Water and wastewater management in the treatment process of a Roman *fullonica*

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**ABSTRACT**

The aim of this paper is to study the treatment process of a Roman fullery (*fullonica*) with particular attention to the water and wastewater management system. Remains of several *fullonicae* have been documented at Pompeii and Herculaneum (Campania, Southern Italy), Ostia and Rome (Latium region, Central Italy), Florence (Tuscany, Central Italy), etc. The common academic perception of Roman *fullonicae* is significantly influenced by the *fullonica* of Stephanus (I 6, 7) in Pompeii, which is assumed to be a paradigmatic case study in this paper. The use of urine as an alkaline chemical agent in the soaping phase of the filling treatment process was overstated, with there also being no evidence of the fact that fullers collected their urine by means of vessels in front of their workshops, as usually reported. Thus, it is not clear how the Roman fullers collected and transported the urine they used in the fulleries. Finally, the rinsing phase can be considered a clear example of water reuse.

**Key words** | fullery, *fullonica*, Pompeii, reuse, wastewater, water

**INTRODUCTION**

The processes of cleaning clothes, finishing new cloth and maintaining or reconditioning old clothes were well-organized in the ancient world, especially in the Roman period (Cleland *et al.* 2007). The clothes of the ancient Romans were mainly made of wool. An anecdote tells that the Emperor Aurelian refused his wife a silk dress because its price was considered outrageous. Two of the most significant aspects that gave particular importance to the art of the *fullonica* were the high price of the gowns and the number of times that they had to be washed. The gowns, in fact, unlike the clothes people wear today, were made of one piece of cloth. The woolen clothes, even the most finely woven, with repeated use tended to lose the design and become rough. A treatment of wetting and pressing was able to maintain texture and softness. This was the aim of the work of fullers: repeatedly wetting and crushing cloths, by jumping on them (Real Museo Borbonico 1827; Davenport Adams 1868).

The importance given by the Romans to the conservation of clothing is testified by the fact that in the year 354 of the Republic, the two Censors C. Flaminius and L. Aemilius drew up a law on the rules that fullers had to follow in order to wash clothes: ‘First you have to wash the clothes with dissolved earth from Sardinia, then they have to be smoked with sulfur and, finally, they have to be purified with good coloured cinolia earth. The earth with a bad colour can be recognized because the sulfur consumes and blackens it, with genuine cinolia reviving faded colours. For white robes after treatment with sulfur, it is more convenient to use the earth called saxum sasso, which, however, is not appropriate for coloured clothes’. To wash the clothes and remove stains, as Pliny says, absorbent earths were mixed with the urine of camels and/or humans used as soap due to the alkaline salts it contained. Particular attention was paid to the use of clear water, as Frontinus states, to the point that it was hypothesized that there were continual disputes with those in charge of the water supply, but there is no evidence. Seneca says that to whiten clothes, fullers sprayed water with their mouth on to the clothes, lifting them from the racks upon which they
were hung out to dry in the sun, and once dried the cycle was repeated until the desired purity was reached. Drawings depicting various phases of the fulling process were found at Pompeii and, in particular, a drawing of a press made from a wooden frame with two levers pushing on a plank, beneath which they lay the clothes to be pressed. In the paintings, it is possible to see how the fullers worked with their feet immersed in water, with, for obvious reasons, their garments rolled up to their belts in order to leave the thighs and legs bare. The fullers are depicted as jumping into a metal bowl filled with water. It seems that small boys were used for this activity. From the pictorial representations, it can be deduced that both men and women worked in the fullonicae. The women were probably occupied only to mend the clothes, while men were involved in the more strenuous activities: causticizing, whitening and removing stains from clothes (Real Museo Borbonico 1827; Davenport Adams 1868).

Flohr & Wilson (2011) stated that in the last century, the use of urine for fullers was overstated, because there is no reliable information about the quantities that were needed or about its dominance in the production process. In particular, they argued that in order to work with a more concentrated solution, the usual amount of liquid under the feet of the fuller was rather limited, thus contradicting the image of a fuller standing all day long in a fulling tub filled with water and urine. Moreover, Flohr & Wilson (2011) stated that there is no evidence about the fullers collecting their urine by means of vessels in front of their workshops, as usually reported. Thus, it is not clear how Roman fullers collected and transported the urine they used.

**THE FULLING TREATMENT PROCESS**

The remains of several fullonicae have been recognized at Pompeii and Herculanenum (Campania, Southern Italy), Ostia and Rome (Latium region, Central Italy), Florence (Tuscany, Central Italy), etc. In particular, at Pompeii the following 13 fullonicae were identified (Flohr 2011b): (1) I 4, 7; (2) I 6, 7 (‘fullonica of Stephanus’); (3) I 10, 6; (4) V 1, 2; (5) VI 3, 6–7 (‘Accademia della Musica’); (6) VI 8, 20–21.2 (‘fullonica of Veranius Hypsaeus’); (7) VI 14, 21.22 (‘fullonica of Vesonius Primus’); (8) VI 15, 3 (‘fullonica of Mustius’); (9) VI 16, 3.4; (10) VI 16, 6; (11) VII 2, 41; (12) IX 6, a; (13) IX 13, 5–6 (‘fullonica of Fabius Ululitremulus’).

The three large Pompeian workshops were situated in private houses with the work taking place in a family context. Most of the others were in tabernae (shops) and were smaller. On the contrary, the fulling factories of Ostia and Rome were purpose-built production halls with large work groups (up to 100 people) (Flohr 2011b).

As discussed in a previous paragraph, the fulling treatment process consisted of three main phases: soaping, rinsing and finishing. Soaping garments consisted of treating them with alkaline chemicals (to dissolve fats and remove pollution) by trampling and scrubbing them in a tub located in the fulling stall (confined work environment – a sort of niche – surrounded by low walls) and, finally, wringing them out. The rinsing phase had the aim of removing the residue of any chemicals and impurities, with it being carried out in specific basins. The finishing phase consisted of brushing and shearing and, finally, putting the garment under a textile press (Flohr 2011b).

**WATER AND WASTEWATER MANAGEMENT**

The water used in the fullery was rainwater coming from the roof of the atrium and/or it was taken from the urban water supply system. As the Pompeian fullonicae were derived from private houses, they often presented extemporaneous solutions for the water supply and even for the wastewater discharge system, because in the construction of workshops, people made the most of whatever material was available (Flohr 2008b). For instance, Flohr (2008a) observes that fullonica VI 16, 6 shared a cistern with the neighbouring shop VI 16, 5. Analogously, the same author observed as in the workshop VI 16, 5. 4 in Pompeii, the first part of the drainage pipe near the rinsing complex consisted of a terracotta pipe, the part near the south end of the platform was made of the lower part of the amphora, and the subsequent canal consisted of an imbric turned upside down (Flohr 2008b). On the contrary, in some Pompeian fullonicae some technologically relevant elements of the water supply system were discovered. Such as in the case of a large water-division box discovered at a slightly lower level of the floor in the fullonica VI 16, 3.4 (Flohr 2011a).
Wastewater management was a key issue in the Roman *fullonicae*. As a matter of fact, the work floors in front of the fulling stalls were surrounded by rims. Moreover, in the Pompeian *fullonicae*, there was a strict distinction between the ‘wet’ area (with the fulling stalls) and the ‘dry’ area of the fullery (Flohr 2008a).

The floor and walls of the basin of the rinsing complex were usually lined with waterproof plaster, with all the corners being strengthened with rims. The basins were fed with lead or terracotta pipes (Flohr 2008b).

Usually, in the rinsing complex, water went in one direction from the first basin, where the water supply ended, to the last basin, where the drain was. Clothes followed the opposite direction, and thus gradually cleaner water came in, allowing for the reuse of water as well as streamlining the production process (Flohr 2008b).

The floor usually served as a central node in the water system of the workshop (Flohr 2011a). All the water from the various parts of the workshop could be collected, transported (usually underneath the pavement) and discharged in the street separately or in one drain. In order not to completely invade the street, the wastewater usually approached the street at an angle of around 45°, flowing away in the right direction to reduce as much as possible the dirtiness of the street (Flohr 2008b).

**THE FULLONICA OF STEPHANUS IN POMPEI**

The common academic perception of the Roman *fullonicae* is significantly influenced by the *fullonica* of Stephanus (I 6, 7) in Pompeii, which appears prominently in archaeological literature and tourist guides. Moreover, it is usually presented as the ‘classic’ Roman *fullonica* (Flohr 2008a). The *fullonica* I 6, 7 is attributed to Stephanus, whose name appears in one of the electoral inscriptions painted on the façade of the building. It was excavated in July 1912 as described in Spinazzola (1953).

The building hosting the fulling facilities functioned as a house with a shop on the street (*Via dell’Abbondanza*) and a workshop in the garden, as shown in Figures 1(a) and 2(a).

The front hall and the surrounding rooms are spatially organized similarly to the Pompeian houses without a workshop, suggesting a residential and representative use. There is a difference in nature between this area and the garden area where the workshop, kitchen and latrine are situated as well as the stairs to an upper floor: these areas were used for different purposes and by different people (Flohr 2009).

In the *atrium* (Figures 1(b) and 2(h)), with a flat roof and skylight, there is the large basin (B4), while along the eastern wall there was a screw press (*pressorum*) (Spinazzola 1953). There is no evidence that this basin was used in the production process. In fact, objects found in the *atrium* suggest that it was just a domestic ornamental basin, with a fountain.

From the *atrium*, using a wooden staircase it was possible to go upstairs. A narrow corridor, shown in Figure 1(a), leads to the *peristyle* in which there is the workshop. In particular, the workshop is equipped with five fulling stalls and a rinsing complex of three inter-connected basins with drains, overflows and working benches. The fulling stalls are located on two sides of the rinsing complex: three (*S*1–*S*3) on the east side and two (*S*4–*S*5) on the west side, as shown in Figure 1(b).

Near the groups of fulling stalls, there are two plateaus with built-in jars: in the southeast corner, there is a plateau of *opus caementicium* covered with waterproof plaster with one built-in jar, while in the northwest corner, there is a similar structure with two built-in jars (Flohr 2009).

The kitchen where meals for the workers were probably prepared is located at the end of the *peristyle*. Hanging on the walls and resting on the kitchen bench, bronze and clay pots were found, a grill and an iron tripod, with the remains of the last meal (bones of sheep, chickens, squid). At the entrance of the complex, a few skeletons were found. Hundreds of coins (mostly silver), for a total value of 1,089.5 sesterces, were found near one of them. It was probably a worker with the last collection of the laundry, rather than a fugitive who had sought refuge within the building. Therefore, the *fullonica* of Stephanus is one of the most active and important laundries in Pompeii if the annual rent of a city *fullonica* was 1,652 sesterces (Spinazzola 1953).

The rinsing phase was developed by means of three adjacent tanks on a north–south axis in the centre of the workshop (*B*1–*B*3). The workshop was connected to the urban water network. The lead pipe providing the water...
Figure 1 | Fullonica of Stephanus in Pompeii: (a) plant of the complex; (b) fluxes of water and wastewater management system; (c) processing cycle (basin B₄ is not part of the cycle; it had a domestic, decorative function).
ended in the northwest corner of basin B₁ and is still visible along the west side of basins B₂ and B₃. The route of the pipe through the rest of the house is not entirely clear. Presumably, it went through the atrium and along the corridor (see Figure 2(b)), but there are no reported traces of it left. The rinsing complex must have had a flowing water system. There are drains and overflows in all the basins, including the last one. The wastewater from the fulling stalls was collected in gutters directly in front of them, as visible in Figures 1(b) and 2(d). The wastewater from the eastern group of fulling stalls was transported to the other side of the rinsing complex by means of a gutter on top of

Figure 2 | Some images of the fullonica of Stephanus: (a) view of the workshop area; (b) basin B₁ with the indication of the inlet fresh water pipe; (c) rinsing basin B₂ and indication of the route of wastewater to discharge; (d) fulling stalls S₁, S₂, S₃; (e) particulars of the fulling stall S₂; (f) fulling stalls S₄, S₅; (g) basin B₄ in the atrium (domestic and decorative function); (h) basin B₄ in the atrium (domestic and decorative function.
the wall between basin B₂ and B₃. To the west of the basins, the gutter carries water into one of the western group of fulling stalls. Just south of the meeting point, there is a narrow groove in the western gutter, probably indicating the place where a small piece of wood could be placed, cutting off the west branch and thus preventing the wastewater from the eastern stalls polluting the western fulling stalls (Flohr 2009).

At some point, the gutters from the fulling stalls were combined with the drain from the rinsing complex. This part of the drainage system can no longer be reconstructed but must have been situated under the northwestern part of the podium, which has been reconstructed after the excavation without recording the original situation. From there, the drain ran through the garden and corridor to the atrium where it was combined with the drain from the impluvium. The whole system must have carried water onto the street, but because of the reconstruction of the pavement, there are no traces of it (Flohr 2009).

The basins of the fullonica have a drainage channel that runs all the way through the house and then ends in the Via dell’Abbondanza. The channel bends a little bit to the East, so the actual outlet is in front of the neighbouring property: this is precisely at the point where the Abbondanza starts to descend towards the east so the water was drained off not through the Via Stabiana but through the Via dell’Abbondanza (see Figure 3).

In Figure 1(c), the fulling process of the fullonica of Stephanus is reported with the typical phases of soaping, rinsing and finishing.

In the first phase (soaping), the clothes were treated in small tubs standing in fulling stalls (the niches surrounded by low walls shown in Figures 2(d), 2(e) and 2(f)). The single fulling tub (or even the fulling stall) can be seen

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**Figure 3** | Scheme of the house of the fullonica of Stephanus in relation with the streets: (a) general plan view with Via dell’Abbondanza and Via Stabiana; (b) detailed plan view with Via dell’Abbondanza; (c) 3D view.
(with a modern perspective) as a batch reactor with the inlet clothes, the urine and/or other alkaline substances (creta fullonica, terra umbriaca, etc.) as chemical agents and the Roman fuller to provide the required mechanical energy. Greases, fats and other dirt residues are removed with the application of the chemical agents.

The next phase had the aim of removing residues of chemical agents as well as dirt residues. This task was performed by the rinsing basins in the following order: B₃ (containing the most dirty water: reused twice), B₂ (containing the medium dirty water: reused once) and B₁ (containing fresh water coming from the urban water supply system). The last phase of the fulling treatment process (finishing) consisted of several treatments depending above all on the demands of the customers. Probably, the treatment processes were: typing, carding, treatment with sulfur, screw press and drying. The treatment with sulfur was carried out for the most delicate clothes (white in colour) and those intended for dyeing.

CONCLUSIONS

The following outcomes based on the performed study can be stated:

- In a fullonica there is a precise spatial organization with a sharp division into a ‘wet’ area (with the fulling facilities) and a ‘dry’ area with particular care for wastewater management.
- The use of urine as an alkaline chemical agent in the Roman fullonicae was overstated.
- The idea that fullers collected their urine by means of vessels in front of their workshops has to be considered as scholarly fiction since there is no written or material evidence.
- It is not clear how the Roman fullers collected and transported the urine.
- The rinsing phase can be considered as a clear example of water reuse performed in antiquity.
- The common academic perception of Roman fullonicae is significantly influenced by the fullonica of Stephanus (I 6, 7) in Pompeii, which is prominently presented in archaeological literature and tourist guides as the ‘classic’ Roman fullonica.
- The picture in the fullonica of Stephanus confirms the results of earlier researches (Flohr 2008a, 2008b; Flohr 2009; Flohr 2011a, 2011b; Flohr & Wilson 2011).

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