H99 Trace Element Analysis of Human Bone Using Portable XRF

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The goal of this study was to investigate the utility of portable X-Ray Florescence (XRF) in the determination of trace element concentrations in human bone. The advent of portable analytical tools for field use presents new applications for the forensic scientist. However, with the new tools comes the challenge of sampling and data interpretation. Potential sources of error in interpretation of analytical results are discussed.

This presentation will impact the forensic community and/or humanity by providing practical insight into the application of portable XRF in analysis of human bone.

Portable XRF technology is a relatively recent introduction to the fields of art conservation, soil science, archaeology, border security and forensic science. XRF analysis gives a rapid reading of the elemental composition of any inorganic material with good sensitivity for elements above phosphorus in the periodic table. The Alpha series XRF from Innov-X (Woburn, MA) was used in this study. This unit utilizes a miniaturized X-ray source for excitation instead of a radioactive isotope, thereby eliminating the need for special permits for transportation and reducing the potential occupational exposure hazard of operators.

A pilot study of 8 cremated individuals was conducted to test the applicability of XRF in trace element analysis of human osseous material. The bone analysis using XRF focused on the trace elements lead (Pb), zinc (Zn), iron (Fe), and strontium (Sr), and concentrations were reported in parts per million (ppm). The pilot study revealed differences in elemental concentration between individuals as well as differences between skeletal elements analyzed (cranial vault, clavicle, humerus, vertebral body, femur, and tibia). These anatomical sites were selected because of differences in bone density. Two physical states of cremated bone were assessed; large fragments as retrieved from the cremation retort and the processed, powdered cremains as prepared for inurnment.

The data show that there is variation in Pb between individuals and between bones. The range amongst all individuals for bone fragments was 0-203 ppm and 0-53 ppm for processed powdered bone. The high Pb level of 203 ppm was in a parietal bone of one individual whose other bones ranged between 0-61 ppm. This high reading was concluded to be surface segregation or contamination because after powdering this parietal bone gave a reading of 46 ppm. Powdering in this case had a homogenizing effect. Of note, the combined powder (all powdered bone together from each person) amongst all individuals ranged from 0-39 ppm. Similar but larger effects were noted for the element zinc (range of 0-1177 ppm in bone pieces and 0-329 ppm in powdered bone; combined powder 0-259 ppm). However, zinc is volatile at the temperatures experienced during cremation, so the resulting sublimation and evaporation effects may be expected to result in variations in surface concentrations. The most consistent data were recorded for the elements of Fe and Sr amongst all bones of all individuals. Only 1 of the 8 individuals had no reading for Fe or Sr in both the clavicle and vertebra. Excluding the zero values, Fe ranged from 199-2286 ppm in bone and 183-866 ppm in powdered bone amongst all individuals, with the combined powder range between 213- 355 ppm. Graphically, the Fe concentration in the powdered skeletal elements adhered to a similar pattern for all individuals. There was a distinct peak for Fe (386-866 ppm) in the vertebral body powder for all 7 individuals, whereas the other powdered skeletal elements did not exceed 471 ppm for any individual or any bone. This finding suggests higher Fe concentrations in the cancellous bone of vertebral bodies. Sr concentrations, again excluding the zero values, ranged between 54-155 ppm in bone, 50-128 ppm in powdered bone, and 58-130 ppm in all combined elements amongst all individuals.

A possible source of error in determination of trace element levels is preferential surface deposition or segregation. If after homogenization, the element concentration appears to drop, then surface effects should be suspected. In addition, if bone of low density is presented to the analyzer, then the values for trace element concentration would be expected to be lower than higher density bone, assuming that the element concentration is the same. This is simply because less material is present in the analysis volume. Powdering in this case can reduce any effect associated with differences in bone density, assuming that the particle size in the powder is relatively homogenous. Furthermore, the hydration state of bone should be considered. In fresh bone the presence of water will absorb the characteristic emitted x-rays, thus giving a low concentration as compared to dry bone. This effect was demonstrated in this study by analyzing a piece of fresh parietal bone that was subsequently dried at 1000C for 30 minutes, and then re-analyzed.

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XRF is a new technology available to the forensic community, not limited to anthropology, but with widespread uses in the crime scene laboratory in the enforcement of justice in drug trafficking, or for exposing the manufacture and disbursement of drugs and potential counterfeit materials. Also, within the field of anthropology and archaeology, handheld portable XRF promises to be another tool in the chemical and physical analysis of human remains, both biological and cultural. As with any other analytical technique, care must be exercised in sampling strategy, preparation of samples and data interpretation. The ease of use, rapidity of analysis and user-friendly interface of portable XRF units are beguiling. However, it is still a technique that demands knowledge of the analyst just as would a fully configured laboratory-based system.

X-Ray Florescence (XRF), Trace Elements, Bone

