Time-Dependent Changes in Human and Chicken Bones in Soil Examined by Infrared, Raman, Inductively Coupled Plasma-Optical Emission Spectroscopy, and Organic Elemental Analysis

Matthew J. Danker[1], Joan Bytheway[2], Donovan C. Haines[1,3]

Department of Chemistry[1], Southeast Texas Applied Forensic Science Facility[2], and Texas Research Institute for Environmental Studies[3]

Sam Houston State University, Huntsville, Texas 77341

Abstract

In this study, bone samples from chicken and human, with associated tissue and muscle, were sectioned with a saw and scalpel. The bone and associated soft tissue samples were then buried in an outdoor piney wood environment at the Southeast Texas Applied Forensic Science (STAFS) Facility, Sam Houston State University, Huntsville, Texas, at a depth of 0.61 meters. The samples were harvested at time intervals based on conditions. The bone samples were then studied by infrared (IR) and Raman spectroscopy to determine the ratios of organic to inorganic material. Soil samples were taken at the same time intervals. The soil samples were taken at three sites for each bone sample: the surface soil above the buried bone, soil immediately adjacent to the bone, and an area in the same environment where no known human decomposition had occurred. The soil samples were analyzed by elemental analyzer for the amount of carbon and nitrogen present in the soil to test the amount of organic material and by inductively coupled plasma optical emission spectroscopy (ICP-OES) to measure the inorganic components in the soil. The ICP-OES and IR instrumentation and support were provided by the Texas Research Institute of Environmental Studies (TRIES), Sam Houston State University, Huntsville, Texas.

ICP-OES and the Element Analyzer preliminary analyses of soil with pre-existing human burial sites at the STAFS facility found that there was a significant difference between soil in which decomposition had occurred and virgin soil. Time-dependent results for ongoing experiments measuring the leaching of bone components into soil will be presented.

In conclusion, this study provides preliminary analysis of time dependency of human and turkey bone decomposition via IR, Raman, ICP-OES, and Organic Element Analysis. Future studies will deconvolute the organic components involved using additional analytical techniques including GC/MS of bone lipids that may migrate into the soil.

Introduction

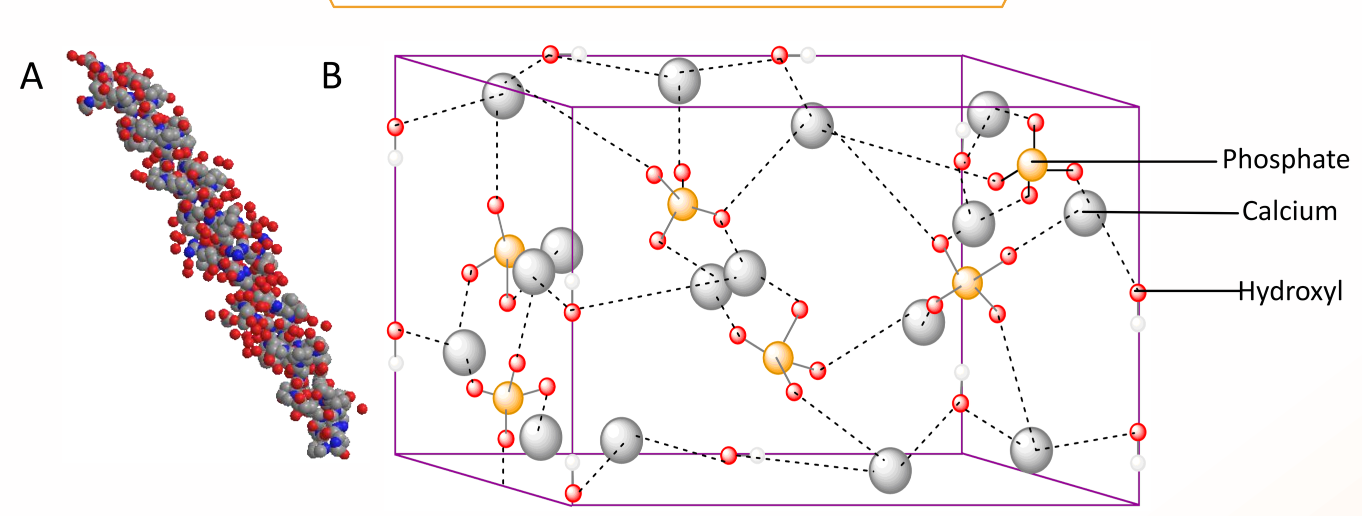

Figure 1: The two main components of bone. *(A)* The protein structure of collagen *(B) The* crystalline structure of calcium hydroxyapatite.[1]

- Bone is approximately 70% inorganic (calcium hydroxyapatite) and 30% organic (mostly collagen).[1]
- Strides have been to use chemical analysis to identify the length of burial for human remains.[2]
- Raman spectroscopy shows a direct correlation between bone samples and burial times based on the inorganic/organic peaks ratio changing.[2]
- At different states of decomposition, various compounds like soap, lactic acid, butyl alcohol, ammonia, and sulfur gases come from the decomposition process of the remains.[3]
- ICP-OES and EA examine remains via chemical analysis. Creating a timeline of chemical composition could lead to establish the species of compounds in the soil and Infrared with the change in the inorganic/organic layers.[4,5]
- Principal Component Analysis can be used to analyze the variance in a dataset.

Methods

- Human femur cross-sections were provided by the Southeast Texas Applied Forensic Science (STAFS) Facility. Chicken Leg samples with tissue were purchased at a local super market. The samples were buried 0.61 meters below ground at STAFS. STAFS is a facility in that handles willed-body donations, more information can be found at http://www.cjcenter.org/stafs
- The human and chicken samples were collected over the course of 13 weeks. The bone/tissue and soil samples closest to the bone and soil on top of decomposition were taken.
- The bone and soil samples were prepped and analyzed by ICP-OES and Elemental Analyzer. The bone samples were analyzed by ATR infrared spectroscopy. The instruments used were provided by the Texas Research Institute for Environmental Studies (TRIES).
- Statistical analysis was done with Principal Component Analysis using R and Microsoft Office Excel.

Results

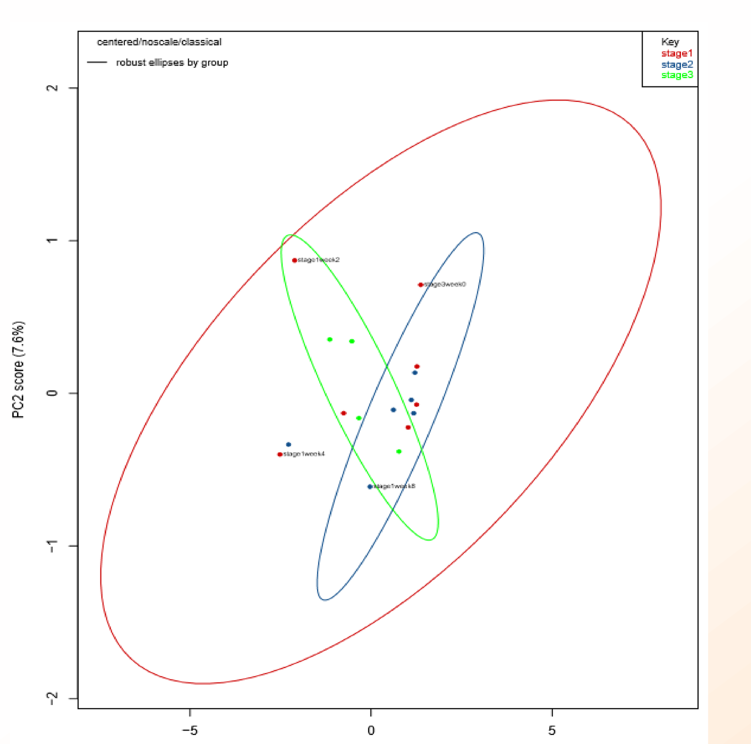

Figure 2. Principal Component Analysis of three types of bones during the decomposition process.

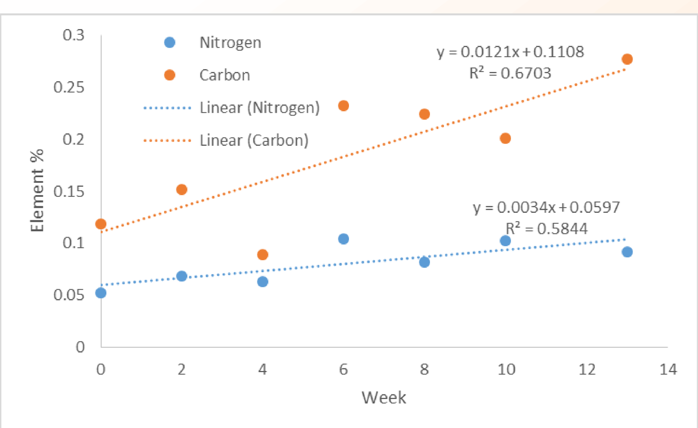

Figure 3. The general trend of Carbon and Nitrogen in the soil around chicken bone.

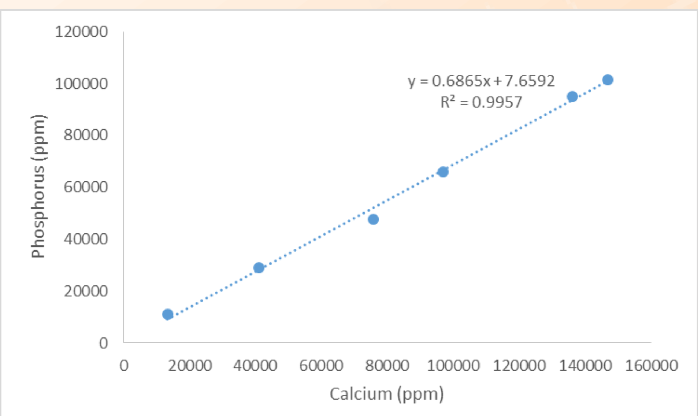

Figure 4. Correlation of the Calcium and Phosphorus species in chicken bone during the span of 13 weeks.

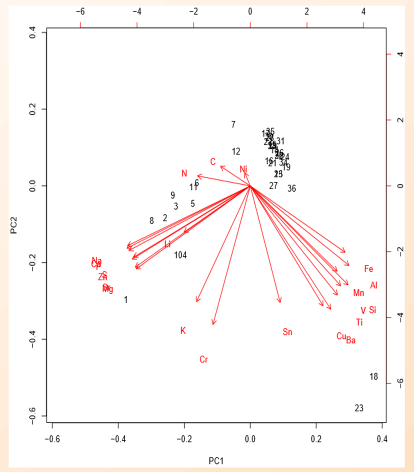

Figure 5. PCA biplot of top soil, decomposition soil and human samples of the ICP-OES and EA data.

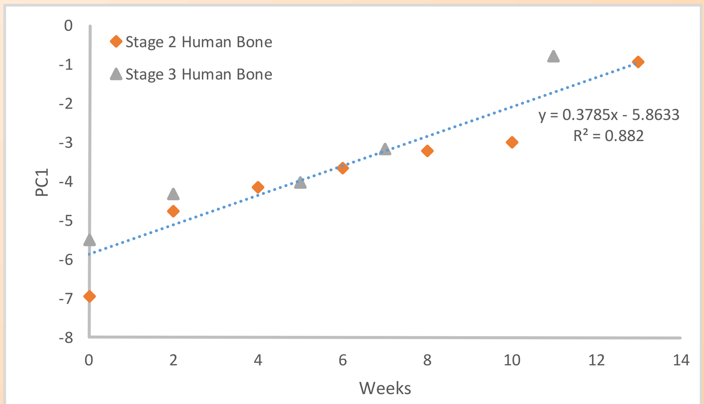

Figure 6. PC1 of Human Bone versus Weeks using the combination principal component analysis of the ICP-OES and EA data

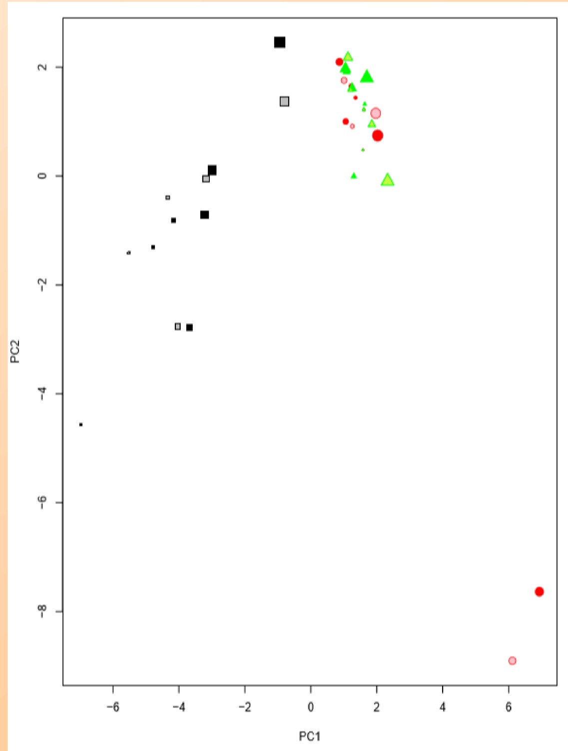

Figure 7: PC1 and PC2 distinguishing the types of samples (soil and bone) of the ICP-OES and EA data. Squares, bone; Triangles, decomp. soil; Circles, topsoil. Symbol size scaled to time, larger symbols represent later samples.

Results Continued

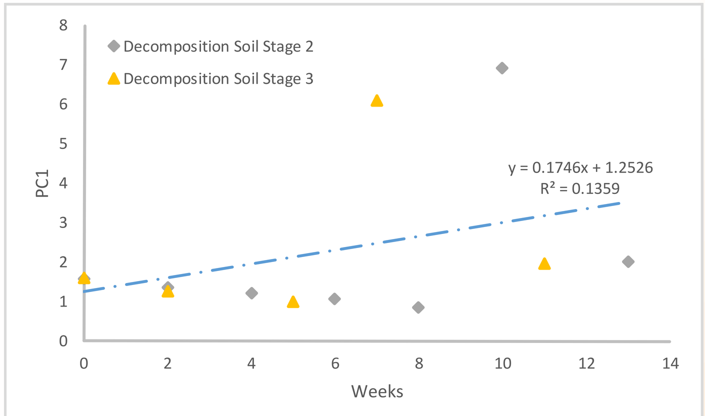

Figure 8. PC1 of Decomposition Soil versus Weeks using the combination principal component analysis of the ICP-OES and EA data.

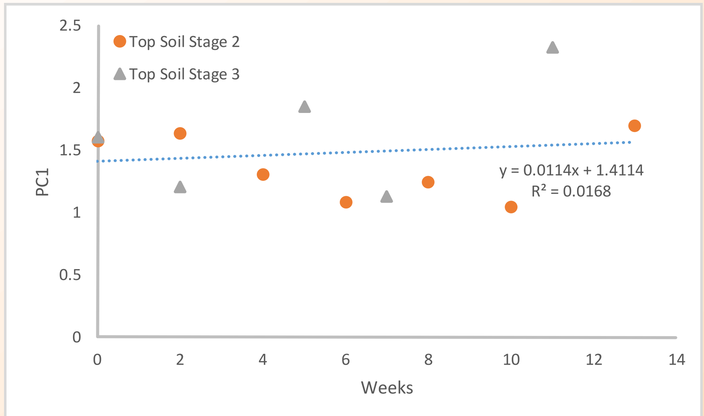

Figure 9. PC1 of Top Soil versus Weeks using the combination principal component analysis of the ICP-OES and EA data.

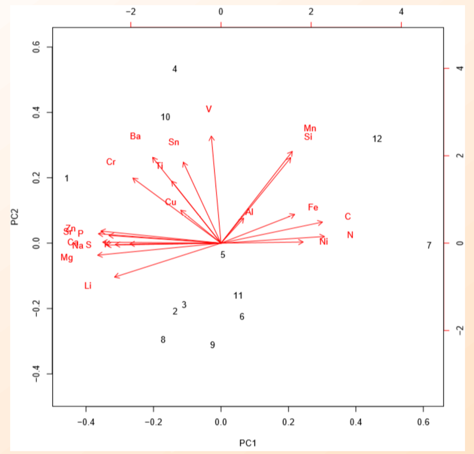

Figure 8. Principal component analysis of the human bone alone of the ICP-OES and EA

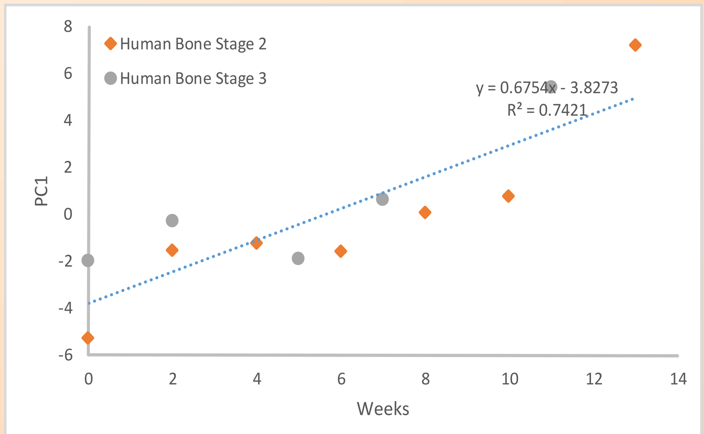

Figure 9. PC1 of Human Bone versus Weeks using the human bone principal component analysis of the ICP-OES and EA data

Conclusions/Future Plans

- ❖ IR spectra were not able to distinguish the time of decomposition between samples.
- ❖ Calcium and Phosphorus showed a linear relationship between the weeks
- ❖ Carbon and Nitrogen content in soil showed an increasing trend.
- ❖ Principal Component Analysis of both the combination and the human bone alone showed a linear trend of PC1 versus Weeks which can possibly be used to deduce time of decomposition.
- ❖ Sample types of bone versus soil could be easily distinguish with PCA
- ❖ Soil had less significant trends. Future studies need to be performed to increase measurement significance.
- ❑ Future Plans: Test reproducibility, different soil types, and different weather.

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