Estimating Time since Death Using Soil Chemistry of Burial Silhouettes

Stefanie M. Butera, Faye Postma, E. Christian Wells, and Erin H. Kimmerle
Cultural Soilscapes Research Group, Department of Anthropology, University of South Florida

Objective

This project examines the formation and longevity of burial silhouettes in sub-tropical lowland environments from the perspective of simulated human interments (using pig cadavers) to determine how these deposits change over time. The greater goal of this effort is to improve predictive models for estimating time since death in southern Florida.

Phosphorus (P) derived from body decomposition is believed to contribute to the production of burial silhouettes, or pseudomorphs, where the former body is outlined with a dark stain at the level of interment. It has been suggested that in sandy, acidic conditions, such as those that characterize many of Florida's soils, organic P complexes attract heavy metals, notably manganese (Mn), which result in dark stains. The phenomenon is poorly understood, however.

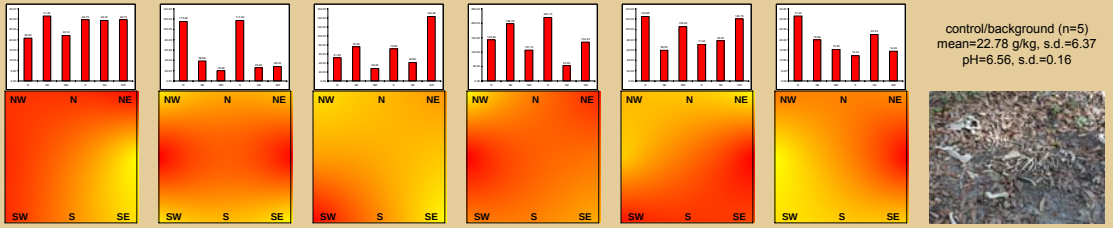
Methods

Six soil samples (taken directionally from the N, NE, NW, S, SE, and SW) were collected from the developing pseudomorphs underneath four open-air model corpses (Cadavers #3, #4, #5, and #6) every 30 days for a period of six months, resulting in 144 samples. Each sample was taken from the same locations each month using a corrosion-resistant, stainless steel hand auger, which was cleaned with water between sampling. For each sample, 25 g of soil was collected and placed into sterilized polyethylene bags. A handheld GPS device (accuracy <1 m) recorded the cadaver locations, and a grid was created for each pig using a measuring tape and compass.

Phosphate (PO_4^{3-}) and manganate (MnO_4^{2-}) ions were extracted using a Mehlich II solution and Hach reagents. Two grams of soil were placed in a test tube with 20 ml of Mehlich II extraction solution and agitated for five minutes. The sample was then filtered into a clean test tube. The extract was diluted (1 ml extract to 9 ml deionized water) into clean glass vials. For extractable P determination, the contents of a Phos Ver 3 powder pillow were added to the solution and dissolved. For extractable Mn determination, the contents of a citrate type buffer powder pillow were added and dissolved, followed by a sodium periodate powder pillow. For both analyses, after waiting 5 minutes for the reagent to react, the solution was analyzed using a portable Hach DR 850 colorimeter.

Results

Extractable phosphate (g P / kg soil), Cadaver #5

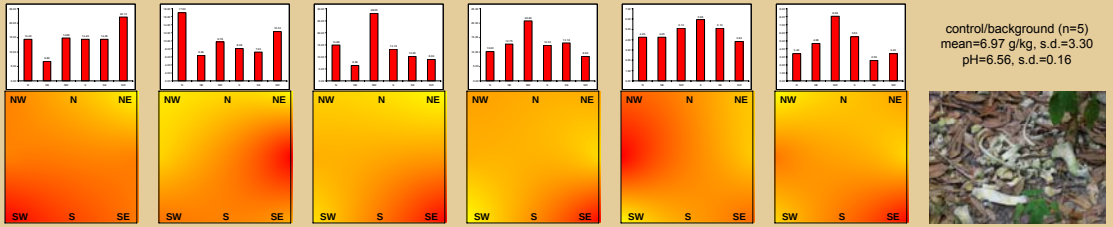


Day 1 | Day 30 | Day 60 | Day 90 | Day 120 | Day 150 | Day 180

control/background (n=5)
mean=22.78 g/kg, s.d.=6.37
pH=6.56, s.d.=0.16

Day 180

Extractable manganate (g Mn / kg soil) Cadaver #6



Day 1 | Day 30 | Day 60 | Day 90 | Day 120 | Day 150 | Day 180

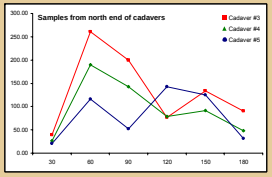
control/background (n=5)
mean=6.97 g/kg, s.d.=3.30
pH=6.56, s.d.=0.16

Day 180

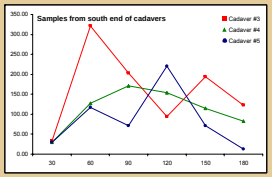
The image maps above show how P (top) and Mn (bottom) concentrations change over time in two particular cases (Cadavers #5 and #6, respectively). The maps are kriged interpolations, based on a linear variogram model. In both cases, P and Mn deposition varies by sample (NW, N, NE, SW, S, SE). There appears to be no clear pattern in the way in which a single sample contributes to elemental deposition over time. This suggests that samples should be aggregated and homogenized from all locations under the cadaver before analysis.

The line graphs at the right show how the concentration of P changes over time. The upper graph shows these changes for three cadavers using the samples taken from the northern portion of the corpse, while the lower graph shows the same study using samples taken from the southern portion of the corpse.

It should be noted that this study began in late fall at the onset of Florida's dry season and ended in early spring before the start of the rainy season. Thus, weather patterns may have played a role in elemental deposition.



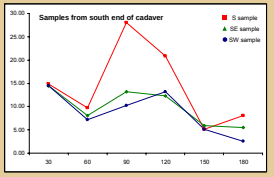
Concentration of extractable P (g P / kg soil) [y axis] over time (days) [x axis]



Concentration of extractable P (g P / kg soil) [y axis] over time (days) [x axis]

Both graphs show similar results. For samples taken at the end of the first 30 days, the concentration of P roughly matches the background level of P (ca. 23 g/kg). After 60 days, the P levels in the soil are as much as 10 times higher. After 90 days, P concentrations decrease by about 50 g/kg, with the exception of Cadaver #4, where P continues to increase slightly. After 120 days, the trend appears stochastic, with no clear pattern evident; P levels for some cadavers increase, while others decrease. There is, however, no dramatic incline in P concentration similar to that which took place during the first 60 days. By the end of the study, after 180 days, all cadavers show marked decreases in P concentrations, in some cases lower than the original background levels.

Finally, the line graph at the upper right shows how Mn varies over time for three different samples from Cadaver #6. In contrast to P, Mn levels at first decline during the first 60 days, and then increase to very high levels by the end of 90 days. This is followed by a consistent decrease in Mn for the remainder of the study. After 180 days, the pattern may become random.



Concentration of extractable Mn (g Mn / kg soil) [y axis] over time (days) [x axis]

Conclusion

This study shows that P and Mn enter the soil record through the decomposition process of the model corpses, and that these analytes have patterned depositions over time. Phosphate ions are at their highest after 60 days, while manganate ions reach their peak after 90 days. After peak concentration times, both ions decrease, but the decline does not appear to be consistent in time or space.