

INTRODUCTION

Book binding in the 19th century used an assortment of pigments containing toxic elements, including heavy metals like lead (Pb), arsenic (As), iron (Fe), chromium (Cr), copper (Cu), and mercury (Hg). Heavy metals are toxic elements classified by their high density, high atomic weight, and high atomic number. They are able to affect critical biological processes and interfere with antioxidant defense mechanisms (Jomova et al., 2025). Inspired by The University of Delaware and Winterthur Museum, Garden and Library's Poison Book Project, this project aims to identify potential toxic elements in books in MTSU's Walker Library Special Collections. X-ray fluorescence (XRF) spectroscopy was chosen to identify toxic elements because it is a non-destructive technique that would not harm any historical books. Analysis of chemical composition by XRF is done by using an X-ray source to excite the atoms and measuring the energy of the emitted photon produced when the atom relaxes to a ground state. Elements can be identified on the book covers because each element has a unique fingerprint. Although XRF spectroscopy identifies the elements in a qualitative way, it cannot identify the amount of each element needed for safe handling (Cecchi et al., 2025). Out of 70 books examined using XRF in fall 2025 and spring 2026, 69 (98.5%) contained toxic elements— notably Pb, As, Hg, Cu, Fe, and Cr.



Figure 1. The American Farmer's Pictorial Cyclopedic of Livestock and Complete Livestock Doctor (Salesman's Dummy). Images of areas of interest including the front cover, back cover, inside cover, and an illustration.

PROJECT WORKFLOW

Select Book

Identify Colors of Interest

Set Up and Scan

Analyze Spectra to Identify Elements

MATERIALS AND METHODS

X-Ray Fluorescence (XRF) Spectroscopy Setup

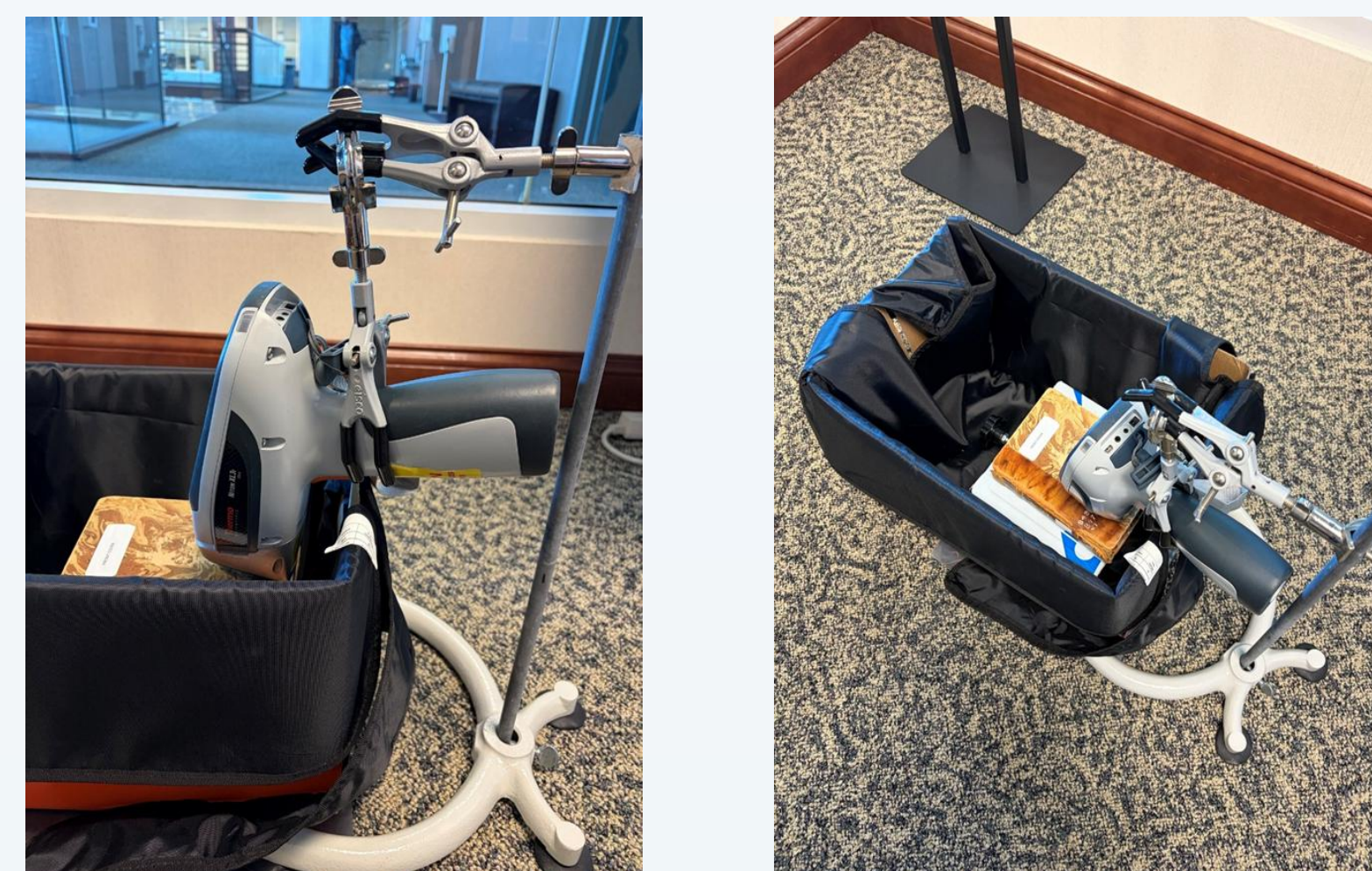


Figure 2. XRF Scanning Setup. Images of the setup used to scan books with the XRF analyzer.

Spectra Analysis

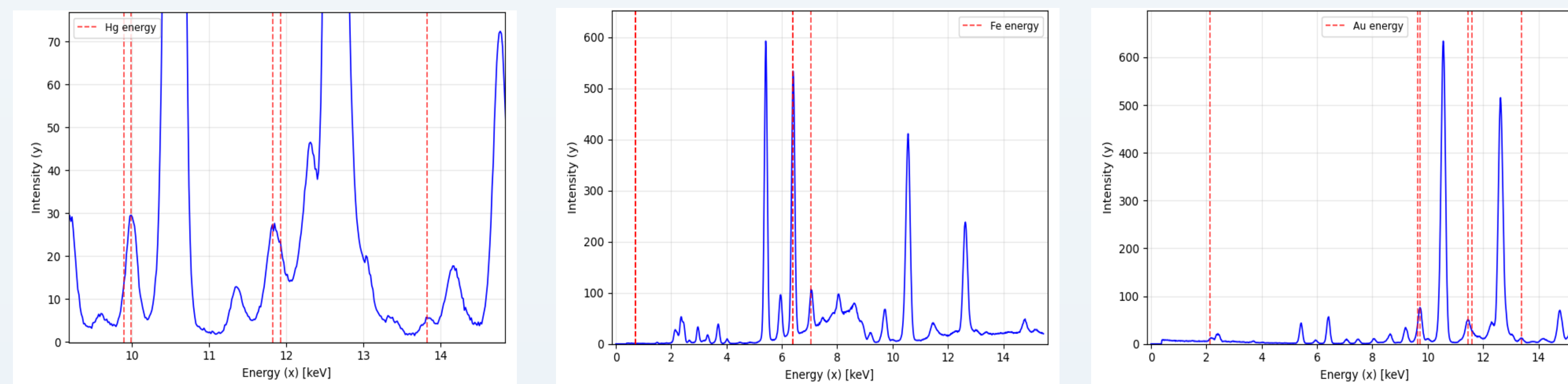


Figure 3. Spectra for The American Farmer's Pictorial Cyclopedic. Spectra showing scans for areas of interest, showing positive results for Pb, Cr, Fe, Au, and Hg. Red lines on the spectrum indicate where peaks should appear for a positive ID.

RESULTS

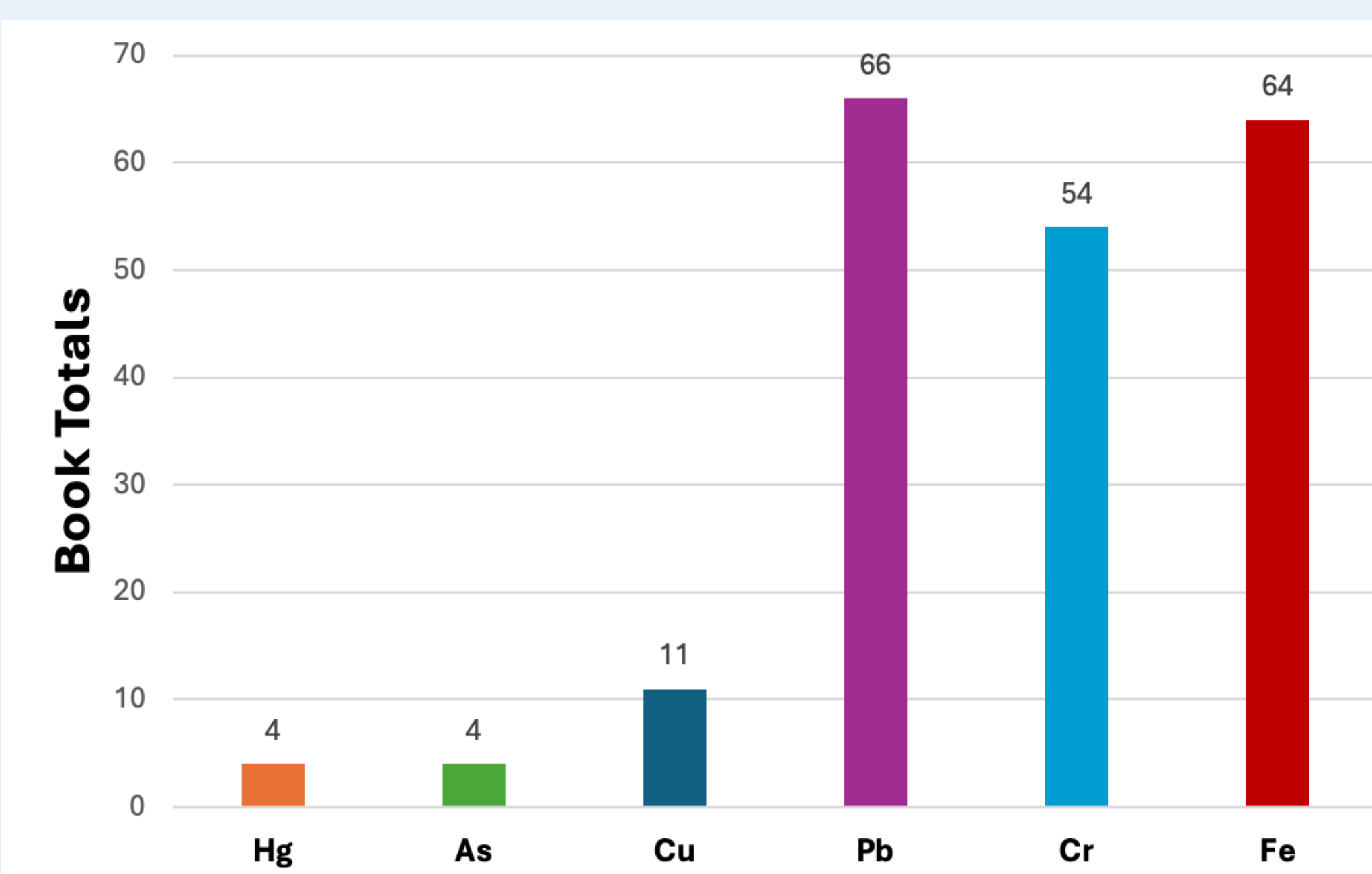


Figure 4. Toxic Elements found in MTSU Special Collection Books. Book total is noted on the y-axis, and toxic elements are labeled on the x-axis. The graph shows how many books of those analyzed contained toxic elements.

CONCLUSIONS

XRF scans of The American Farmer's Pictorial Cyclopedic indicate the presence of lead, chromium, iron, gold, and mercury. While XRF does not provide a molecular structure for the pigments scanned, the identity of the elements present and the color of the scanned area can be used to speculate which pigments were used to color the book bindings. It is important to note that the identity of the pigments decided this way are not certain; they are tentative conclusions drawn using knowledge of commonly used pigments of the era and their chemical compositions.

The presence of chromium and lead in a yellow area of the book likely indicate the use of chrome yellow (PbCrO_4). The presence of iron with blue coloration could indicate that Prussian blue ($\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$) was used, and gold is most commonly found when gold leaf is used in lettering on the book covers or spine.

A total of 70 books were scanned in the fall 2025 and spring 2026 semesters. Out of that 70, 69 (99%) tested positive for at least one heavy metal, with several testing positive for multiple. The most common were lead and iron. Lead was found in 94% of books and iron was found in 91%. Chromium was found in 77% of books. Copper was found in 16% of books. The least common, mercury and arsenic were each found in 6% of books.

The results of this study can be used by the librarians in the Walker Library Special Collections to ensure the safe handling of books containing these toxic elements. Exposure to heavy metals can create adverse health effects, including inflammation, skin discoloration, tremors, lung and cardiovascular dysfunction, kidney and liver damage, chronic fatigue, gastrointestinal disorders, and increased cancer risk (Jomova et al., 2025). Because many of these materials can be absorbed through the skin, it is vital for exposure to be limited as much as possible. Confirmation of the presence of heavy metals in the bindings of the books in the Walker Library Special Collections allows the librarians to keep themselves and the students they serve safe by taking precautions to limit exposure.

REFERENCES

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