

SPECTRAL ANALYSIS OF HISTORICAL INKS ASSISTED BY MACHINE LEARNING

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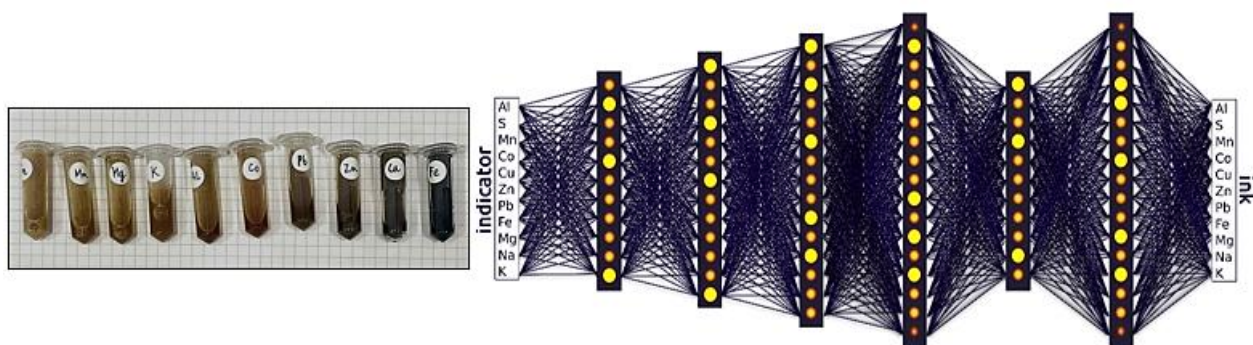
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A non-destructive analytical workflow was developed for the investigation of historical manuscripts written with iron-gall inks. The methodology combines indicator-paper sampling, laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), and machine-learning (ML) data processing. Instead of direct sampling of valuable documents, chemical information was transferred from manuscript surfaces to specially prepared indicator papers acting as carriers of elemental signatures.

The indicator papers are then analysed using LA-ICP-MS to provide spatially resolved, multielemental data with high sensitivity and minimal material consumption. However, as the interaction between the ink components and the indicator substrate is governed by complex, nonlinear chemical processes, the measured signals cannot be directly interpreted as the composition of the original inks.

Machine-learning models were therefore trained using experimental datasets obtained from reference materials and historical samples, in order to decode this indirect analytical information. These models enabled the reconstruction of the elemental composition of the source inks and improved discrimination between different writing media.

The methodology was applied to manuscripts dating from the 11th to the 20th century, yielding information relevant to conservation assessment, ink discrimination, and studies of document history. The results demonstrated that combining the use of specific indicator papers and LA-ICP-MS with machine learning is a powerful approach for safely analysing documents.



The picture of model ink solutions used to create mock-ups for indicator-paper sampling prior to LA-ICP-MS measurements and ML data processing

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