Middens, Waste Disposal, and Health at Çatalhöyük

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Panorama of Building 80 in the South Area excavation at Çatalhöyük. Flikr (CC BY-NC-SA 2.0).

The transition from a mobile hunter-gatherer lifestyle to a settled way of living is one of the most significant processes in human history. There were undeniable benefits to this process, with increased food security and longer lifespans, but there were also negative consequences associated with an increased density of living. At Çatalhöyük we have over one thousand years of continuous occupation from the Pre-Pottery Neolithic to Chalcolithic period (7100–5700 BCE). The settlement changes from a dense agglomeration in its earliest phase, where individual buildings are constructed wall to wall with no gaps or streets between them, to a more open nucleated settlement towards the end of the occupation. Large numbers of people living in a fixed location inevitably leads to the production of large amounts of waste. One of the most significant consequences of these activities is the creation of "pollution," both in the physical environment, and the decline in air quality.

The term *midden* has traditionally been used in archaeology to define a "trash" deposit containing waste occupation debris from food processing, fuel burning, and other activities. Deposits classified under the category of midden can be very heterogeneous (Shillito 2015). The middens of Çatalhöyük are one of its distinctive features. Large, expansive deposits with exceptional preservation of organic materials, the middens are the main source of many of the environmental remains found at the site. As well as the materials contained within them, the midden deposits themselves have been subject to extensive and long running investigation, better to understand their formation processes and the activities represented within them (Shillito and Matthews 2013; Shillito and Ryan 2013; Portillo et al. 2019). Their composition is diverse, consisting of mixed "waste" debris including animal bone and shell, charred plant macro-remains, pottery sherds, ground and chipped stone, building debris, large volumes of ash related to various fuel burning activities, and substantial quantities of fecal material from both humans and animals (Shillito, Matthews et al. 2011; Garcia-Suarez, Portillo, and Matthews 2018).

The middens are located in areas between buildings, or within abandoned buildings (fig. 1). Recent research on middens at Çatalhöyük has developed to explore the health risks associated with living in close proximity to these large quantities of waste, and the activities associated with them (Shillito, Mackay et al. 2017). While there has been extensive research on the health of the Çatalhöyük population from the osteoarchaeological record (Hillson et al. 2013; Larsen et al. 2015), gastro-intestinal and respiratory health (and the former in particular) are more difficult to address, as they do not commonly leave traces that can be identified on the skeleton. Early studies at Çatalhöyük for example identified black carbon residues on the interior surface of ribs from three individuals, which have been interpreted as evidence for the respiratory disease anthracosis (Andrews et al. 2005; Birch 2005), although this interpretation is not universally accepted. There is also the paradox that skeletons showing significant traces of disease are likely to be survivors who have been subject to illness for an extended period of time, whereas an individual who succumbed very quickly to a disease would not have time for the skeleton to be impacted.

Understanding the presence and impact of respiratory and gastro-intestinal disease necessitates a multiproxy approach, bringing together different methodologies and different strands of evidence. This article presents an overview of how this approach is being used to investigate the relationship between human activity, waste disposal, and health in the built environment at Çatalhöyük, and how the long-term nature of the

Figure 1. Excavation of Building 80 at the end of the 2010 season, showing large midden deposits in the upper left and upper right. Photograph by Jason Quinlan.

archaeological record has the potential to help inform our understanding of the relationship between health and the built environment in the present and future.

Gastro-Intestinal Health

The shift from a mobile hunter-gatherer lifeway with dispersed groups to a sedentary lifeway where large groups of people live together has been termed the first epidemiological transition, characterised by an increase in infectious disease transmission, amongst other ailments. The transmission of infectious disease is facilitated through accumulation of human waste, and it has been argued that intestinal diseases such as parasitic infections may have been altered during this period of human history (Harper and Armelagos 2010; Reinhard et al. 2013; P. D. Mitchell 2015). The picture is complex as the life cycles of parasite species are different, and the changing environment may have facilitated the spread of certain parasites while hampering the spread of others (P. D. Mitchell 2013).

Early work on coprolites found within middens at Çatalhöyük determined that many of these deposits are human (fig. 2; Shillito, Bull et al. 2011), determined through fecal lipid analysis. The identification of fecal waste as human or animal can be determined on the basis of sterol and bile acid profiles, related to diet and gut biochemistry (Bull et al. 1999), and determination of coprolite species using fecal biomarker analysis has become a well-established method in archaeology (Shillito et al. 2011b; Shillito et al. 2013; Prost et al. 2017). More recently this technique has been combined with the analysis of coprolite contents, providing both a species determination and an identification of parasites contained within the coprolites (Ledger et al. 2019). Two coprolites identified as human at Çatalhöyük were found to contain eggs from whipworm. This is the first evidence for intestinal parasite infection at a Neolithic town in the mainland near east. Both human whipworm (*Trichuris trichiura*) and pig whipworm (*T. suis*) produce eggs of similar appearance on microscopy. While pig whipworm eggs are on average a little larger than human whipworm, there is some overlap in their size ranges (Beer 1976). By using fecal biomarkers we can make a distinction between parasite species that infect different hosts, but whose eggs appear morphologically similar, in this case supporting the identification of human whipworm, *T. trichiura*.

T. trichiura is spread by the fecal contamination of food and water. The life cycle involves the infected person defecating;

Figure 2. Human coprolite from Çatalhöyük. Photograph by Lisa-Marie Shillito.

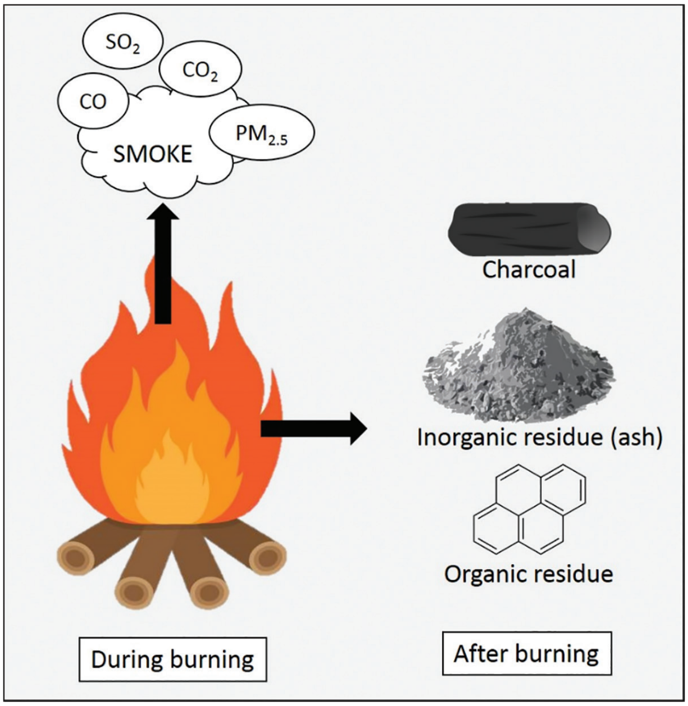

Figure 3. Archaeological analyses of fuel remains has traditionally focused on charcoal, which is most readily detected within archaeological deposits. Geoarchaeological methods have shown that inorganic residue (ash) and organic residues are especially important when characterising non-wood fuels, which typically do not leave charcoal remains but are transformed to inorganic residue (ash). The component of ash is variable depending on fuel type, with major and trace elements (Shillito 2019).

the eggs then mature in a damp, shady environment for one to two weeks, when they mature and reach the infective form. If the eggs are then swallowed by another person the eggs hatch in the intestines, develop into adult worms, mate, and lay eggs, which become incorporated into the feces. While the eggs have not yet been observed in the midden deposits themselves, it is clear that these deposits would have provided an ideal environment for the maturation of these parasites. The concentration of the eggs was relatively low at four to twelve eggs/g (Ledger et al. 2019), which indicates either a low infection, or could be the result of taphonomic processes. Parasite eggs can be easily damaged or destroyed by postdepositional processes such as fungal decay and bioturbation. If the people who deposited these coprolites genuinely had a low number of worms in their intestines, they may not have shown symptoms. In modern studies, individuals with a significant whipworm infection have symptoms ranging from abdominal pain, anaemia, and diarrhoea to stunted growth in children (Stephenson, Holland, and Cooper 2000; Bethony et al. 2006; Jourdan et al. 2018).

Studies of parasites from other Neolithic sites in the Mediterranean have identified a mix of zoonotic species such as tapeworm (*Taenia sp)* and liver fluke (*Fasciola sp.*) which spread from animals to humans, and geohelminths such as roundworm and whipworm, which spread between humans through contaminated soil and food. In later periods in the Mediterranean, the parasite assemblages are dominated by geohelminths, and zoonotic species are increasingly rare (Anastasiou et al. 2018). One hypothesis that has been presented to explain this is the change in subsistence patterns from the Neolithic, with a mixed subsistence pattern, to a heavy reliance on farming and herding from the Bronze Age onwards. At Çatalhöyük, a dominance of domesticated cereal crops and domesticated animals such as sheep and goat (Bogaard et al. 2013; Bogaard et al. 2017; Russell et al. 2013) is more similar to Bronze Age and Iron Age populations of the Mediterranean than other Neolithic sites where parasites have been found, with the hypothesis that the lifestyle and diet of the Çatalhöyük inhabitants resulted in a more restricted range of parasite species (Ledger et al. 2019). This is a hypothesis to be tested in future through analysis of a larger assemblage of coprolites from Çatalhöyük.

Respiratory Health

As with parasite infections, we know from modern studies that exposure to the by-products of fuel burning causes substantial negative impacts on the environment and on health, particularly in low and middle-income countries such as Turkey (Babalık et al. 2013). Domestic heating is thought to be a greater cause of pollution than industry, especially during winter when people are more likely to be burning large quantities of fuel indoors (Tasdemir, Cindoruk, and Esen 2005; Özden, Döğeroğlu, and Kara 2008), and levels of exposure are linked to both age and sex (Mentese et al. 2015). Given the large quantities of ash present in middens, and the ubiquity of fuel burning activities across the site, it is highly likely that the inhabitants of Çatalhöyük were regularly exposed to respiratory irritants.

Figure 4. A reconstructed building at Çatalhöyük. Photograph by Lisa-Marie Shillito.

During the early occupation of Çatalhöyük we see the beginnings of pottery production in the region, and changes in fuel management strategy, where animal dung fuel became more prominent over time (Shillito, Matthews et al. 2011; Bogaard et al. 2013). There is also evidence that certain fuel-burning activities were relocated outdoors (Bogaard et al. 2013; Shillito and Ryan 2013). Fuel in the archaeological record has typically been approached through the analysis of wood charcoal in association with architectural features such as hearths, ovens, and kilns. Non-wood fuels such as animal dung, agricultural by-products, and reeds/grasses are more difficult to detect as they are rapidly transformed to ash on burning (fig. 3; Canti 2003; Matthews 2010). Geoarchaeological techniques have demonstrated the potential for identifying these previously "invisible" fuel signals, and numerous case studies now show that techniques such as sediment micromorphology, in combination with inorganic geochemistry and microfossil analysis of ash, can identify fuel types when wood charcoal is not preserved (Mentzer 2014; Shillito 2012), and when nonwood fuels have been used (Shillito, Matthews et al. 2011; Matthews 2016). A wide range of fuel materials have been identified in ash deposits at Çatalhöyük, including reeds, grasses, and animal dung, as well as a range of different types of wood in the archaeobotanical record (Asouti 2005, 2012).

Pilot studies were conducted in Turkey during 2017 to assess the feasibility of the idea that the methodologies used for monitoring air pollution in modern cities could be applied to archaeological settlements. Wood and dung fuel were burned in a reconstructed experimental building (fig. 4), and emissions monitored using particle counters. Samples of the remaining ash deposits were also collected to assess differences between particulates produced during burning, with observations indicating high levels of silica from the burning of dung, as expected. The levels of fine particulates (PM $_{2.5}$) measured in reconstructed prehistoric houses at Çatalhöyük were at incredibly high levels, in one experiment reaching 18,000 $\mu g/m^3$ within 20 minutes and fluctuating around that value for around 1.5 hours before decreasing (Shillito, Mackay et al. 2017). The WHO guideline safe level for PM 2.5 is an average 25 $\mu g/m^3$ over a 24 hour period (WHO 2016). The construction of houses at Çatalhöyük are likely to have contributed to these levels, with very poor air circulation. Pollution is exacerbated by a lack of ventilation and lack of flues, and the observations from this pilot study strongly support the hypothesis that the prehistoric inhabitants were exposed to exceptionally high levels of fine particulate matter on a regular basis, which is likely to have caused serious respiratory health problems for the settlement.

Lessons from the Past?

Multiproxy studies of middens at Çatalhöyük are providing unique insights into the presence and potential impacts of respiratory and gastro-intestinal disease, and how these may relate to the change in lifeways that occurred during early sedentism and urbanisation. Future research needs to integrate these approaches with osteoarchaeological analysis to explore broader patterns of health and incorporate spatial analyses better to understand the spatial distribution of fuel burning activities and waste deposition in relation to habitation areas, and how this changed over time. The GIS and Çatalhöyük data archive offer many possibilities in this regard, which are only just beginning to be explored.

But the Çatalhöyük record offers possibilities beyond an understanding of the human past. With the advent of the Anthropocene, archaeologists are beginning to look at how we can use the lessons of the past to tackle modern day problems, for example understanding sustainable agriculture (Marchant et al. 2018; Stump 2010) and historical ecology (Braje et al. 2017; J. Mitchell 2017). Such studies demonstrate the importance of understanding long-term (greater than lifetime) records of human-environment dynamics in order to make informed decisions regarding modern-day responses to environmental change. As noted by Lane (2015), the archaeological contribution so far has been constrained to providing a better definition of when humans began impacting their environments and describing the nature and scale of these impacts.

A recent policy brief developed through the WHO Regional Office for Europe was produced in response to the increasing awareness of the relationships between culture and health and advocates the application of research from humanities and social sciences (Napier et al. 2017). The gap between knowledge and practice in public health is an ongoing concern, and research has shown that policy makers are often faced with complex information that can be difficult to access (van de Goor et al. 2017). The way that research is reported and framed has a strong influence, with media attention and tailored approaches facilitating the use of research evidence by policy makers. Both traditional and social media have been found to be useful in framing problems. Archaeology became an important part of Turkish national identity in the 1930s following the establishment of the Republic (Tanyeri-Erdemir 2006), and continues to play a prominent role today, as "both an economic and a diplomatic commodity" (Özgüner 2015). As a World Heritage Site, the high profile of Çatalhöyük already attracts significant attention in the media in Turkey and globally.

Future research will build on the pilot studies discussed here, conducting a systemic analysis of the entire settlement to understand how fuel burning activities and waste deposition change over time, and the relationship with a changing settlement layout, and the spatial distribution of fuel burning and fecal waste deposition. Simultaneously, the aim is to expand collaborations to include anthropologists working on heritage and community health, and to understand how archaeology could be used to highlight public health issues in Turkey and beyond.

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