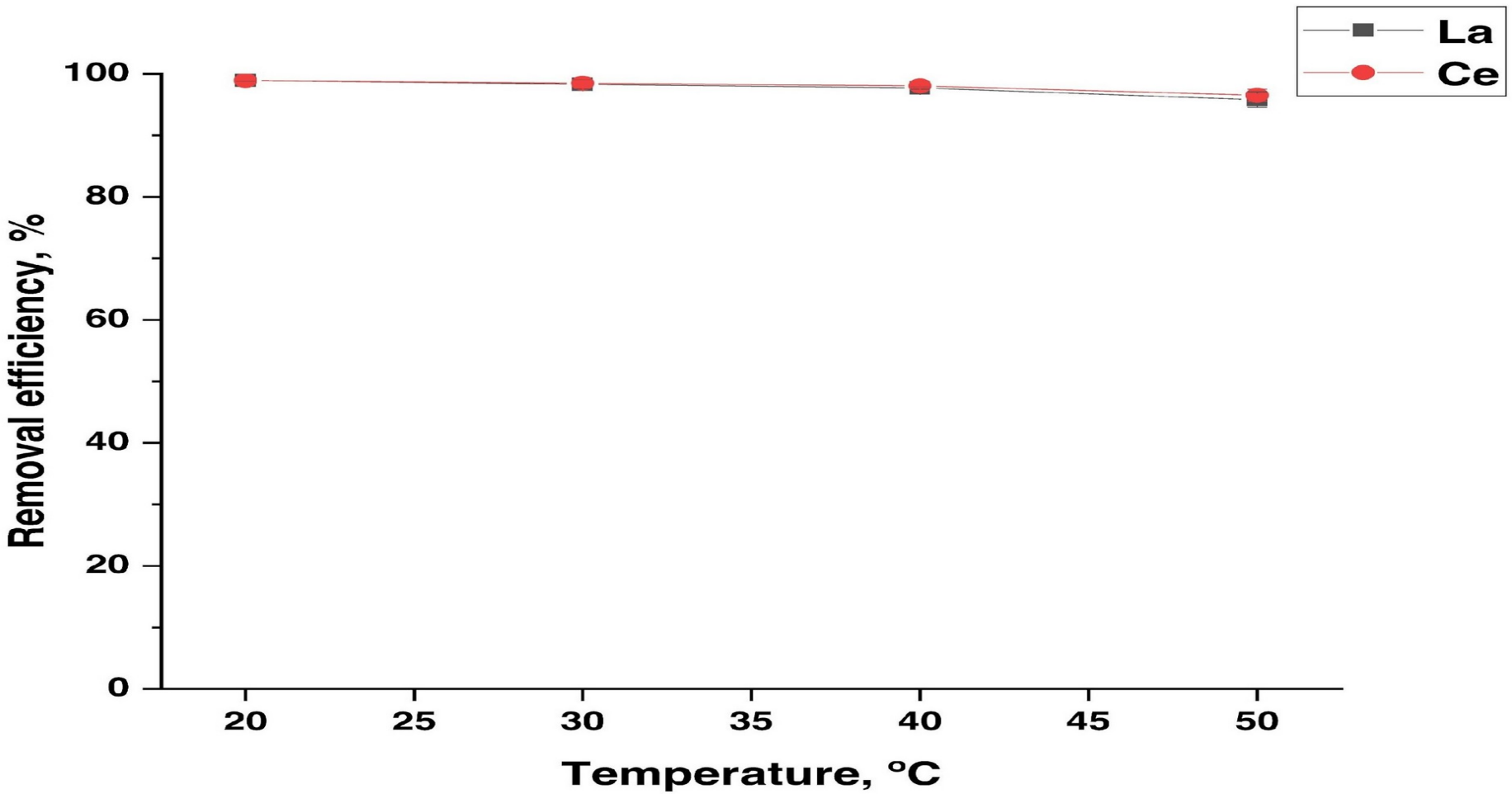
(a)





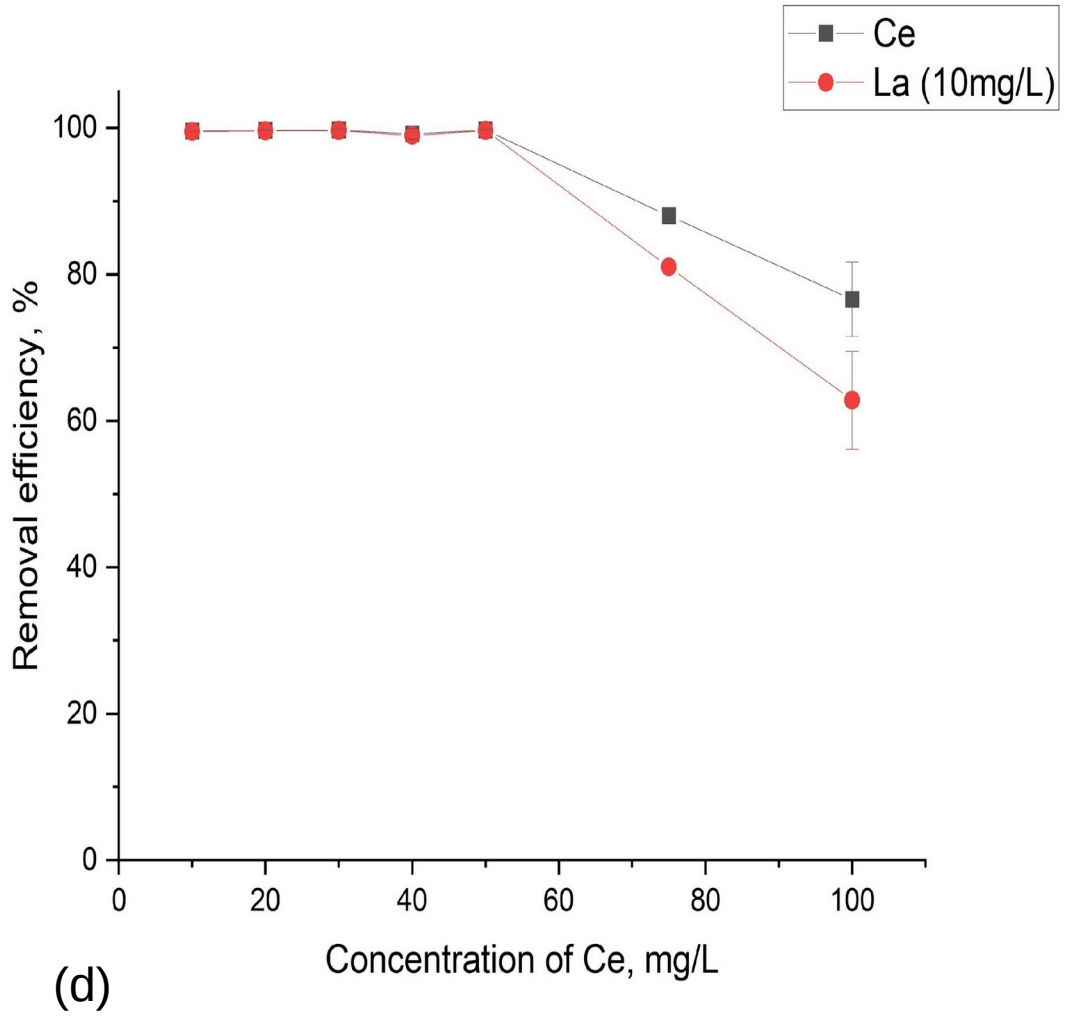
(b)

Effect of Temperature on La and Ce removal from wastewater

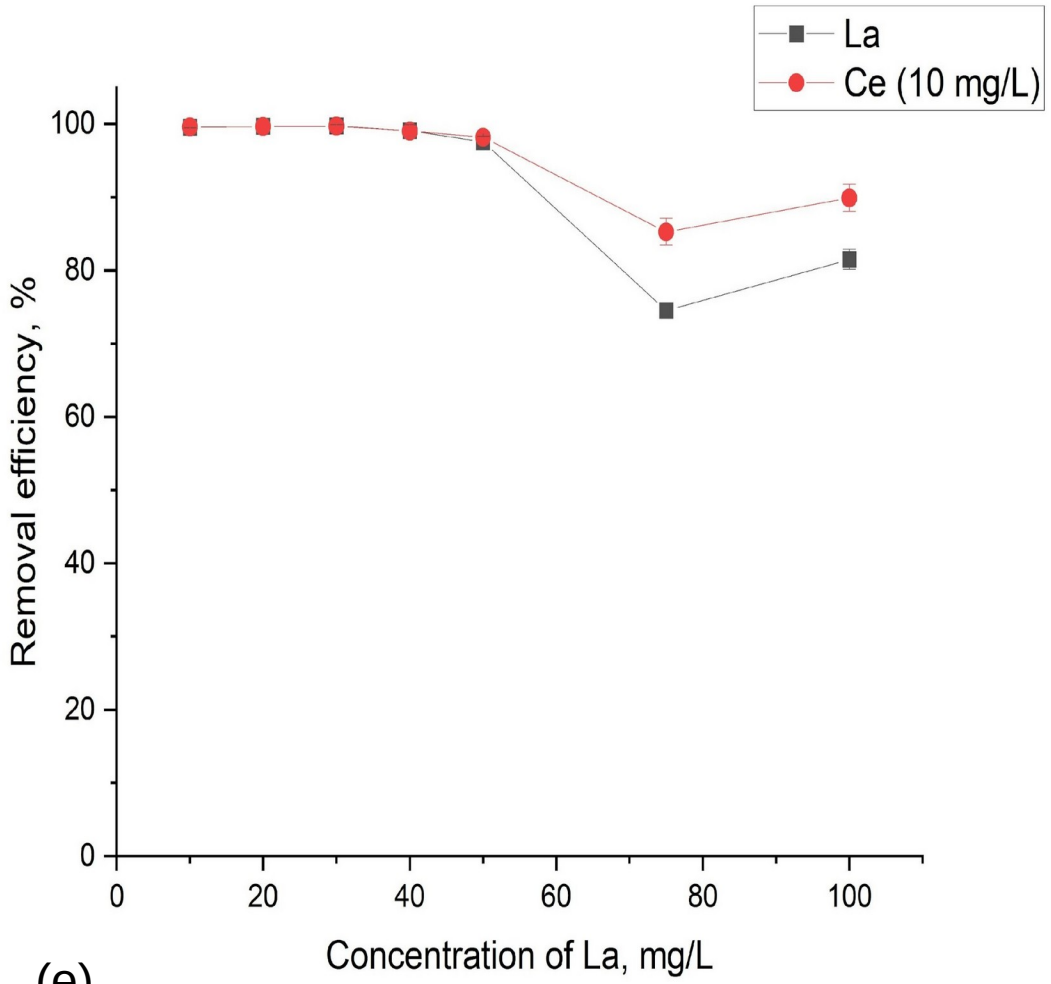


(C)

Results conti...The Effect of concentration on metals removal efficiency



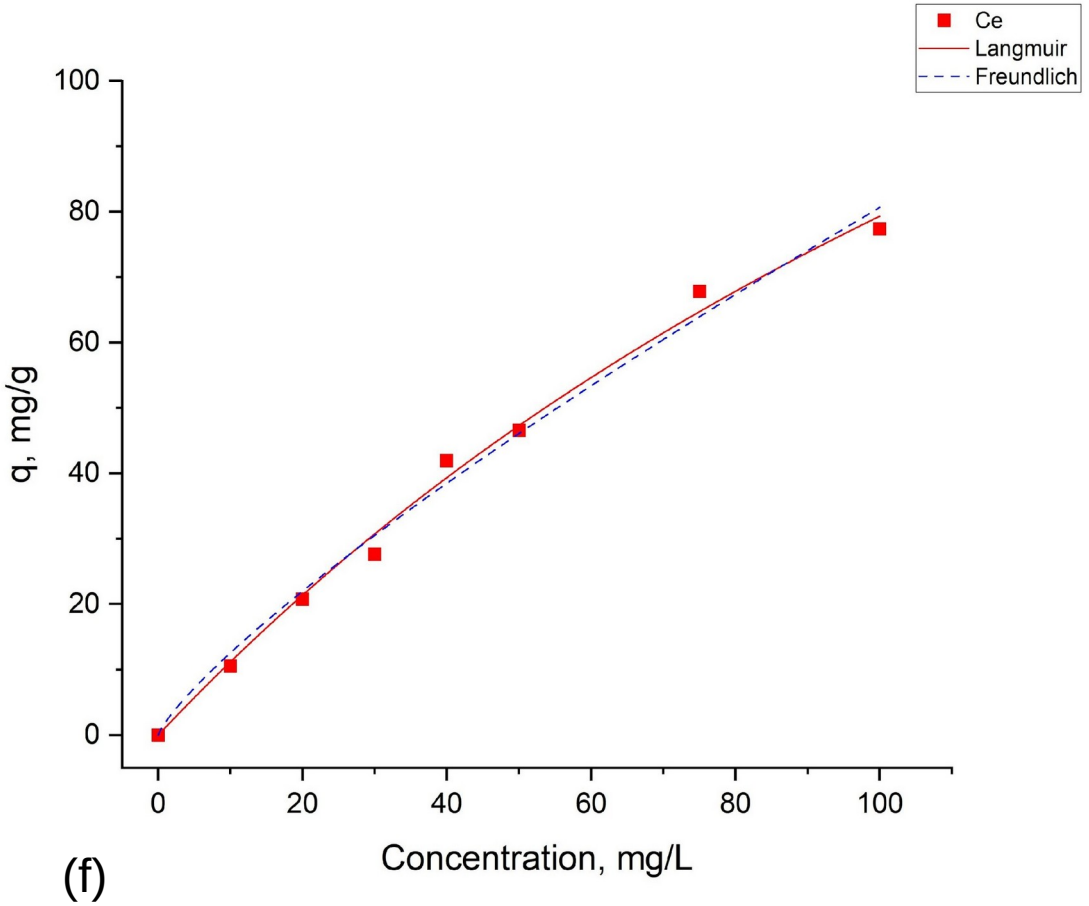
(d)

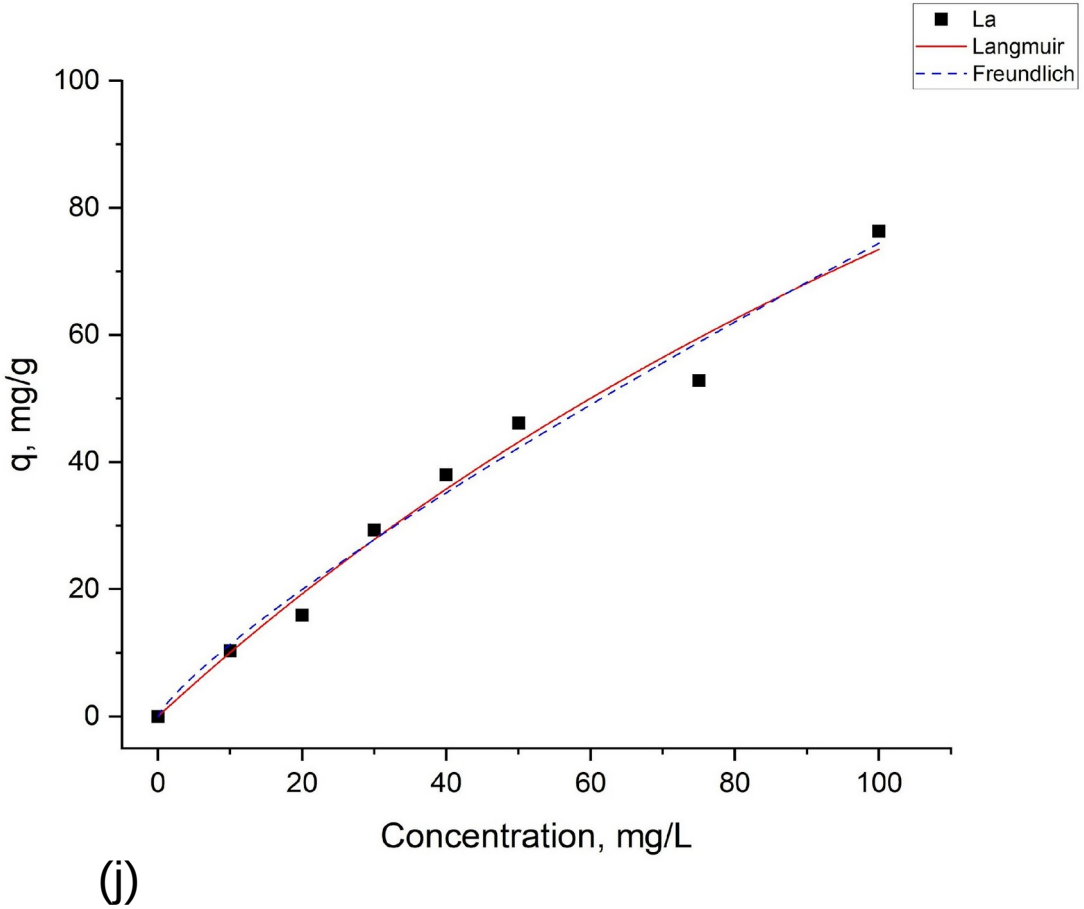


(e)

Results conti...

Isotherms of La and Ce adsorption onto ETS-10





Conclusion

- Titanosilicate ETS-10 was used for the adsorption of La and Ce ions from aqueous solutions, showing a rapid adsorption process that was completed in no more than 7 minutes.
- The adsorption efficiency was strongly dependent on pH, with a maximum removal of 99% achieved at pH 3.0.
- Additionally, the adsorption process was found to be temperature-independent, maintaining a high removal rate of 94–99% across a temperature range of 20–50 °C.
- This indicates that ETS-10 is an effective sorbent for quick and efficient removal of La and Ce ions under mild conditions.

References

- Zinicovscaia, I., Yushin, N., Humelnicu, D., Grozdov, D., Ignat, M., & Humelnicu, I. (2023). Adsorption Capacity of Silica SBA-15 and Titanosilicate ETS-10 toward Indium Ions. *Materials*, *16*(8), 3201. https://doi.org/10.3390/ma16083201
- Zinicovscaia, I., Yushin, N., Humelnicu, D., Grozdov, D., Ignat, M., Demcak, S., & Humelnicu, I. (2021). Sorption of Ce(III) by Silica SBA-15 and Titanosilicate ETS-10 from Aqueous Solution. *Water*, *13*(22), 3263. https://doi.org/10.3390/w13223263

Acknowledgements

Thank you!