J Archaeol Method Theory (2010) 17:175–182
DOI 10.1007/s10816-010-9089-5

Prologue to Uses of Chemical Residues to Make Statements About Human Activities

Vance T. Holliday · Denise Lawrence-Zuniga · Victor Buchli

Published online: 22 June 2010

Abstract Soil chemistry provides the potential for interpreting the archaeological record without necessarily resorting to artifacts, historical documents, ethnoarchaeological observations, or experiments. The range of studies incorporating new technological developments, such as mass spectrometry and multi-element analyses, for analyzing and interpreting the chemical residues found at archaeological sites or modern contexts are increasing in the literature. However, the dilemmas of interpretation concentrate on evaluating the advantages and disadvantages of different techniques. Analytical approaches to how scientists make use of chemical residues to make statements about the past, discussed here, expand the potential of the breadth of techniques to investigate daily life activities and further our understanding of the materiality of social life.

Keywords Soil chemistry · Chemical residues · Chemical analysis · Human activities · Social space

Introduction

Evaluating chemical analyses and techniques for the archaeological interpretation of human activities in the past and present derives from a symposium presented at the 2006

V. T. Holliday
Department of Anthropology, University of Arizona, Tucson, AZ, USA

V. T. Holliday (✉)
Department of Geosciences, University of Arizona, Tucson, AZ, USA
e-mail: vthollid@email.arizona.edu

D. Lawrence-Zuniga
California State Polytechnic University, Pomona, CA, USA

V. Buchli
Department of Anthropology, University College London, London, UK

Society for American Archaeology annual meeting in Puerto Rico, organized by Sandra L. López Varela, Christopher D. Dore, and Manuel Palacios-Fest. The idea for organizing the symposium was to reunite a group of influential scholars and to honor Dr. Luis Barba from the National University of Mexico (UNAM) for his leadership in the analysis of chemical residues. Besides this well-deserved recognition, it was time to evaluate and discuss different techniques, field strategies, and theories to support the interpretation of human behavior in archaeological, historical, and ethnoarchaeological cases.

Soil chemistry is a very important component of geoarchaeology for the study of human activities by archaeologists, chemists, and soil scientists. In its early stages, soil phosphorus analysis was the first and remains the best known of soil chemical indicators of human activity (e.g., Arrhenius 1931, 1934; Lorch 1930, 1939; Proudfoot 1976; Eidt 1973, 1977; Bethell and Máté 1989; Holliday and Gartner 2007). The introduction of semiquantitative techniques by Luis Barba, deriving from agronomy and geochemistry, expanded the potential of soil chemistry for the interpretation of human activity areas mainly in Mesoamerica.

Soil phosphorus studies are still at the heart of most soil chemistry research in archaeology (Holliday 2004) and a component of most studies interested in the definition of the so-called activity areas across obvious occupation surfaces. There is a tendency for investigators to consider phosphorus as an unequivocal indicator of human activity, but it is not. Some, if not many human activities, leave no obvious soil phosphorus signature (see Middleton *et al.* in this volume). Over the years, some investigators have expressed rather negative assessments of phosphate analyses, accusing archaeologists of randomly choosing any one of literally dozens of phosphate methods for simple fishing expeditions (e.g., Bethell and Máté 1989, pp. 14, 16, 17). However, the potential of phosphorus analysis raises innovative questions regarding the stability of soil phosphorus over longer time scales. Phosphorus seems to be fairly stable at scales of hundreds to perhaps thousands of years, but apparently less so at scales of tens of thousands of years (Walker and Syers 1976). There are examples of phosphorus studies in sites on the order of 10,000 years old (e.g., Konrad *et al.*). On the recent end of the archaeological scale, sites resulting from sedentary and more complex human activities are likely to leave substantial chemical residues, for example, at Maya sites (see Wells in this volume), in Roman cellars in Italy (see Middleton *et al.* in this volume) or in farmsteads in Scotland, dating to the XVII–XIX centuries (see Abrahams *et al.* in this volume).

Advances in instrumental techniques have revolutionized and allowed the incorporation of a remarkable array of approaches using other chemical elements and compounds found in the surfaces of habitations to define human activities. One especially exciting development is the detection of fatty acids, carbohydrates, and amino acids to identifying various food products and other waste residues (see Middleton *et al.* in this volume). This type of residues offers significant insights into the kinds of ephemeral materials used in ritual contexts.

Beyond Phosphorus, New Strategies to Define Human Activities

Despite the innovations associated with this growing and promising field of inquiry into the activities that single out social life in the past, limitations in the uses of soil chemistry exist. Difficulties emerge when trying to distinguish the activity by a given number of chemicals, in discerning whether one or more activities took place in one location, and in clarifying the whole range of activities across dimensions of time and space. The analysis of chemical residues continue to support their results in various ways, for example, by correlating the findings to the specific area understudy and accompanying artifacts, by means of historical documents where available, by ethnoarchaeological observations, and by experiments. However, the ways these extra tools are used to support interpretations are now discussed in heuristic terms by several authors (see López Varela and Dore in this volume), as the archaeological preoccupation of relying on artifacts and built structures impose a certain limitation to the way the material world is understood.

In refining the potential of chemical residues to specify human activities with greater accuracy, multi-element analyses became a major step in archaeological soil chemistry (Wilson *et al.* 2008), with the pioneer work of various research teams headed by Luis Barba (e.g., Barba *et al.* 1996) and William Middleton and Douglas Price (e.g., Middleton and Price 1996; Middleton 2004), along with Jane Entwistle, Robert Dodgshon, and Peter Abrahams (e.g., Entwistle and Abrahams 1997; Entwistle *et al.* 1998, 2000). Their contributions are good examples of continuing advances in this aspect of soil chemistry in archaeology.

The application of soil chemistry, in its early stages, concentrated mostly on domestic contexts. The potential of soil chemistry has taken archaeologists to move to non-domestic settings and are now the subject of analysis. The incorporation of instrumental techniques and the detection of multiple chemical residues are revealing ephemeral material practices, normally undetected by archaeological excavation strategies or often unavailable to the ethnographer. Today, scholars have correlated fatty acids with food preparation in ritual settings (see Middleton *et al.* this volume). The combined concentrations of phosphates, fatty acids, carbohydrates, and proteins recovered in the Hall of the Eagle Warriors in Mexico City's Templo Mayor are associated with altars, braziers, ceramic sculptures, and images where rituals, including sacrificial acts, were carried out. Historical documents detailed the interpretation of these ritual activities that were chemically identified to such specificity that it was possible to recognize the materials used at each ritual location.

Uses of soil chemistry have also extended to demonstrate cultivation practices in infields and outfields near settlements, such as the Ben Lawers Historic Landscape project (see Abrahams *et al.* in this volume). However, the cultivation of these lands were associated with pre-eighteenth century sod houses, which are elusive, as these required frequent rebuilding and often changed location. Traditional artifact-based approaches are at a loss here. In such cases, in the absence of artifacts, the only way one can understand the domestic lives of the dwellers is through the chemical analyses of residues.

Advances in instrumental techniques are most likely to develop the analysis of chemical residues even further. Different analytical traditions between the Americas and Europe have their own choices of techniques. In Europe, the use of X-ray fluorescence spectrometry for the analysis of chemical residues is far more welcomed than in the Americas. The technique is capable of fully quantifying the concentration of a great number of chemical elements. The situation is about to change as portable X-ray fluorescence analyzers are becoming more affordable and precise (see Abrahams *et al*. in this volume).

The chemical analysis of residues has concentrated on analyzing “inorganic” chemical residues. An exception is the work of Luis Barba, who always expressed interest in studying organic residues to better understand what took place in the past. It is no wonder that this volume is dedicated to him, as Luis Barba is one of the few scientists using semi-quantitative techniques to determine fatty acids, carbohydrates, and proteins. In assessing the future of chemical analysis of residues in archaeology, the next step would be to incorporate quantitative organic chemical analysis, for example, through high-performance liquid chromatography to determine a different range of activities taking place in space (see López Varela and Dore in this volume).

In discussions of soil chemistry, there is an increasing interest in evaluating field strategies and sampling procedures (see Wells in this volume), as these crucial activities have an impact on the interpretation of human activities. In studying a particular archaeological context through chemical residues, the collection of samples represents an array of human activities that produce an almost infinite number of combinations of chemical elements and compounds. In the laboratory, samples are converted into quantitative measures and the analyst has to figure out what the numbers mean. This situation has compelled those working in this field of studies to incorporate refined sampling designs and spatial statistics in mutli-element analyses to manage vast amounts of data (see Wells, López Varela and Dore, Dore and López Varela in this volume).

Sampling strategies are key to the study of chemical residues for various reasons. The strategy followed in the sampling of a specific area will enhance the potential of finding activities or an absence of activities. Furthermore, sampling strategies determine the number of activities performed in a given space. Several studies have found that chemical enrichment in some instances is more intense in exterior spaces than in interior spaces, for example, in an ethnoarchaeological study in the Yucatan (see Middleton *et al*. in this volume). The approach by most of these studies of sampling guided by the concepts of interior and exterior spaces is under scrutiny today. What if we were to set aside the concepts of the built environment and instead considered archaeological sites as a palimpsest of discrete events? This approach would give every activity that took place in space equal chances of being selected with simple systematic and random sampling. Combined with this sampling strategy, image analysis and spatial statistics are introduced as heuristic tools to better approach social life in the past (see López Varela and Dore in this volume)

Heuristic Strategies for Analyzing and Interpreting Chemical Residues to Define Human Activities

The complex interplay of human activity and soil is in itself a complex relationship, even more so when it comes to interpretation. Theoretical interest in scientific and instrumental innovations has been mostly restricted to the development of social theory in relation to the sociology of sciences (Barad 2007; Latour 1987; Law 2004; Rouse 1993). One would think, with that degree of interest already firmly established in science and technology, that archaeology would be ready to address how scientists reason to analyze and interpret chemical data, particularly in relation to built spaces. Adopting a heuristic approach to soil chemistry has never been attempted before and it certainly brings new insights to address this complex relationship (see López Varela and Dore in this volume).

A heuristic approach reveals that the archaeologist's interpretive task involves far more than simply reporting the presence, intensity, combinations of chemicals, and the list of human activities they represent. The use of chemical analysis to define human activities is a process that necessarily has to address how to differentiate the chemical patterning of residues left by humans from that of animal behavior. In addition, there is a consideration that built spaces influence human behaviors, determining not only the activities that can be performed but also the concentration of chemical residues. The realm of everyday life includes many activities that are shaped, repeated, perpetuated, and materialized according to our subjectivities.

In many instances, some of these activities are performed with lesser or greater intensity through time at a particular location. With the incorporation of instrumental techniques and the detection of multiple chemical residues, soil chemistry is revealing ephemeral material practices, normally undetected by archaeological excavation strategies or often unavailable to the ethnographer, such as ritual practices. Today, scholars have correlated fatty acids with food preparation in ritual settings (see Middleton *et al.* this volume). The combined concentrations of phosphates, fatty acids, carbohydrates, and proteins recovered in the Hall of the Eagle Warriors in Mexico City's Templo Mayor are associated with altars, braziers, ceramic sculptures, and images where rituals, including sacrificial acts, were carried out. Historical documents detailed the interpretation of these ritual activities that were chemically identified to such specificity that it was possible to recognize the materials used at each ritual location.

Those studies using soil chemistry generally demonstrate a direct relationship between human activity and a chemical residue. Recent ethnoarchaeological investigations of domestic pottery production caution against overly simplistic interpretations, especially from analyzing single chemical elements of compounds that associate a particular physical location with a single behavior, urging to recognize that any particular behavior can occur in many different locations (see Dore and López Varela in this volume). There is no necessary or absolute relation between any particular behavior and any particular space. In applying soil chemistry to modern contexts, the archaeologist moves easily between behaviors and named spaces because the spaces are immediately accessible and seemingly obvious.

Understanding how these modern spaces are embedded in activities, conceived and reproduced by the inhabitants, is easier. However, imputing these connections to the unseen human behaviors and imagined spaces of the past is a real challenge. Assuming continuities with the past, especially as seen through our eyes, can be deceiving, as cultural practices and people change. The capacity for humans to recombine, reinvent, and restructure their relations with their material surroundings through time makes the archaeologist's interpretive task all the more challenging. The power of chemical residues for the interpretation of human activities should not be subdued to analogies. The potential of these techniques might begin to pose generalized observations on their own terms that might be considered along side, rather than subservient to, the insights provided by ethnographic research.

The problem of discerning particular human behaviors in particular settings recalls to a certain extent the mnemonic technique used by architects as an imagining design tool to anticipate and structure human domestic behavior in the “room”, the “living room”, the “bedroom”, or the “kitchen”. In the end, living humans will adapt these spaces to their own needs. The archaeologist, much like the architect, endeavors to inscribe the built forms of the past to define the humans who occupy, act in, think about, and feel the spaces they excavate. Archaeology and architecture are similarly engaged, as the first has to derive interpretations from scant physical remains, pertaining to their last use but that were used differently at other times. From these scant remains, the archaeologist has to give meaning to the complex of interrelated activities and to their place in space. Fortunately for the archaeologist, humans are creatures of culturally induced habits, returning to the same spot to repeat the same activities with the same materials, providing the chemical residues used by the archaeologist to demonstrate patterns of cultural behaviors. The reproduction of sociospatial forms assures the architect, for example, some predictability in design. The architect, however, builds spaces produced from ‘utopic vision’ but cannot predict how humans will adapt to the created spaces. Even in an ethnoarchaeological study, where it would be “obvious” that food preparation and cooking occur in the “kitchen”, the denomination of these spaces can undermine the interpretive intent as many other activities also take place in the kitchen that are unrelated to food preparation. Each, however, aims to create a meaningful homunculus, a scale model of the complete experience of living in a built space, by drawing on culturally constructed schema and knowledge about the material world.

Raising these issues enable us to literally think outside of the box of a ready-made science (Latour 1987) or, rather, of the analytical box in which only visible artifacts are relevant to archaeologists. Analytical techniques used in the study of soil/floor samples suggest a very intriguing potential to think of the materiality of the world without being in thrall to the concept of the artifact of material culture itself. Material culture is an analytical technique on its own. But the preoccupation with our carefully constituted artifacts suggests a certain limitation to the way we can understand the material world.

Unfortunately, there has been very limited engagement between the science of archaeology and material culture studies in general to address how we might research and represent an inconsistent representation of the past. A closer engagement is critical. The analysis of chemical residues to define human activities is currently giving significant steps towards addressing this gap.

New trends in chemical analysis allow us to think outside of the “house” as well, which has been the subject of much discussion in the social sciences. Basically, the present is demonstrating a very productive degree of “analytical philistinism”, if we may borrow a term from Alfred Gell (1999), to suggest that in recent studies of chemical residues a departure from conventionalism prevails. Introducing philosophy of science to the analysis of chemical residues is setting up a path focusing squarely on what the empirical chemical analyses suggest as an independent inquiry, regardless of what our presumptions, ethnoarchaeological analogies, and much loved analytical categories such as “house” or “artifact” might suggest to us. In a very similar way, that Gell (1999) suggested to depart from

Western art scholarship tending to view art devoid of social significance and instead search for an anthropological understanding of art, the heuristic approach to study chemical elements or compounds is suggesting that intense social activity takes place in space that may or may not leave traces (see López Varela and Dore in this volume).

Most likely, important events in the lives of humans are rarely intensive, a festivity takes place once a year or a person is initiated into adulthood only once. These observations support the call by Colloredo-Mansfeld (2003) for a renewed appreciation of the relative degrees of intensities of materiality, especially the ephemeral in the understanding of social life. A surface having an absence of intensity or a significantly decreased level of intensity of chemical residues are critical indicators of the relation humans maintain to the material world (see Middleton *et al*. in this volume).

These new approaches to chemical analyses promise new possibilities to more accurately represent the experience of humans living in built spaces. Thus, the instrumental and heuristic approaches to identify human activities are an opportunity for expanding our understanding more intently than that offered by ethnography, with its methodological focus on the ethnographic moment—one that is more materially focused on the relationship between these intensities and the ways in which people fashion daily life both in the past and in the present.

Acknowledgements Thanks to Sandra López Varela and Christopher Dore for organizing this session. They, plus anonymous reviewers, provided considerable help in finalizing the manuscript.

References

Arrhenius, O. (1931). Die bodenanalyse im dienst der archäologie. *Zeitschrift für Pflanzenernährung, Düngung, and Bodenkunde Teil B, 10*, 427–439.

Arrhenius, O. (1934). Fosfathalten I Skanska Jordar. *Sveriges Geologiska Undersökning, 28*, 1–30.

Barad, K. (2007). *Meeting the universe halfway: quantum physics and the entanglement of matter and meaning*. Durham: Duke University Press.

Barba, L. A., Ortiz, A., Link, K. F., López Lujan, L., & Lazos, L. (1996). The chemical analysis of residues in floors and the reconstruction of ritual activities at the Templo Mayor, Mexico. In M. V. Orna (Ed.), *Archaeological chemistry: Organic, inorganic and biochemical analysis* (pp. 139–156). Washington: American Chemical Society.

Bethell, P., & Máté, I. (1989). The use of soil phosphate analysis in archaeology: A critique. In J. Henderson (Ed.), *Scientific analysis in archaeology and its interpretation* (pp. 1–29). Los Angeles: U.C.L.A. Institute of Archaeology, Archaeological Research Tools 5.

Colloredo-Mansfeld, R. (2003). Introduction: matter unbound. *Journal of Material Culture, 8*(3), 245–254.

Eidt, R. C. (1973). A rapid chemical field test for archaeological site surveying. *American Antiquity, 38*(2), 206–210.

Eidt, R. C. (1977). Detection and examination of anthrosols by phosphate analysis. *Science, 197*(4311), 1327–1333.

Entwistle, J. A., & Abrahams, P. W. (1997). Multi-element analysis of soils and sediments from Scottish historical sites. The potential of inductively coupled plasma-mass spectrometry for rapid site investigation. *Journal of Archaeological Science, 24*(5), 407–416.

Entwistle, J. A., Abrahams, P. W., & Dodgshon, R. A. (1998). Multi-element analysis of soils from Scottish historical sites. Interpreting land-use history through physical and geochemical analysis of soil. *Journal of Archaeological Science, 25*(1), 53–68.

Entwistle, J. A., Abrahams, P. W., & Dodgshon, R. A. (2000). The geoarchaeological significance and spatial variability of a range of physical and chemical soil properties from a former habitation site, Isle of Skye. *Journal of Archaeological Science, 27*(4), 287–303.

Gell, A. (1999). The art of anthropology: Essays and diagrams. In E. Hirsch (Ed.), *London school of economics monographs on social anthropology 67*. London: Athlone.

Holliday, V. T. (2004). *Soils in archaeological research*. New York: Oxford University Press.

Holliday, V. T., & Gartner, W. G. (2007). Methods of soil P analysis in archaeology. *Journal of Archaeological Science, 34*(2), 301–333.

Latour, B. (1987). *Science in action, how to follow scientists and engineers through society.* Cambridge: Harvard University Press.

Law, J. (2004). *After method: Mess in social science research*. London: Routledge.

Lorch, W. (1930). Neue methoden der siedlungsgeshichte. *Geographische Zeitschrift, 45*, 294–305.

Lorch, W. (1939). Methodische Untersuchungen zur Wüstungsforschung. Arbeiten zur Landesund Volksforschung. *Anstalt für geschichtlich Landeskunde* Band 4, Friedrish-Schiller Universität, Jena.

Middleton, W. D. (2004). Identifying chemical activity residues on prehistoric house floors: a methodology and rationale for multi-elemental characterization of a mild acid extract of anthropogenic sediments. *Archaeometry, 46*(1), 47–65.

Middleton, W. D., & Price, T. D. (1996). Identification of activity areas by multi-element characterization of sediments from modern and archaeological house floors using inductively coupled plasma-atomic emission spectroscopy. *Journal of Archaeological Science, 23*(5), 673–687.

Proudfoot, B. (1976). The analysis and interpretation of soil phosphorus in archaeological contexts. In D. A. Davidson & M. L. Shackley (Eds.), *Geoarchaeology* (pp. 93–113). Boulder: Westview.

Rouse, J. (1993). What are cultural studies of scientific knowledge? *Configurations, 1*(1), 1–22.

Walker, T. W., & Syers, J. K. (1976). The fate of phosphorus during pedogenesis. *Geoderma, 15*(1), 1–19.

Wilson, C. A., Davidson, D. A., & Cresser, M. S. (2008). Multi-element soil analysis: an assessment of its potential as an aid to archaeological interpretation. *Journal of Archaeological Science, 35*(2), 412–424.