

WASTE MANAGEMENT AND ATTITUDES TOWARDS CLEANLINESS IN MEDIEVAL CENTRAL EUROPE

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MOTTO:

The sewer is the conscience of the city.

Victor Hugo

ABSTRACT

The paper deals with the relationships between people and waste in the Middle Ages, primarily in urban environments in Central Europe. At the center of interest are the attitudes of the inhabitants of medieval cities towards cleanliness and a description of different waste management practices. This paper also describes an experiment using ashes to launder clothing as one possible use of a particular waste material.

Keywords: Middle Ages, waste, waste management, recycling, environment, hygiene, cleanliness, ashes, clothes laundering

INTRODUCTION

Today, when people think of the past, they often attribute a sense of backwardness to our ancestors. This opinion seems to be stronger the deeper we delve into human history — and pre-history. This view clearly stems from the linear view of human progress over time; history has gradually led from primitivism to today's "perfect state of progress." But we are often surprised when we discover historical facts that reveal how advanced—technologically, artistically, or otherwise — our predecessors were. And the further back we go in time, the greater our surprise.

Similar prejudices prevail in how we imagine the sanitation and waste management practices of our predecessors. Another common belief is that societies that produced only organic waste did not have to deal with waste management because everything they threw away decomposed on its own. This stereotype, however, cannot really be applied to any actual society. It cannot be assumed that if only organic waste was produced, its presence did not need to be dealt with. The Middle Ages are generally thought of as the dark ages. Perhaps

how medieval society viewed public space¹ or the hegemony of the Catholic clergy who called for purity of spirit at the expense of bodily cleanliness² (see further) contributed to this conception. Well-worn images of people dumping waste from their windows; narrow, muddy city streets; and ubiquitous dirt and disease are applied to the entire Middle Ages. The aim of this paper is to re-examine the above-described views of this period. We will focus on whether the relationship of medieval society to waste and public space was truly so hopeless, as well as examine how people managed waste. Based on case studies documented in historical, written sources as well as in material, archaeological ones, we will attempt to shed some new light on this issue in Europe. Considering the fact that there are no set, universal dates for the medieval period, as its duration differed from region to region, we must establish a suitable timeframe for our study. This study shall focus on the German High Middle Ages between 1050 and 1250, and the late Middle Ages between 1250 and 1500. At the same time, our geographical focus is mainly on waste management in Central Europe. This paper focuses in detail on the urban environment because it can provide a greater source of data about waste management (in the form of archaeological findings and written sources) than rural areas. Towns, with their confined nature, had a more urgent need to solve waste-related problems.³

DEFINING WASTE

Every living organism produces waste. Human beings are no exception; in fact, they produce much more waste than other organisms. This fact stems from humans' ability to adapt using artefacts, thanks to which they could acclimate to the variety of natural conditions found throughout the Earth. People produce an abundant variety of waste. On the one hand there is universal, ubiquitous bodily waste; on the other, human activities have resulted in waste specific to the place and time in which it was produced. This type of waste is an important source of information about the lives of ancient people that we can uncover with the help of archaeological research.

We can obtain a wealth of information from waste: it can tell us about common everyday items, the technologies used to produce them, long-distance trade (when items of distant provenience are found), and social differences on the basis of the use of luxury items and common objects. Waste deposits are also an important source of information about food sources (thanks to animal bone and plant macro-residue finds), about the health of the population (e.g., parasite egg finds), or about the natural environment at the settlement and its vicinity. Considering the fact that towns have had to deal with waste since they first

¹On the basis of written sources, Norbert Elias showed how understandings of public space, the shame associated with bodily functions, violence, and table manners changed in the transition from the Middle Ages and the Early Modern Era (Elias, 1969).

² It must be added that Catholic clergy along with educated monks comprised the only educated class in medieval society. Innovations in monastery architecture made ingenious contributions to waste management in these buildings.

³The fact that the contemporary Fresh Kills landfill on Staten Island is the largest manmade structure on Earth with an area of twenty square kilometers bears witness to the key function of waste in human society.

emerged,⁴ urban waste is a valuable source of information about the day-to-day lives of town dwellers. Dozens of archeobotanical studies that provide invaluable information have been conducted on medieval waste deposits in many European cities. Urban waste can often tell us much about agricultural practices in a town's hinterlands because the composition of weeds found therein is a good reflection of the conditions under which grain was grown (weeds were often sorted from grain before milling; therefore, these weeds found their way into the town). On the basis of macro-residue found in medieval pits in Olomouc, a detailed reconstruction of synanthropic vegetation growing directly in the town has been conducted (Opravil, 1994).

In the following text, we shall, however, examine waste from a slightly different perspective. Breaking with tradition, we want to use it to study the waste itself. We are interested in how our ancestors managed waste and what were their attitudes towards it, and more generally, towards the cleanliness of their environment. Due to waste's fluid nature, we shall first attempt to define and categorize waste. Several categories of waste can be defined (Graph 1); in the Middle Ages waste was made up of kitchen waste, human and animal excrement (this category includes two sub-categories based on how this material was deposited), construction waste, and waste created when producing artefacts.

Fig. 1: Graph 1 (Author: Filip Havlíček)



⁴For example, the Neolithic settlement of Çatal Hüyük in modern Turkey, where the study of waste resulted in great knowledge about the relationships between local inhabitants.

Ore mining waste also existed in the form of gangue; mixed waste can also be found. We can also include a category of *other waste* because some materials defy identification.⁵ According to Guillaume, in our list we must also include waste water, which was produced when organic materials such as hides, wool, hemp, and flax were soaked before further processing (Guillaume, 1988). However, as we are interested in the relationships people had with their waste in the past, mechanical classification based on origin will not suffice. All waste needs to be evaluated in context, not as an independent entity. The attitude we have towards a particular type of waste plays a fundamental role in our perception of it. Thus, the term *waste* contains many meanings and how it is perceived depends on its context.⁶ Just as a resource may transform into waste, waste, too, may become a resource. It all depends on how we view the given material. Instead of a one-way view of the waste process in which resources transform into waste, we work with a model of recycling or reutilization, which were typical practices before the Industrial Revolution. Cognitively speaking, waste is located somewhere outside of the human order. Waste de facto ceases to exist only once it has fully and definitively decomposed. In practice waste management has a fully causal relationship with the size of the population⁷ of a given agglomeration. A suitable place for observing these environmental problems is the city—that is, a place where a large amount of people coexist in a relatively small space.

THE MEDIEVAL TOWN AND DEPOSITING WASTE

Medieval cities⁸ were compact, layered, and closed off by walls; market squares functioned as the economic and social heart of the city. This definition points to some of the basic attributes of cities. The more a town began to grow, the greater its need for waste management. Unlike rural areas, where the contents of dung heaps and waste pits could be used as fertilizer, towns were dependent upon the regular removal of waste, which was ideally performed by municipal offices (Jenner, 1991).

Towns, with their limited surface area, were forced to constantly grow upward. In a city such as Prague, with its well-preserved historical urban core, we can easily demonstrate the tendency for cities to develop upward. The original ground floors of medieval houses are today usually cellars. In some cases, it was best to artificially raise the land or in places level

⁵If a rare artefact is found amongst waste, it could have gotten there by chance, and therefore it would not be appropriate to consider such waste as mixed waste. Thus, this category helps us “blur the edges” of the other sharply defined waste categories and include here objects that are open to classification.

⁶Mary Douglas gives the example of how differently hair is viewed when on people’s heads and when found in soup (Douglas, 2003).

⁷Its production is an indelible part of the functioning of all organisms.

⁸There is a German saying that “the air of the city is liberating” (Le Goff, 1997). Moving from the countryside to the city meant for many people an opportunity to leave behind a socially bound group of relatives and acquaintances for the anonymous environment of the city. Cities, which over the course of the centuries filled with new inhabitants, sometimes did not easily accept new arrivals. The large market, money, and number of people were all advantages. To become a burgher was not easy and many landless people were unable to overcome the barriers that the minority of original inhabitants set up in order to protect their high status. Nonetheless, it was the countryside that to a large extent facilitated urban growth (Le Goff, 1997).

the ground by filling with waste or gravel. This was the case in Prague's New Town, where the location of previous wetlands (surrounding today's V jámě Street) was used as a dump for household waste and construction waste. Filling in this space resulted in new building plots (Březinová & Selmi Wallisová, 2016). It is, however, difficult to trace the evolution of waste in towns with any continuity in the medieval period. Due to regular street cleaning, today we do not know the full stratigraphy of street waste in some towns (Březinová & Selmi Wallisová, 2016). As Moravec notes, in seventeenth-century Ostrava, bailiff's instructions were issued that prohibited the accumulation of waste in front of and behind buildings, in the streets, and along town walls (Adamus, 1929 in Moravec, 2014).⁹ However, as some archaeological studies of urban spaces demonstrate, such regulations were not always adhered to. For example, in the lower part of today's Wenceslaus Square waste deposits greater than one meter in thickness have been found (Pokorná, in press). Several thin layers of polished river stones are clearly recognizable between refuse layers containing common kitchen waste and various scraps and unfished products from artisans' workshops. It seems that from time to time the surface of the square was levelled and waste was covered in gravel that was transported in.

Waste can be categorized based on its material nature, that is, whether it is organic or inorganic, or its place of origin, that is, from dwellings, from workshops, or from construction sites. Understandably, these proposed categories cannot be isolated, closed-off units; their mutual effects on each other and their intermingling demonstrate the complexity of the processes associated with the production, existence, and subsequent study of human waste. We can theoretically classify archeologically proven waste storage areas into four types:

- 1.) Sites created primarily for this purpose – pits, which likely served for depositing any type of waste (organic kitchen waste, fecal matter, artefacts). Pits were generally square shaped with a support beam in each corner; wooden braces were placed horizontally between the trams to provide greater support, whereas the back of the pit was lined with wooden boards (Moravec, 2014). These pits were sometimes up to 5 meters deep (Moravec, 2014). Following the concepts put forth in Neustupný's theory of waste areas (2007), we can define the waste contained in these pits as secondary waste. Considering the moist, anaerobic environments in pits, artefacts made of organic materials, which under normal conditions in an oxygenated environment would rapidly decompose, as well as ecofacts, such as floral macro-residue, were often preserved.
- 2.) Sites primarily serving another purpose, which saw secondary use for depositing waste (e.g., dried-up wells or cellars of abandoned and decaying houses, or pits originally dug for other purposes, such as clay pits, etc.). This type of waste management is evidenced from the Neolithic Age, when abandoned houses were used as waste dumps (Květina, 2010). Again, this type of management results in secondary refuse following E. Neustupný's classification.
- 3.) Surface waste areas, dumps (again secondary refuse according to E. Neustupný). The above-mentioned layers of waste from Wenceslaus Square certainly fall into this category.
- 4.) Randomly located, disorderly and irregularly deposited or discarded waste. (primary refuse according to E. Neustupný).

It is remarkable to note that findings clearly indicate that organic artefacts, which could have been used as heating fuel, often ended up in pits. A large amount of wooden materials

⁹The potential use of waste deposits during sieges by enemy combatants was already mentioned in ancient Rome. Therefore, it was forbidden to deposit waste nearby town fortifications (Pichtel, 2005)

has been found in such sites (fragments as well as nearly complete wooden artefacts). The variety of organic material also includes bones, wood scraps, and scraps of leather (e.g., from shoemaking), and organic macro-residue, including the stones of cherries and other fruits, eggs shells, animal bones, and hearth ashes (Moravec, 2014). Inorganic artefacts found in Moravská Ostrava include stone and metal fragments (including slag), glass artefacts, daub, and pottery (Moravec, 2014). Thus, it seems that all material that was for some reason attributed the status of waste ended up in pits.

Occasionally, artefacts appear in pits that we assume were discarded by accident (classified as “other waste”). One such example is a polished piece of chalcedony discovered in a fecal pit from Prague’s Horse Market (Koňský trh, the location of today’s Wenceslaus Square) near the house of physician Matyáš Borbonius of Borbenheim; this stone was allegedly used for reducing fever (Pokorný, 1999). The composition of waste materials might indicate the social status of the inhabitants of each plot. For example, the rare presence of silk in a waste deposit might be a sign of prosperity and the high socioeconomic standing of the person who used it, as opposed to the owners of more common woolen or linen textiles (Březinová & Selmi Wallisová, 2016). The discovery of rare exotic spices and fruits bears witness to the exceptional status of a property owner, and at the same time it provides us with information about long-distance trade; examples include the discovery of nutmeg in Beroun (Čulíková, 1994) or discoveries of less common plants (Čulíková, 1995; 2007). It is also interesting to note that pits were often emptied after they filled up. The material was likely deposited somewhere outside the town walls. As Moravec notes, if refuse was thrown into a river, it is nearly impossible to find. According to Hoffman, however, town leaders took care of water quality in rivers (Hoffmann, 2009). Moravec assumes that pits were cleaned out every three to five years and that one pit could be used for about twenty to thirty years.¹⁰ Understandably, we must take these figures with a grain of salt (we do not know how many people used one pit or how often), as the author himself mentions (Moravec, 2014). If a pit was regularly cleaned out, then the archaeological findings reflect the last phase of its use. Conserved full pits that have been covered with a thick layer of clay can also be studied using archaeological methods. Beginning in the fourteenth century and picking up in intensity from the sixteenth century onward, waste sites were permanently lined and regularly cleaned out after filling up.¹¹

¹⁰Larger pits that exceeded 20m³ in volume could be used for about 50 years (by four to six users) (Schütte, 1986).

¹¹Nonetheless, previously dried-up wells were already used for depositing waste. It is remarkable to note that medieval society, before the rise of science during the Enlightenment, did not associate epidemics with waste and contaminated water (cesspits have been discovered in the immediate proximity of well, for example). At the time people saw the link between disease and environmental pollution more in terms of air quality. Therefore, it is no wonder that medieval society suffered from cholera epidemics and various parasitic diseases, as studies of medieval ponds indicate. Waste usually found a way into the water (Pokorný, 1999).

WASTE IN THE STREETS

If the streets and squares of a medieval town were paved, it was an exception; their surfaces were usually covered in just a thin layer of sand, stones, branches, or boards. Universal paved streets might seem at first glance to be major advancement, but sometimes paving might have resulted in unexpected problems. If urban paving stones¹² were not combined with other measures, they “plugged up” the relationship between the town and the soil (Sterner, 2008)¹³; there was no natural means for waste to dissipate and soak into the soil. Such problems arose in Paris, when King Phillip Augustus decided in 1292 to pave all of Paris’s streets (in part because of bad odors) (Corbin, 1986). Smaller streets and side streets in towns were sometimes intentionally used as aboveground sewers for draining rain water, as well as waste water (and thus fecal matter as well, most likely). These ditches contributed to making smells worse (Hoffmann, 2009). Astronomer and physician Křišťan of Prachatic¹⁴ was clearly talking about Prague when he said, “Oh, how fitting would be a clean town free of the malodors of rotten carcasses, hanged men on the gallows, and empty cellars, for more people would be healthier... (Hoffmann, 2009). In the Zbraslav Chronicle one can encounter the following sentence in a passage on famine: “When the poor were turned away from the doors of Prague houses and were not admitted for lodgings due to the thefts they had committed, at night lying on the streets and squares, they, for the nakedness of their bodies and the chill of the frost, would climb, like pigs,¹⁵ into dung that had been thrown from horse stables into the street” (Dudák, 2002). Such references seem to fit in well with stereotypical notions about the common occurrence of throwing fecal matter¹⁶ and waste from buildings onto the street.¹⁷ However, such ideas seem to be far from the truth. After a few months’

¹²From written sources (specifically from a decrees of paving rights in the Bohemian town of Louny) we can learn that “*Due to the depth and immensity of the mud up, until now for many people it was not easy to wade across the street and looking at it made you sick to your stomach*” (Hoffmann, 2009).

¹³Before paving came into use and in places where stone was inaccessible, corduroy roads made of logs bound together. They allowed movement in wet environments.

¹⁴In Plzeň Hilarius Litoměřický also preached about keeping the streets clean and warned against malodorous dung, which was a source of the plague.

¹⁵Every situation was unique and reflected the local situation and politics. For example, in Frankfurt raising pigs in the old town was forbidden in 1481 due to the mess they made. According to town leaders, this practice was incompatible with the size of a city such as Frankfurt (Pounds, 2014).

¹⁶Large cities such as London, Paris, and Venice had tens of thousands of inhabitants in the Middle Ages (Schofield, 2003). The average medieval urban dweller may have produced on average 150 g of stool per day; today’s average is 128 g (Rose, 2015). In earlier times, people ate more fiber than in today’s Europe. If we do the math, each person produced about 55 kg of excrement per year. Even though human stool contains up to 75% water (Rose, 2015), even smaller towns would be filled up with it quickly. People did defecate on the streets, but they often did so on smaller side streets and alleys. In Plzeň and Louny streets existed in the Middle Ages that bore vulgar names such as Usraná ulička (Beshitten Lane) (Hoffmann, 2009).

¹⁷It must also be mentioned that free-roaming animals, such as dogs and pigs, could have partially cleaned the streets of organic waste and excrements (for more about this idea, see the current situation in Madagascar). Animals owners were likely not anonymous and their animals were somehow marked,

time, medieval streets would have been impassable.¹⁸ Written sources indicate that waste was transported outside of town walls with a frequency that was likely related to the intensity with which the streets filled with waste.¹⁹ In the Middle Ages there were even reportedly citizens' initiatives demanding streets in front of buildings were kept clean (Rawcliffe, 2012).²⁰ Waste areas were created outside of towns, where paid workers would transport street waste when need be (Jørgensen, 2008). As medieval towns grew, new, previously unexpected situations emerged that needed to be dealt with systematically.²¹ In 1469 throwing refuse out of windows onto the street was prohibited; it could only be discarded in public spaces when it was raining so that it would be washed out of the town (Hoffmann, 2009). The town would only pay for street cleaning after large events, such as markets. People from the lowest walks of life—beggars and vagrants—were hired to do this job (Hoffmann, 2009). The fear of epidemics was one of the driving forces behind urban environmental management.²² Knackers, shepherd, prisoners, and paupers were hired to clean the streets of animal carcasses and waste (Sádlo, 2005).²³ According to Cipolla, northern Italian cities such as Florence, Genoa, Milan, and Venice had the most progressive solutions for waste management in the Middle Ages and Early Modern Period (Cipolla 1981). Cipolla associated this progressiveness with the Roman Empire's advanced state of technology and society; he even talks about it being part of the heritage of the empire. For example, concern about the atmosphere comes from Classical times; we can encounter it in the thinking of Hippocrates. There was, however, nothing superstitious about it; in the Classical world, for example, when cities were built, much greater attention was paid to wind

e.g., with bells (Hoffmann, 2009). This method of "grazing and ownership" related to waste management is known from more recent times from cities such as Cairo (Eriksen, 2011).

¹⁸Assuming that accumulated waste was not dealt with in any way and inhabitants relied on rainwater to wash it away.

¹⁹For example, Schütte (1986) states that the central German town of Göttingen (6,000 inhabitants) produced more than 1,200 tons of waste per year and more than 88 million liters of wastewater.

²⁰Despite bans, sometimes waste was thrown out of windows, as evidenced by several relevant court cases (Hoffmann, 2009).

²¹Thick layers of organic materials made up mainly of horse manure have been found by archeologists in Prague's Old Town. Older paving stones were placed atop these layers (Březinová & Selmi Wallisová, 2016).

²²In the Middle Ages it was a commonly held belief that diseases (such as the plague) were spread through the air through noxious vapors (i.e., miasmata) emitted by decaying material contained in waste deposits, dung heaps, etc. (Eriksen, 2011). Today, we know that the plague was transmitted to humans by fleas that fed on rats. Therefore, the rats that lived off of human-produced waste posed a major public health threat. This theme was later incorporated into the medieval German legend of the pied piper of Hamelin.

²³Before glass windows appeared, windows were shut by wooden shutters. Prior to the fourteenth century small windows were covered with translucent film made of animal offal (Hoffmann, 2009). These types of openings must have permitted outdoor stenches to penetrate dwellings with greater intensity than if there had been glass windows. The issues of light and ventilation (especially in winter) can only be debated.

currents, humidity, and so on, than today. In Venice one island was set aside only for depositing waste, which was transported there daily by boat.²⁴

Some interesting, local evidence about waste management in medieval Prague and its progression over time has been preserved. Organic material filled into the Old Town moat has been analyzed (Beneš *et al.*, 2002); this material comes from several periods in the moat's existence. During the thirteenth century, when the moat was used for defensive purposes, it was kept clean (clean water flowed through it and refuse did not accumulate here). After the establishment of the New Town in 1345 the moat lost its defensive function, at which point it only served as a border between the two neighboring towns. It became a welcomed space for depositing refuse, and it quickly filled with organic material.

It is interesting to note that after a certain amount of time, the intensity in which refuse was discarded here diminished; we know this thanks to the species composition of plants found here (species that grow on abandoned land without long-term disturbances). Written sources indicate that in the sixteenth century citizens established gardens along the entire length of the former moat. At the same time, there is evidence of efforts by town officials to clean the ditch, which indicates that it was still being filled in with waste (Pokorná *et al.*, in print). The existence of gardens established on former dumps sparks an interesting question: Would such an idea be thinkable today? Contemporary waste contained only organic and natural materials, which acted as good fertilizer; nonetheless, waste from some trades could also be highly toxic.

TOILETS, LATRINES, AND GARDEROBES

The woodcarving depicted in Fig. 3 is often interpreted as illustrating medieval attitudes towards public space (see Pichtel, 2005; Sterner, 2008; etc.). However, this scene most likely shows just the punishment for disturbing the peace at night. The woman dumping the contents of the vessel on the heads of street musicians is probably not interested here in waste management; she wants to force the rabble-rousers to be quiet.²⁵ Although it is certain that wastewater was sometimes dumped from windows, this practice was almost certainly not a standard form of waste removal. Smith mentions, for example, that close stools or chamber pots kept under the bed were used as medieval toilets in Western European bedrooms (Smith, 2007). If a family was of a certain means, they modernized their dwelling, built a second floor, added a chimney, and set aside a special place for dirty activities located generally outside in the yard (Smith, 2007). In most castles pit toilets and latrines were built and could number several dozen. Most places, however, lacked sewers²⁶ and flush toilets were a rarity (Smith, 2007); in the Czech lands most people did not have a toilet in their home until the sixteenth century (Hoffmann, 2009).

²⁴Similarly, in 1947 the Fresh Kills Landfill was established on one of New York City's islands.

²⁵Hoffmann notes that louder trades were performed farther away from churches or outside of town walls (Hoffmann, 2009).

²⁶The town that Leonardo da Vinci proposed for King Francis I of France, was ahead of its time. He planned to connect all buildings in the town to a sewer system that drained into a river (flowing water, not stagnant water, was an important element here). One of the pillars of this proposed town was waste management and related air quality measures (Sterner, 2008). Although this was not a new idea (recall the Cloaca Maxima in Rome), it was significant in its view of the city as a whole (Sterner, 2008).

Today, we can still find many preserved medieval toilets in castles. Castles and monasteries often had latrines that drained into rivers or moats. The garderobe is a type of medieval castle toilet (Durdík, 2000) that generally extends from an exterior castle wall. After defecating, excrement fell down the castle wall and into the moat. At Buchlov Caste, we find see a toilet with a waste chute leading directly to the second courtyard (Figs. 3, 4, and 5). The question still remains of how this material was dealt with afterward. At the same castle one can find a fortified toilet with an arrowslit; the toilet itself and the drain “pipes” were covered in sheathing (Fig. 6, 7, 8, and 9). The seat was usually made of simple stone or wood (depending on its user’s status, it could also be upholstered). Toilet paper, in today’s sense of the word, however, did not exist for common people. Jiří Sádlo has put forward a remarkable idea—in some cases it seems that moss was used in place of toilet paper.²⁷ Archaeologists have found moss in pits (Schütte, 1986; Sádlo, 2005). The most common species include red-stemmed feathermoss (*Pleurozium Schreberi*), glittering woodmoss (*Hylocomium splendens*), and *Neckera crispa* (Sádlo, 2005). Moss also could have been used to make something akin to today’s menstrual pads. This type of hygienic aid is known to have been used even after World War I.²⁸ Moss might have been utilized for its antiseptic effects (Morton *et al.*, 2010). In the countryside, bodily waste was applied to the soil as fertilizer with a high potassium and phosphorous content (Gibson et Farrar, 1974). This strategy of reutilizing human excrement as fertilizer was an important part of medieval agriculture (Stern, 2008).²⁹ Nearly all organic waste was brought to the fields to be used as fertilizer. Here, rural areas were significantly different from medieval urban areas, where it was impossible to effectively reuse this unpleasant waste. In this context, Gandy notes a disrupted continuation between waste and productivity, between agriculture and waste, and between town and countryside.³⁰ Thus, the malodor³¹ of waste does not evoke the productivity of the town, but becomes its unpleasant partner. In the eyes of urban dwellers, the countryside was a place of leisure and recreation (Gandy, 1999).

Fertilizer, however, was not the only use for human excrement. It was occasionally put to use when laying siege to castles; the attackers would employ a strategy intended to contaminate their enemy’s position with infection and bad smells. Barrels filled with fecal matter, animal carcasses, and other unclean items were shot from trebuchets and catapults.

²⁷Jiří Sádlo also toys with the idea of a specialized trade—“mossmen,” who would collect and sell moss for various construction and sanitary purposes. Moss was used in buildings as insulation and perhaps as damping material in stone buildings. The recent discovery of the use of moss (most likely to spread out the weight of the stonework) on stones contained in the ninth arch of Prague’s Charles Bridge is remarkable (interview with Petr Pokorný). In the Wallachian region of the Czech lands, moss was still used in the twentieth century as insulation for wooden cottages, where it was stuffed in between the beams the cottage was made of.

²⁸http://americanhistory.si.edu/collections/search/object/nmah_729448

²⁹This manner of fertilizing is still used in some parts of the world today (such as in China).

³⁰It was the disconnection of the town from agriculture and the inclination towards industry and commerce that definitively separated the urban environment and the rural into two worlds dependent upon each other.

³¹From the thirteenth century onward, the air was considered unbearable in towns. The need of burghers to spend the summer in rural retreats probably reflects this idea. (LeGoff, 1997). Here, we can see an analogy with ancient Rome (Hughes, 2001).

One well-known case is the siege of Karlštejn Castle of 1422, when the contents of such barrels (there were reportedly 1822 of them) were collected in Prague's cesspools (Uchytíl, 2012). Considering the fact that at castles the source of drinking water was often rainwater, fecal matter that struck the roof could contaminate drinking water of the troops defending the castle in the future.

A remarkably comprehensive analysis of the contents of medieval toilets was conducted in Worcester (Greig, 1981). Researchers found thirty-eight beetle species, some of which evidently lived off of the uninviting contents of the latrines, whereas others hunted and ate these insects. In addition, they discovered various crop pests that may have been thrown away when rotten food was discarded. Woodworms that may have fed off the toilet seats have also been found. And of course, moss was also found. The seeds of edible plant species were also found and include mustard, flax, grapes, gooseberries, raspberries, blackberries, cherries, plums, apples, coriander, fennel, figs, hazelnuts, blueberries, and oats. A similar variety of edible plant remains has also been found in medieval Czech cesspits.

WASTE AND SOCIETY

Written sources provide evidence that the streets of medieval towns often did feature piles of waste accompanied, especially in warmer months, by strong odors and swarms of insects. On the other hand, town dwellers were certainly not pleased with this situation and on many occasions tried to rectify the problem, with varying degrees of success. Thus, it seems that in the Middle Ages certain general rules about cleanliness already existed. The mere existence of such often unwritten rules did not automatically guarantee perfect cleanliness; such rules, however, express a certain ideal that should guide the way. It was up to each person whether or not he or she would live by them. As Mary Douglas (2003) has demonstrated, if rules of cleanliness exist, we must ask what is their political significance, or, more specifically, who is excluded and discredited by these rules.³² The same patterns of behavior can be observed in how waste is managed. During plagues or other wide-scale infectious epidemics that broke out during the Middle Ages, it was believed that Jews were responsible; this notion sometimes resulted in pogroms. In the Middle Ages Jews were separated from the social majority in ghettos. Hoffmann writes: "The cause was often sought out amongst the Jews—unjustifiably [when Jewish bathing rituals were thought] to contaminate water, and justifiably when Jewish homes [that] were often overcrowded and filthy" were viewed as the cause. (Hoffmann, 2009).³³ The sociopsychological phenomenon of the diffusion of

³²Environmental protection efforts are often mainly motivated by economics, as Martin O'Brien demonstrates (2008).

³³It is worth noting that today's city centers and wealthy neighborhoods are cleaned more often using public money than poor areas and ghettos. Eriksen states that in Western Europe, prestigious parts of the city were generally situated in the western part of the city. There was a rational reason for this—the wind blowing from the sea from the west was not contaminated with the smell of waste (Eriksen, 2011). The driving forces behind the location of more prestigious neighborhoods in cities are quite interesting. In many cases they are located on hills, perhaps due to better air, views, etc. Some sort of evolutionary paleo-instinct leads us to copying this pattern. We naturally seek out vantage points (lookout towers and elevated spots) when we go hiking in our free time. The desire to find look-out points is probably the result of natural selection, an adaptation that might have occurred in the Paleolithic Era. Having a view of the land enabled our ancestors to observe migrating animals, a necessity for hunters and gatherers. On the other hand, in cities at higher elevations, and with thinner air, more prestigious, wealthy neighborhoods are found in the lower parts of the city (e.g., in Quito, Ecuador, and in La Paz, Bolivia).

responsibility is often manifested in how waste is handled. In some cases, this model could represent people's attitude towards waste. For people, it is clearly easier to make a place that is already dirty dirtier than it is to dirty a clean place. In practice, places where waste has been collected will acquire more waste faster than the street, which is clean; the reason is that someone else is responsible for starting the waste pile and we are merely contributing to it. In the process, we avoid the responsibility of the initial pollution. Diffusing responsibility is a prosocial behavior. In practice, we attribute the responsibility of a certain phenomenon to other people involved in it, of course, while excluding ourselves (Darley & Latane, 1968).

Religion and its influence on day-to-day life could have played a role in evaluating cleanliness and related attitudes toward waste management in the Middle Ages. Theoretically, the medieval way of life was focused on caring for the mind, whereas caring for the body as a value was kept in the background (Hoffmann, 2009). The cult of the body, bodily pleasure, and cleanliness as well, may have been in conflict with the dogmatic teachings of the Catholic Church, which called for spiritual cleanliness. Some verses in the Old Testament (for example in Leviticus) proscribe things that are unclean—for example, some animals, childbirth, the unclean skin of lepers, and sexual uncleanliness. It is also forbidden to touch animal carcasses, human corpses, animal and human excrement, and unclean places. Copulation, “unclean” women (most likely those that were menstruating), diseases, sperm, blood, nakedness, and physical deformities were also considered unclean (Smith, 2007). The rejection of caring for one's body is a remarkable change considering these Old Testament rules and the preceding Classical era with its baths, decorated latrines, etc. Although medieval cities did have baths, they often had bad reputations as brothels (Hoffmann, 2009).

As Smith notes, society was not dirty; if a man wanted to get somewhere in life, he had to take care of himself and dress properly in clean clothes (Smith, 2007). From the perspective of hygiene, Christianity, as the dominant religion in medieval Europe, called for spiritual cleanliness at the expense of bodily cleanliness (for example, in Islam and Judaism great emphasis is placed on ritual cleanliness, bathing, animal slaughter, and food preparation). Christian rules stood in contrast to the “exuberant pagan life,” ancient Greece's cult of the body, and the hedonistic life of the Roman elite. Christian asceticism focused on dogmatic teachings about forgoing sex, fasting, and extended periods of isolation. The rituals associated with animal slaughter in Judaism are very strict. Cleanliness is emphasized (special rooms exist for different activities) and it was not possible to slaughter animals in public space, as Bartosiewicz notes in his study of the “archaeology of bad smells” (Bartosiewicz, 2003).

However, we would like to avoid overgeneralization and labeling the entire Middle Ages as a period of filth. It is definitely necessary to keep in mind the fact that dirtiness was a problem that was to a significant extent an economic and technical problem. The medieval elite were concerned with cultivating the body—for example, women adorned themselves with various items and a cult of the strong, graceful body of the knight existed. As has already been mentioned, many monasteries (for example, those belong to the Cistercian Order) had a sanitation infrastructure for waste management that was a highly advanced for the era (Vlček *et al.*, 1997).

RECYCLING AND THE SECONDARY REUSE OF WASTE

Recycling played a fundamental role in the medieval life. Practically all usable material was recycled or otherwise reutilized. In rural areas fecal matter was used as fertilizer. This use was also possible in medieval towns, where land between houses could be used for small-scale farming. In Central Europe, which in this period was to a certain extent in the “shadow” of the richer western and southwestern regions of Europe, buildings were often rebuilt instead of new buildings being constructed. Perhaps the greater extent of the secondary use of all major construction materials such as wood, stone, brick, and perhaps even daub stemmed from this fact. For example, in some cases building materials (bricks and roof tiles) from older Roman buildings were used to make buildings in both the early and high Middle Ages. Examples include the Great Moravian basilica in Bratislava (Novotný, 1986), the Děvín church in Uherské Hradiště – Sady (Hochmannová-Vávrová, 1957), and French cathedral of Autun (Clark, 2006; Bailiff *et al.*, 2010). Recycling and reutilization took place at markets, where raw materials such as glass and metal were bought (Davis, 2010).

Palimpsests are also evidence of reutilization. Important communications were written on parchment, which was a very expensive item that was often cleaned and reused for writing another document. Writing was scraped off parchment and washed off of papyrus. Today, X-ray technology can help us read the original documents that have since been written over (Lyons, 2011). The recycling of textiles for repairing and altering clothes has been documented (Rammo, 2012 in Březinová & Selmi Wallisová, 2016). As a matter of fact, out of frugality the clothes and bedding that dead people left behind were not thrown out, not even during epidemics (Hoffmann, 2009).

One interesting example of recycling, or rather reusing waste material, is its use for insulation. At Prague Castle the filled-in vaults under the floor of Vladislavský Hall, which contain waste from carpenters’ workshops as well as kitchen waste and construction debris from the sixteenth and seventeenth centuries, have been studied (Košňovská, 2011; Beneš *et al.*, 2012). This material served to insulate the space under the hall’s wooden floor. Today it is a unique witness to life at the time that has been preserved extraordinarily well, thanks to the dry environment. A large part of it is made up of plum pits and nut shells. Due to the exceptional location of this site at Prague Castle the unique remnants of what were at the time very rare imported plants can be found here; they included olives, almonds,³⁴ peanuts (certainly the oldest documented in Central Europe), pistachios, and coffee beans. Ash was a ubiquitous waste material that could be reused to wash clothes. Ashes from herbs such as rosemary were used as toothpaste.³⁵ When wood ash is combined with water it creates an alkali solution that can dissolve fats and thus remove the dirt that adheres to them. Wood is mostly made up of organic materials that when combusted mostly transform into gas. With an ample supply of oxygen (complete combustion) minerals are concentrated in the ash; they are thermally stable or do not transform into inadequately volatile or completely non-volatile oxides. These materials make up the chemical foundation of ashes. Thanks to their basicity these oxides are able to bond to the carbon dioxide released during combustion, and therefore they can be found in ashes in the form of carbonates. With the most important compounds being K_2CO_3 (potash) and Na_2CO_3 (sodium carbonate). These carbonates are, in terms of their chemistry, strong base salts (KOH, NaOH) and weak acid salts (H_2CO_3); therefore,

³⁴Almonds, however, (if they really were from the Middle Ages) did not necessarily have to be imported. During the medieval warm period, almonds and figs may have grown in Bohemia.

³⁵Instead of brushes, pieces of fabric were used (Hoffmann, 2009).

when they react with water, hydrolysis occurs and an alkali solution is created. Historically, these compounds were extracted from wood ash in raw form and then further purified through boiling and evaporation into potash. This material, however, was not pure K_2CO_3 (the chemical formula used today for potash), but rather a mix, a majority of which consisted of K_2CO_3 (30–90 %) with residual potassium sulfate (K_2SO_4), potassium chloride (KCl), sodium carbonate (Na_2CO_3), compounds of phosphorous, iron, and silicates, and organic impurities (Woitsch, 2009). This raw material played a key role in glassmaking as well as other industries that required alkali substances. Raw wood ash acted not only as a base for making potash, but also as a useful substance used in common households. In emergency situations when soap is not available the World Health Organization recommends the use of ash as a substitute for hand washing and disinfection.³⁶ We can assume that people were aware of these qualities of ash in the past and could intentionally use it for both personal hygiene and laundering clothes.³⁷

AN EXPERIMENT WITH LAUNDERING CLOTHES

An experiment was conducted to verify the hypothesis mentioned above. The use of historically available materials and feasibility under simple outdoor conditions were stressed. Ash produced from burning a mix of beech and hornbeam wood was used as the input material. It was combusted in a well-ventilated stove; the raw ash produced contained a visually small amount of incompletely combusted residue, which was removed using a fine sieve. The sorted ash was very light in color, which indicated a high percentage of mineral compounds over incompletely combusted organic matter, which is dark in color.

We measured out 200 grams of ash, which was mixed with 3 liters of fresh rainwater. We mixed this suspension several times and then let it rest for one hour. The resulting solution was then poured through a clean linen cloth to remove undissolved matter. The filtered solution was colorless. The approximate pH of the solution was measured using pH test paper; we recorded a pH of about 11.

We used a piece of finely woven painter's canvas cut into 10x20 cm rectangles, which we then smeared with an ample amount of pork lard so that the fabric was fully soaked and a large stain was created. This dirty piece of fabric was then soaked by hand in the solution while rubbing it to clean it. The washed samples of fabric were then air dried.

Upon visual inspection, the hand-washed and dried fabric in no way differed from the original, unsullied cloth. The grease stain that was clearly visible on the sample before being washed had disappeared; after being washed it was impossible to tell where the stain had been and how large it was. This simple experiment confirmed the very good washing effect of a solution gained from leeching ashes. The solution, with his high alkalinity, could easily dissolve fats and thus remove dirt. Although terms such as “alkali solution” are the trappings of modern science, we can assume that in the distant past people were aware of these qualities due to their empirical experiences. When we washed by hand in the solution we could clearly feel it burning our skin, resulting in a slippery feeling on our fingers. If the skin is already clean, the upper skin layer will be removed. But for dirty skin, this solution is a relatively effective means of cleaning and disinfection.

³⁶http://www.who.int/water_sanitation_health/emergencies/qa/emergencies_qa17/en/

³⁷In the twentieth century, ash was used still used in cities to clean silverware and plates.

CONCLUSION

We can hardly reconstruct the environment of medieval Europe. Then, like today, some places in Europe were more polluted than others. Behind this fact are many causes, which cannot be fully explained. In our analysis presented in this paper, we have just slightly opened the door to studying waste management—we must conceptualize waste from a social, political, economic, and technical perspective. Society and waste can never be fully separated from each other; unwanted material must be viewed as part of our environment. Popular stereotypes about omnipresent trash and dirt in public spaces in the Middle Ages most likely do not fully reflect the historical reality (Magnusson, 2013). Compared to today's world, in the Middle Ages there was likely relatively little waste.³⁸ It is likely that, if we exclude excrement, the greatest volume of waste consisted mainly of building waste and ashes, a situation that remained unchanged for several hundred years after the Middle Ages.

REFERENCES

- Adamus, A. (1929). *Sbírka listin k dějinám města Mor: Ostravy*. Nákladem Města Moravská Ostrava.
- Bailiff, I. K., Blain, S., Graves, C. P., Gurling, T., & Semple, S. (2010). Uses and recycling of brick in medieval and Tudor English buildings: insights from the application of luminescence dating and new avenues for further research. *Archaeological Journal*, 167(1), 165-196.
- Bartosiewicz, L. S. (2003). There's something rotten in the state...': bad smells in Antiquity. *European Journal of archaeology*, 6(2), 175-195.
- Beneš, J., Čulíková, V., Kosňovská, J., Frolík, J., & Matíášek, J. (2012). New plants at Prague Castle and Hradčany in the early modern period: a history of selected species. *Interdiscip. Archaeol*, 3(1), 103-114.
- Březinová, H., & Selmi Wallisová, M. (2016). Odpadní vrstvy a objekty jako pramen poznání stratifikace středověké společnosti—výpověď mocného smetištního souvrství z Nového Města pražského. *Archaeologia historica* 41, 1, 2016, 179–191.
- Beneš, J., Kaštovský, J., Kočárová, R., Kočár, P., Kubečková, K., Pokorný, P. & Starec, P. (2002). Archaeobotany of the Old Prague Town defence system: archaeology, macro-remains, pollen and diatom analysis. *Vegetation History and Archaeobotany*, 11, pp 107–119.
- Cipolla, C. M. (1981). *Fighting the plague in seventeenth-century Italy*. Univ of Wisconsin Press.
- Clark, W. W. (2006). *Medieval cathedrals*. Greenwood Publishing Group.
- Corbin, A. (1986). *The foul and the fragrant: odor and the French social imagination*. Harvard University Press.
- Čulíková, V. (1994). Nález zbytku plodu muškátovníku vonného (*Myristica fragrans* Houtt.) v Berouně – The finding of the rest of a nutmeg (*Myristica fragrans* Houtt.) in the town of Beroun. *Archeologické rozhledy*, 46, pp 252–254.
- Čulíková, V. (1995). Zpráva o prvním archeobotanickém nálezu tabáku (r. *Nicotiana L.*) ve střední Evropě. *Archeol. Hist.*, 20, pp 615–619.

³⁸Besides wild and domesticated animals, worms and microorganisms helped get rid of it.

- Čulíková, V. (2007). Zpráva o prvním archeobotanickém nálezu líčidla amerického (*Phytolacca americana* L.) ve střední Evropě a o dalších druzích užitkových rostlin z Prahy-Hradčan. *Archeologické rozhledy*, 59, pp 353–370.
- Davis, J. (2010). Marketing secondhand goods in late medieval England. *Journal of Historical Research in Marketing*, 2(3), 270-286.
- Darley, J. M., & Latane, B. (1968). Bystander intervention in emergencies: diffusion of responsibility. *Journal of personality and social psychology*, 8(4p1), 377.
- Douglas, M. (2003). *Purity and danger: An analysis of concepts of pollution and taboo*. Routledge.
- Dudák, V. (2002). *Pražský poutník, aneb, Prahou ze všech stran*. Baset.
- Durdík, T. (2000). *Ilustrovaná encyklopedie českých hradů*.
- Elias, N. (1969). The civilizing process, vol. I. *The history of manners*.
- Eriksen, T. H. (2011). *Søppel: avfall i en verden av bivirkninger*. Aschehoug.
- Gandy, M. (1999). The Paris sewers and the rationalization of urban space. *Transactions of the Institute of British Geographers*, 24(1), 23-44.
- Greig, J. (1981). The investigation of a medieval barrel-latrine from Worcester. *Journal of Archaeological Science*, 8(3), 265-282.
- Guillerme, A. (1988). *The age of water: the urban environment in the North of France*.
- Hochmannová-Vávrová, V. (1957). *Nálezy římských cihel ze Starého Města u Uherského Hradiště*. Sborník prací Filozofické fakulty brněnské univerzity. E, Řada archeologicko-klasická. roč. 6, č. E2, s. 23-36
- Hoffmann, F. (2009). *Středověké město v Čechách a na Moravě*. Nakl. Lidové Noviny.
- Hughes, J. D. (2001). *An Environmental History of the World*. Routledge. London.
- Jenner, M. S. R. (1991). *Early Modern English conceptions of 'cleanliness' and 'dirt' as reflected in the environmental regulation of London c. 1530-c. 1700* (Doctoral dissertation, University of Oxford).
- Košňovská, J. (2011). *Archaeobotanical analysis of the waste-vault infill from Vladislav Hall, Prague castle*. MS. Master diploma thesis. Deposited: Faculty of Science, University of South Bohemia, České Budějovice, Czech Republic.
- Jørgensen, D. (2008). Cooperative sanitation: managing streets and gutters in late medieval England and Scandinavia. *Technology and culture*, 49(3), 547-567.
- Le Goff, J. (Ed.). (1997). *The medieval world*. Collins & Brown.
- Lyons, M. (2011). *Books: a living history* (p. 224). J. Paul Getty Museum.
- Magnusson, R. J. (2013). Medieval urban environmental history. *History Compass*, 11(3), 189-200.
- Moravec, Z. (2014). Odpad ve středověké Moravské Ostravě. *Ostrava: příspěvky k dějinám a současnosti Ostravy a Ostravska*, 28, p. 229-252.
- Morton, E., Winters, J., & Smith, L. (2010). *An Analysis of Antiseptic and Antibiotic Properties of Various Treated Mosses and Lichen*.
- Mumford, L. (1938). *The culture of cities*.
- Neustupný, E. (2007). *Metoda archeologie*. Vydavatelství a nakladatelství Aleš Čeněk.
- Novotný, B. et al. (1986) *Encyklopédia archeológie*. 1. vyd. Bratislava : Obzor, 1986.

- O'Brien, M. (2008). *A crisis of waste?: understanding the rubbish society*. Routledge.
- Opravil, E. (1994). Synantropní vegetace ze středověku a z počátku novověku města Olomouce. *Zprávy České botanické společnosti*. Roč. 11, Materiály (1994), s. 15-36
- Pichtel, J. (2005). *Waste management practices: municipal, hazardous, and industrial*. CRC Press.
- Pounds, N. J. G. (2014). *An economic history of medieval Europe*. Routledge.
- Pokorná, A. (v tisku). *Před hradbami Starého Města. Archeobotanická analýza a rekonstrukce středověké synantropní vegetace v Praze*.
- Pokorná, A., Pokorný, P. Meduna, P. (v tisku). *Město naruby aneb Praha pod Prahou*. Botanické pátrání po vágním terénu ve středověkém městě.
- Pokorný P. (1999). Svědectví smetiště, stok a jímek, Středověké město očima přírodovědce. In: *Vesmír* 78, 136.
- Rammo, R. 2012. Fragments of Clothing from Medieval Tartu (Estonia). In Haak, A. and Rammo, R. (eds.) *Medieval Urban Textiles in Northern Europe*, (125–146).
- Rawcliffe, C. (2012). Sources for the Study of Public Health in the Medieval City. *Understanding Medieval Primary Sources: Using Historical Sources to Discover Medieval Europe*, 177-95.
- Rose, C., Parker, A., Jefferson, B., & Cartmell, E. (2015). The characterisation of faeces and urine; a review of the literature to inform advanced treatment technology. *Critical Reviews in Environmental Science and Technology*, (just-accepted), 00-00.
- Sádlo, J., Pokorný, P., Hájek, P., Dreslerová, D., & Cílek, V. (2005). Krajina a revoluce. *Významné přelomy ve vývoji kulturní krajiny českých zemí. Malá Skála, Praha*.
- Schütte, S. (1986). Brunnen und Kloaken auf innerstädtischen Grundstücken im ausgehenden Hoch- und Spätmittelalter. *Zur Lebensweise in der Stadt um, 1200*, 237-255.
- Schofield, J., & Vince, A. G. (2003). *Medieval towns: the archaeology of British towns in their European setting*. A&C Black.
- Smith, V. (2007). *Clean: a History of Personal Hygiene and Purity*. Oxford University Press.
- Uchytíl, B. (2012). *Bojové chemické látky – historie ve starověku, odzbrojovací aktivity, zapojení ioo lb do úmluvy o zákazu chemických zbraní*. (Chemical warfare agents – history from ancient era, disarmament activities. The science for population protection. Zvláštní vydání/2012.
- Vlček, P., Sommer, P., & Foltýn, D. (1997). *Encyklopedie českých klášterů*. Libri.
- Woitsch, J. (2003). *Zapomenutá potaš: drasláři a draslářství v 18. a 19. století*. Vyd. 1. Praha: Etnologický ústav Akademie věd České republiky, 2003. 305 s. ISBN 8085010534.
- Woitsch, J. (2009). *K hospodářskému využití lesa v raném novověku. "Lesní řemeslal" v 17.-18. století*. Disetační práce.
- Sterner, Carl S. (2008). Waste and City Form: Reconsidering the Medieval Strategy. *Journal of Green Building: Summer* 2008, Vol. 3, No. 3, pp. 67-78.

APPENDIX

Fig. 1: Fifteenth-century wood carving (Pichtel, 2005).



Fig. 2: A walled-in shaft leading from a toilet to the second courtyard at Buchlov Castle, autor: F. Havlíček (2016)



Fig. 3: Shaft opening under the arch of a stairwell in the second courtyard (Buchlov Castle), author: F. Havlíček (2016)



Fig. 4: Original state of castle toilet (Buchlov Castle), author: F. Havlíček (2016)



Fig. 5: Fortified toilet with an arrowslit (Buchlov Castle) author: F. Havlíček (2016)



Fig. 6: The interior of a fortified toilet (Buchlov Castle), author: F. Havlíček (2016)



Fig. 7: A detail of a toilet (Buchlov Castle), author: F. Havlíček (2016)



Fig. 8: Detail of the toilet drainage system (Buchlov Castle), author: F. Havlíček (2016)



Fig. 9: A dried-up castle well filled in with waste (Buchlov Castle), author: F. Havlíček (2016)



Fig. 10: Images from experiment washing clothing in ashes. Author: F. Havlíček, J. Zálešák (2016)

