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# Water systems and Sanitation in the houses of Herculaneum*

GEMMA C.M. JANSEN

SUMMARY

In Herculaneum several types of water supply systems (rainwater collection, wells and a system of water pipes), sanitation (cesspits, continual flush toilets and hand flushed toilets) and drainage (through the streets or the sewers) can be found. These systems were introduced successively. Some of the older systems stayed in function while other ones were replaced or included in the new system.

## INTRODUCTION

Most publications of Roman water supply systems deal with large-scale water supply and hydrotechnic aspects. Comparetively little research has been done on small-scale water supply- and drainage systems and sanitation in Roman houses, and the essential urban infrastructure. The reason for this is clear: there are only a few sites that are suited for this kind of research. Only one of these has been studied in depth: Pompeii (Eschenbach 1979; Mygind 1917, 1921). To gain more insight into these watersystems in cities and houses the writer of this article has been doing research on the various water supply-, drainage- and sanitation systems in the houses of Herculaneum. The excavated part of the city offers an unique opportunity for this kind of research, because both the houses and the urban infrastructure have been well preserved. Special attention has been paid to those elements which have not been investigated thoroughly so far, such as the system of water pipes in the houses and drainage, including latrines[1].

This article begins with a sketch of the enviroment and the cultural background of Herculaneum. Then the various systems found in this town are discussed. Their interrelation becomes evident in the light of their historical development. Since the systems in the houses cannot be detached from the large-scale urban systems, the latter are dealt with in this article as well: it concerns the urban water pipe system, the rainwater discharge through the streets and sewers. Moreover the differences between Herculaneum and Pompeii are discussed. Finally some suggestions for further research are given.

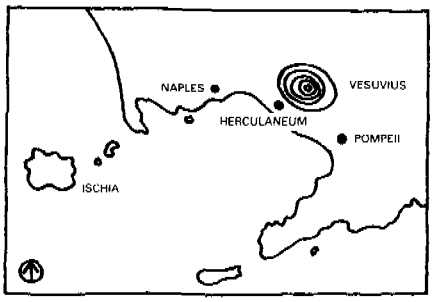


Fig. 1 Position of Herculaneum

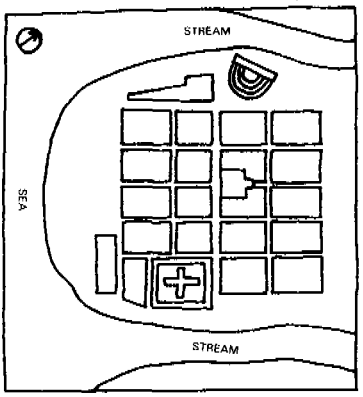


Fig. 2 General plan after La Vega

ENVIRONMENT AND CULTURAL BACKGROUND

For a good understanding of the watersupply and drainage of Herculaneum it is necessary to have a closer look at some aspects of its enviroment and cultural background.

*Geology and climate*[2]: Herculaneum (fig.1) is situated on a promontory formed out of hard, compact tuff, and its excavated part has a steep fall of 14.5 metres. The sea stretches to the west. To the north and the south the promontory is bound by the cleaved beds of two streams (fig 2). A spring has not yet been found. Groundwater can be found at a depth of eight to ten metres. Assuming that the climate has not changed, the city had a Mediterranean climate: moderately maritime with dry summers. The average annual rainfall is 900 mm. On the average the area has 90 rainy days, most of them in winter. The showers are short but heavy, which has some specific consequences for the rainwater catchment and the discharge of superfluous rainwater. The climate is pleasant: the average temperatures vary between 9 and 25 C.

*History and infrastructures*[3]: It is not clear by whom and when Herculaneum was founded. However it is an established fact that the site had been occupied by various tribes (Strabo V.4.8) when the Romans conquered Campania in 89 B.C. A period of peace and quiet settled in, which made the construction of a large-scale, but vulnerable, system of water pipes possible. In the Roman period Herculaneum was probably inhabited by four to five thousand people[4]. The urban infrastructure predated the Roman era. Of old the city had a regular street pattern. The insulae were bounded by decumani and cardines, being at right angles with each other. The Decumanus Maximus functioned as a market place. Privat houses as well as public buildings, such as two thermae and a palaestra (fig.3), have been laid bare.

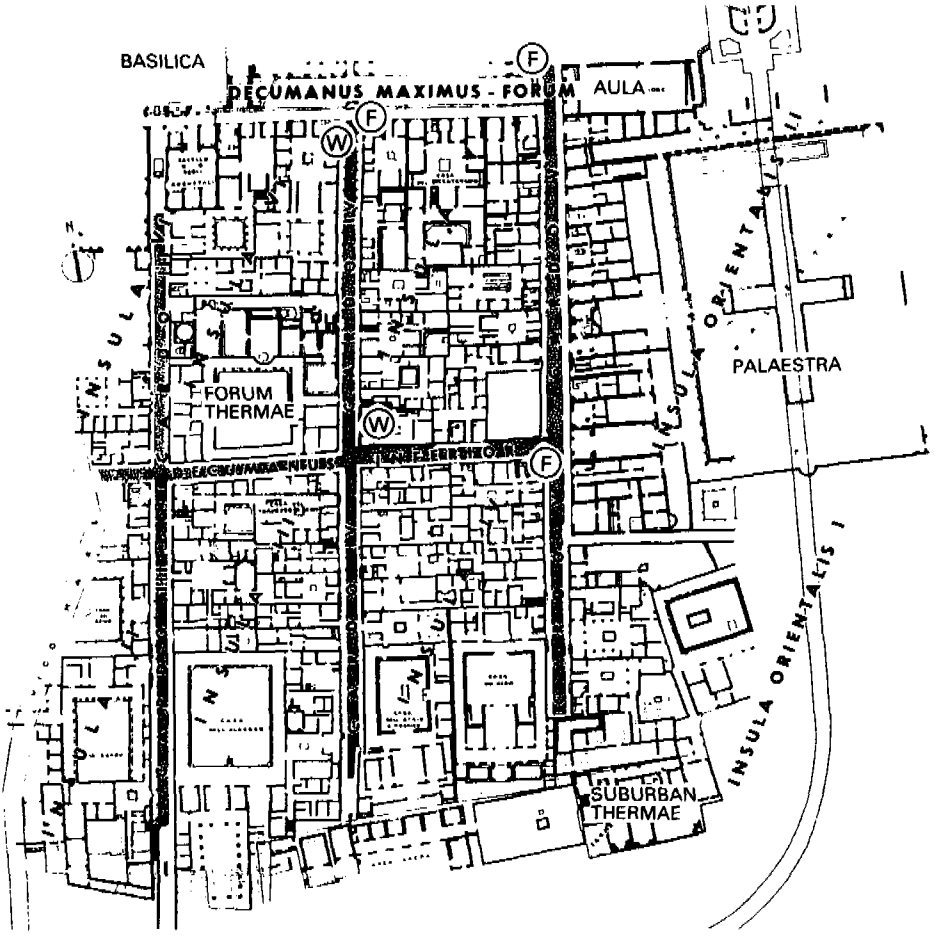


Fig. 3 Excavated part of Herculaneum with public buildings, water-towers (W) and public fountains (F) after Maiuri

THE WATER SUPPLY AND SANITATION SYSTEMS AND THE ELEMENTS THEY CONSIST OF.

Unfortunately, a statistical presentation of the systems is not possible for several reasons. In the first place, Herculaneum has been excavated only partly and some important elements of the large-scale water pipe system are still buried.
Secondly, little value was attached to some elements in the past. That is why, occasionally, they were excavated incompletely. The cisterns and wells are examples; the majority of these have a shaft-depth of about 50 cm. This is not deep enough to be able to distinguish a cistern from a well[5]. All these indefinable shafts

(in total 32) are left aside of consideration in this article. The same problem applies to the latrines. In most cases only their upper parts have been excavated, whereas their lower parts -below ground level and crucial for the interpretation- have been left untouched. In the third place, in case the elements had been excavated, they were sometimes treated uncarefully. For example, it is difficult to trace the course of the water pipe system, because most pipes were sold during the Bourbon periode (1738-1765) to raise money for further excavations. Unfortunately, the origins of a certain number of pipes which have been excavated later, have not been listed. These are now in the storage rooms of Herculaneum.

Yet, in spite of the fact that it is impossible to give a statistical presentation, it is nevertheless possible to make some observations about the water supply and drainage systems.

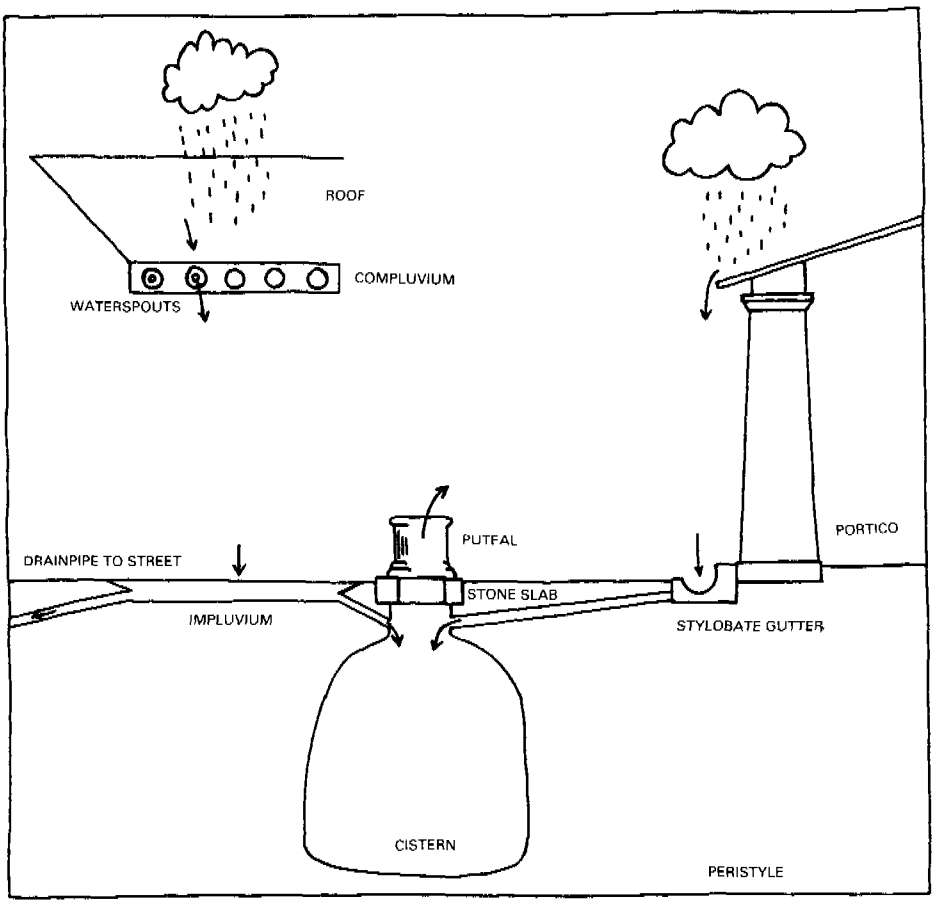


Fig. 4 Schematic presentation of a rainwater catchment system in an atrium and a peristyle

A. WATER SUPPLY SYSTEMS

In Herculaneum three diferent systems of watersupply can be found. The inhabitants of this town provided themselves with rain- and groundwater by building cisterns or digging wells in their courtyards respectively. The third system was constructed and controlled by the local authorities. It was a system of waterpipes of wich all the citizens could profit to a smaller or greater extent.

*Cisterns*. A cistern is a cool, subterranean reservoir for storing rainwater. It is the final element of a rainwater catchment system located in one of the courtyards of the houses. Although these catchment systems can vary from very simple to extreme complex, a kind of standard pattern for each type of courtyard can be distinguished. In some atria (fig.4) one can still see[6] compluvia, decorated with fine waterspouts (fig.5), directing the rainwater to the impluvium situated underneath. From here the water is led either to a cistern or to the streets. In peristyles this system can also be seen, but its construction is more simple (fig.4): from the slooping porticus roof the rainwater flows to the stylobate gutter underneath. From here the water is also distributed either to a cistern or to the streets. The cortile system is the most simple one: rainwater flows from the roof on to the cortile floor and this way it is directed to a cistern[7]. In the excavated part of

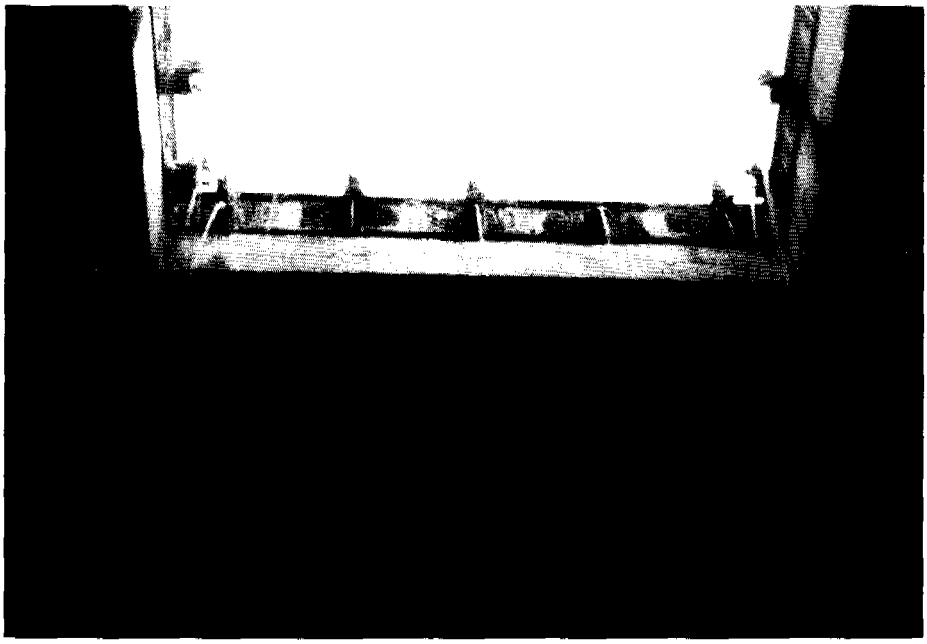

Fig. 5 Waterspouts in operation, casa sannitica V,1-2

Fig. 6 Puteal from casa del colonnato tuscanico VI,17

Herculaneum seven cisterns have been found in six houses. Only two of them have been completely excavated[8]. They have a shaft running into a kind of tank with a depth of approximately 3.5 metres. The upper part of the shaft consists of masonry and is provided with a waterproof stucco coating. The lower part is dug in the compact tuff layer.

*Wells.* A well is a pit dug in the ground to obtain a supply of groundwater. The majority of the thirteen wells[9] found in the houses of Herculaneum are located in the same places as the cisterns. They are connected to the same elements of the rainwater catchment. However, their function was not to collect and store the rainwater, but to carry it off to the groundwater. Sometimes a well can be found in other parts of a house, for instance in the kitchen or in a passage. The wells are eight to ten metres deep, which is relatively shallow in comparison with the wells of Pompeii (Maiuri 1958 p.51). They have oval shapes and they broaden as they deepen. A well-shaft is constructed in the same way as a cistern shaft: the upper part is formed of masonry and the lower parts is sunk in the compact tuff layer.

Both cisterns and wells were covered by large slabs with holes in the middle for lowering buckets. These holes were closed with lids or decorative well- heads, puteals[10] (fig.10), which protected the cistern- and the well-water against sunlight and dirt. Moreover, this way they created no danger to playing childern and

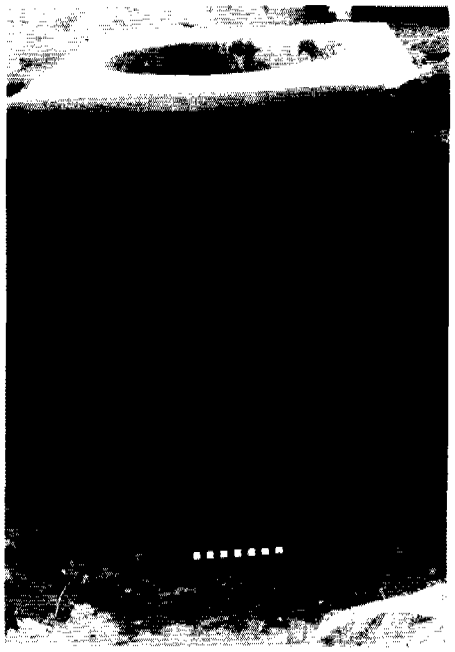

Fig. 7 Well-head in masonry from casa a graticcio III,13-15

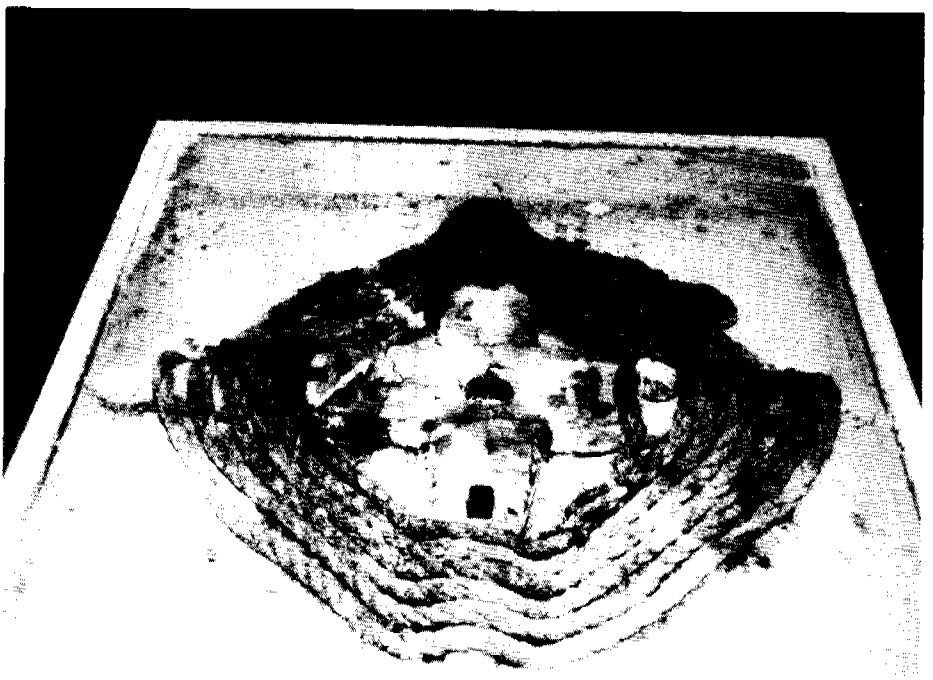

Fig. 8 Windlass and original rope found in casa a graticcio III,13-15 (photo by R. Kragting)

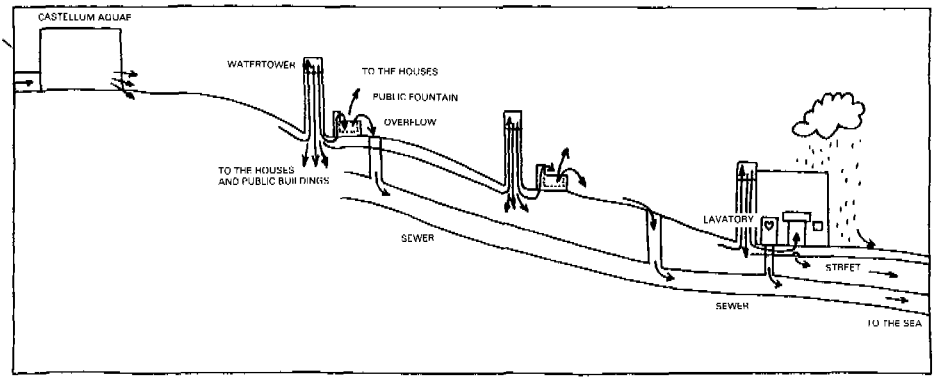


Fig. 9 Survey of the elements of a Roman municipal pipe water system

inattentive grown-ups. The rims of the slabs and the puteals show signs of wear caused by the ropes with which the buckets of water were hauled up. Wells situated in working areas or in the back of a house were not supplied with puteals, but with masonry wellheads. As a matter of fact, such a well head was more solid than a puteal, and sometimes it formed a base for a little well-house[11] (fig.7). In such a well-house the water could be pulled up with a bucket on a pulley or a windlass[12] (fig.8).

*System of water pipes*. Unlike building cisterns and wells, constructing and maintaining a system of water pipes was beyond the power of a private individual. Usually the local authorities fulfilled this task. This was probably what was happening in Herculaneum as well. The infrastructure of conduit-pipes consisted of a number of standard elements, of which only a few have been found in Herculaneum (fig.9). As it is, the city has not yet been excavated completely. This is why so far only hypoyheses regarding the source and the main conduits which possibly led the water from the source to the city[13], exist. The castellum aquae -the place where the water entered the city, where it was purified and distributed all over the city- has not yet been excavated as well.

*Water-towers*. From the castellum aquae the water was directed through lead water pipes, situated underneath the footpaths, to the so-called water-towers[14]. Two of these towers can still be seen in Herculaneum (fig.3,10,11). The Roman water supply systems made use of the laws of gravity. Because of the great difference in height in Herculaneum, pressure mounted up in the waterconduits. The pressure had to be reduced and stabilized all over the city districts, which was effected by means of these watertowers. Moreover, the water was distributed from these towers, not only to public buildings and private houses, but also to the public fountains.

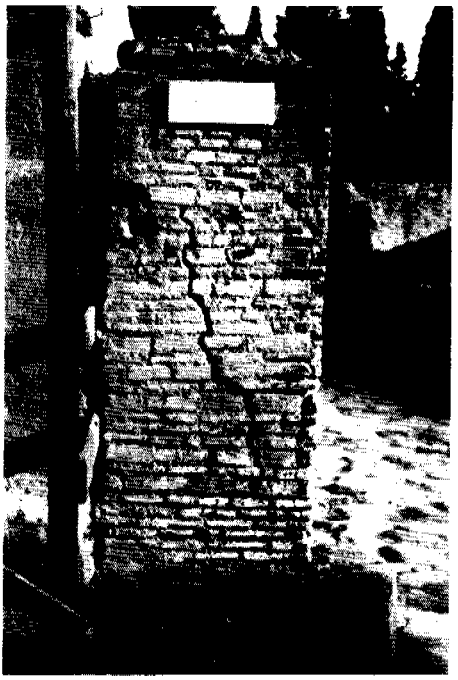

Fig. 10 Water-tower at the crossing of Cardo IV and the Decumanus Inferior

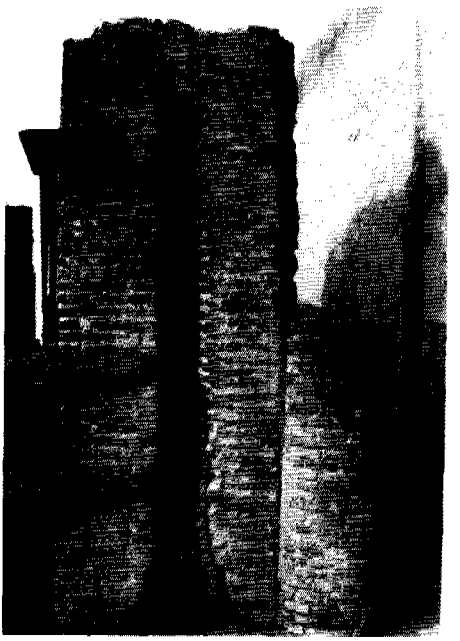

Fig. 11 Water-tower at the crossing of Cardo IV and the Decumanus Maximus

Fig. 12 Fountain of Neptune

Fig. 13 Position of water-conduits, visible on the mosaic floor of casa dell'atrio a mosaico IV,1-2

*Public fountains*. These were not fountains in the real sense of the word. They were formed by a basin of slab-stones. One of these slabs was slightly raised and decorated with a relief[15] (fig.12). At the back of such a relief-slab a conduit-pipe ran upwards, went through the slab and squirted the water into the fountain-basin. The fountain-water was drained off by one or more overflow gutters in the basin-rim. The overflow streamed into the streets or into a discharge gutter. Traces of use indicate that passers-by used to take a mouthfull of water at the fountain inlet and that people living in the neighboorhood used to take water for domestic use from the fountain-basin. The three public fountains of Herculaneum were situated on busy places and close to appartments which had no water supply of their own (fig.3).

*Private water pipes*. The citizins responsibility with regard to the water system started at his private connection to the watertower. From the tower a conduit-pipe ran underneath the footpath to the house. The pipe entered the house through the fauces and, as a rule, it split up in the atrium. Most pipes run underground. Sometimes they were clearly indicated in the floor mosaic, which facilitated reparations (fig.13,14). Every now and then the pipes run overground, which is still visible along impluvia rims and the stylobate gutters of the peristyles.

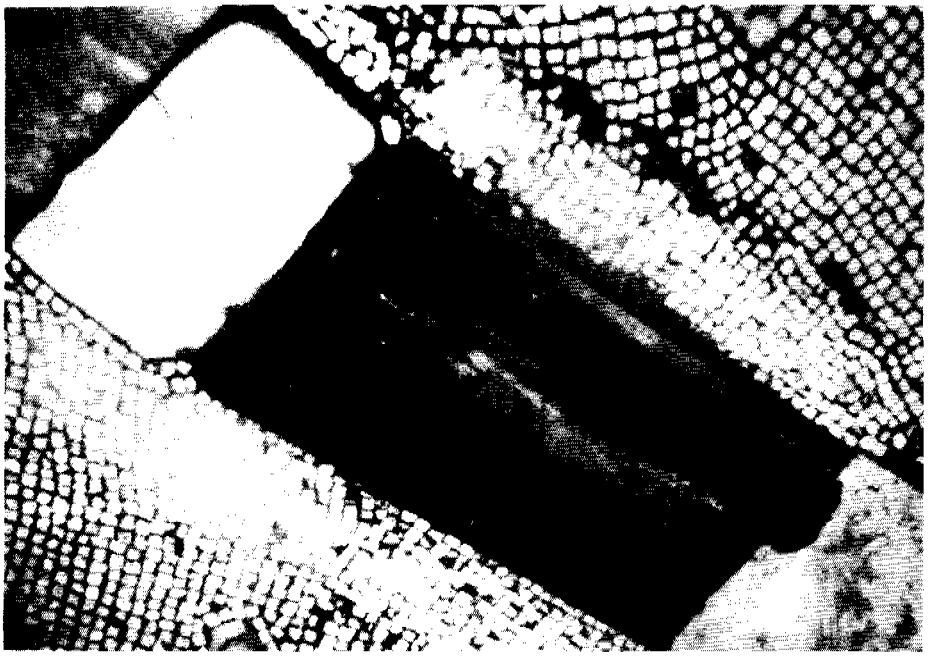

Fig. 14 Detail of the water-conduits in the mosaic floor of casa dell'atrio a mosaico IV,1-2 (photo by R. Kragting)

It stands to reason that the water pipes ran to those parts of the house which had been connected with water supply of old: the courtyards. In these courtyards the piped water was used to feed the fountains. Water pipes ran also to kitchens and latrines for obvious reasons[16]. Taps have not been found in situ in the houses of Herculaneum. As far as is known, twelve houses were connected to this system of water supply[17].

### B. DRAINAGE SYSTEMS

The citizens took care themselves of the discharge within doors, but as soon as the waste water left the house the local authorities took over. Indoors all kinds of liquid waste had to be disposed off: urine and faeces, superfluous rainwater and domestic waste water. Drainage systems were more complex and of a greater variety than the water supply systems, because many households invented their own solution for their waste water problems. So as to leave no doubt, the systems used are not dealt with separately (as above), but they are related to the kind of waste water discharged. The urban systems, however, are discussed separately.
*Discharge of urine and faeces.* The discharge of urine and faeces occurred by

Fig. 15 Latrine (two-seater) of casa del tramezzo di legno III,9

means of latrines. In Herculaneum nearly every house or appartment, on ground floor as well on the upper floor[18], had one. Some of the housing units even had two[19]. Large households were supplied with multi-seaters, which could accomodate two to six people[20] (fig.15). It was not costumary to build a latrine in a separate room. A latrine was usually situated in the kitchen, a shop or a workshop, near a small courtyard or under a staircase[21] (fig.17).
Of old latrines had been connected to cesspits. Because none have been excavated so far, it is not known what cesspits in Herculaneum looked like. The only fact known is that cesspits were emptied regularly and that people had to pay for this service according to the inscription EXEMTA.STE(R)CORA.A(SSIBUS) XI[22].
After the construction of the first municipal sewer under Cardo III, some citizens had their latrines connected to this sewer[23]. These latrines were probably flushed with a bucket of water. It was not until later, after a house had been connected to the water supply system, that it became possible to introduce continual flush toilets. Usually these flushed toilets were multi-seaters and they bore a great resemblance to the so-called public latrines.
The urine and faeces could be discharged in different ways, but the seats of the latrines were constructed in an uniform way. They all consisted of a board with a hole in the middle, supported by a ledge in the wall, or by wooden or stone pilasters. The front either had a hole or was completely open to make use of a

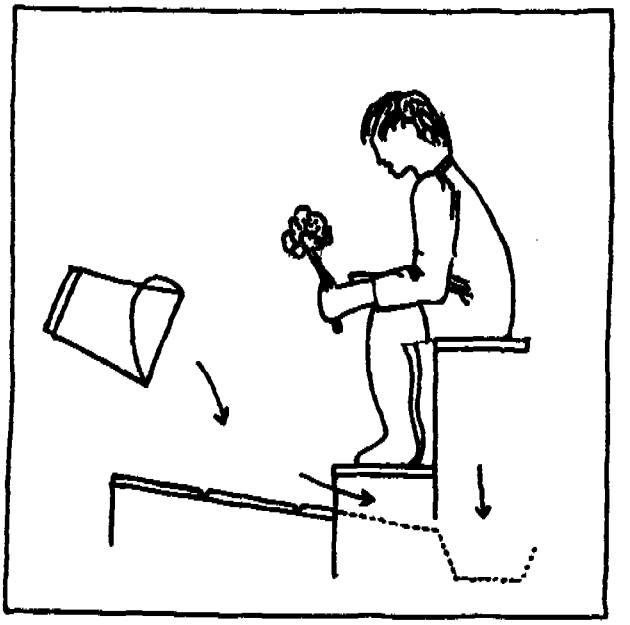

Fig. 16 reconstruction of the latrine of casa del tramezzo di legno III,9

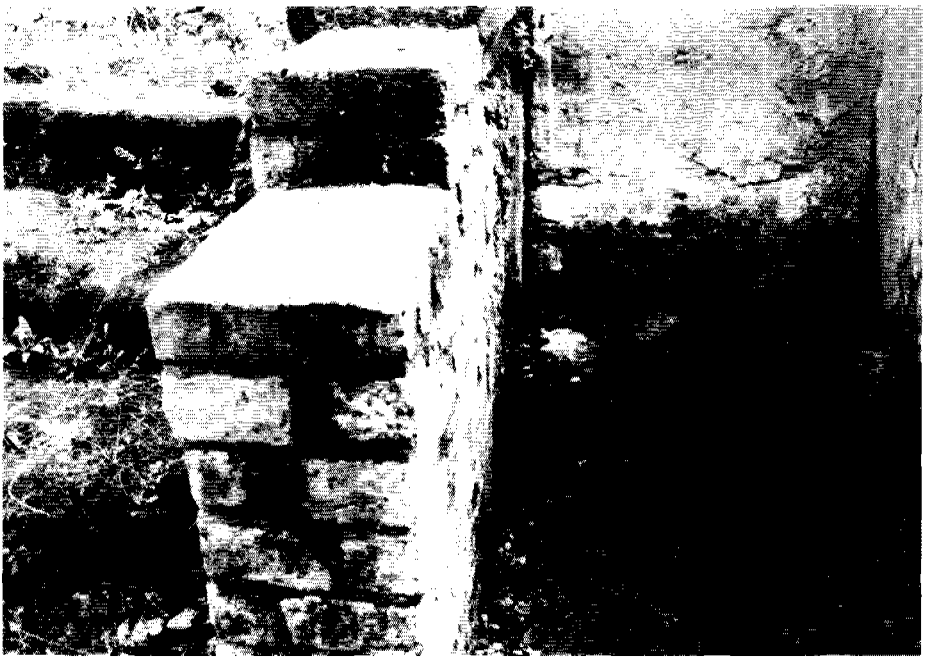

Fig. 17 Latrine of casa del gran portale V,35

sponge-stick, the Roman variant of our toilet paper[24], possible. After use this sponge-stick could be cleaned in a little water-basin or gutter situated near the latrine. Latrines were used for the discharge not only of urine and faeces, but also of domestic waste water. For this purpose latrines, in kitchens and shops in particular, had tiled sloping plateaus at the front (fig.15,16). To keep the user's feet from getting wet footrests were installed, so that the waste water flowed away under their feet to the drain-pipe.

*Discharge of superfluous rainwater.* For the discharge of superfluous rainwater there were two possibilities. It was either drained away via a well to the ground-water, or from the impluvium to the streets through a drain-pipe. As far as location, construction and diameter were concerned those pipes were not standardized.

*Discharge of domestic waste water.* It is not surprising that most facilities for discharge of domestic waste water were found in the kitchens, considering that this was the place were it mainly occured. Waste water could be drained by way of a sink, a latrine or a sloping kitchen floor. Such a sloping floor led the water through a hole in the wall outside the kitchen[25]. The drain pipe running from the impluvium out in the streets could serve the same purpose.

*Drain pipes from upper storeys.* In contrast with the outlet pipes mentioned above, these pipes form a uniform system: terracotta conduits having the same size, vertically built in or against the walls. These pipes were probably used for all kinds of fluid waste. It is not always clear where they run into, but sometimes they discharged into a latrine on the ground floor, or a sewer or a sewer branch situated underneath.

*The streets as discharge system.* Outside the houses the local authorities took over the responsability for the discharge of all different kinds of waste water mentioned above. In most cases rain- and domestic waste water were directed to the sea through the well-paved and sloping streets of Herculaneum (fig.18).

*Sewarage.* Beside the street system, Herculaneum had an extensive system of sewers , consisting of at least two main sewers and a number of minor sewers, all of them discharging their waste into the sea[26] (fig.19,20). The main sewers were built one after another and therefore their location and construction differ. In the first place those sewers served as discharge channels for the enormous amount of waste water from the Forum thermae and the Palaestra. Furthermore, latrines and waste pipes of private citizens were connected to the sewarage. The sewers were constantly being washed with the overflow of the three public fountains[27]. Rainwater could enter the sewarage only in a few places.

Fig. 18 Rainwater discharge by way of the street (Cardo V)

Fig. 19 Sewer in the middle of Cardo III

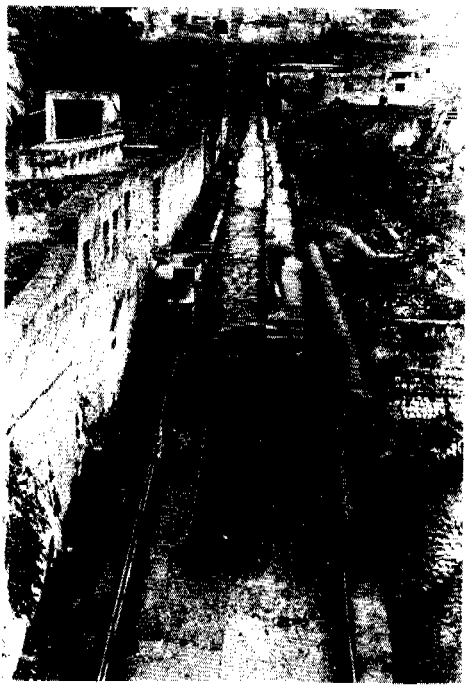

Fig. 20 Detail of sewer of Cardo III

## THE COEXISTENCE OF VARIOUS SYSTEMS

The systems dealt with above were all in use at the time of the Vesuvius' eruption. In order to understand how it was possible that these systems could exist side by side, it is necessary to examine the historical development regarding the introduction of these systems first of all. It will become evident that the introduction of a particular water supply system was closely linked with a particular drainage system and vice versa. The historical development can be divided into five phases[28].

With regard to the first phase, the beginning of occupation of the promontory, we can only express a few assumptions. The first inhabitants of Herculaneum probably used water from the sea and the streams. As yet, there is no evidence that a spring existed. During this period there were no latrines, most likely people simply went for a walk in the bush!

During the second phase houses were built with wells and cisterns. As the water table was not too deep, it was just as easy to dig a well as to build a cistern. This way the well became a rival for the cistern. Because of this the traditional Roman domus with a cistern in the atrium and/or a cistern in the peristyle was not a common feature in Herculaneum. There existed many variations, such as atria and peristyles with a well instead of a cistern, or atria and peristyles without either, in case there was a well in any other part of the house. Sometimes wells and cisterns existed side by side in one house, or sometimes even in the same courtyard. During this periode latrines connected to cesspits were introduced. Domestic waste water and superfluous rainwater were led to the sea through the streets.

During the third phase, the pre-Augustean period, the Forum thermae were built. These were supplied with well-water. In order to dispose of the waste water a sewer was constructed underneath Cardo III. Some inhabitants living in this street had their latrines connected to this sewer.

In phase four, the Augustean period, the town was provided with a piped water supply system. As a result a different kind of latrine was developed: after all, now it was possible to connect a latrine not only to the sewer, but also to the piped water system. This resulted in a continual flush toilet.

During the final phase, the post-Augustean period, a second sewer was constructed underneath Cardo V. The Palaestra, the adjacent appartments and shops, and the sewer were designed and constructed during the same time. The sewer ran under the front of the houses. Not only the swimming pool of the Palaestra but also private waste pipes (such as the outlet pipes from the upper floors or the drain-pipes from sinks and latrines on the ground floor) were connected to the sewer.

The reason these systems could exist side by side was due to the fact that the systems newly introduced did not replace the older ones completely. Facilities

could not be relied on completely and people were inclined to hold on to the traditional patterns that had been established for the use of water. The citizens had the choice to replace their old systems by new ones. Some people did, others did not. Besides, the older systems could be integrated into the new systems. This created a situation in which only a few houses had the same combination of water supply- and drainage systems.

One is probably inclined to think that all the rich houses[29] were connected to the new systems of water supply (piped water) and drainage (sewers), whereas all the poor ones were not. This was not true however. It occurred that only a few of these rich houses were connected to the new system of watersupply. It follows that not all the rich houses had installed fountains, flush toilets and other waterworks introduced together with these new systems. Although a poor house connected to the piped water system has not yet been discovered, it was nevertheless quite normal that a simple appartment or a shop were connected to the sewer and that they had a hand flushed latrine accordingly[30].

### HERCULANEUM VERSUS POMPEII: WELLS

The fact that the groundwater table in Herculaneum was relatively shallow had far-reaching consequences. As had been said before, in Herculaneum it was rather easy for the citizens to sink a well which could provide them with continual water supply. The consequences of this advantage may seem trivial, but they become evident when we compare Herculaneum with nearby Pompeii. In the latter city groundwater could be found at a depth of 20 metres: two or three times as deep as was the case in Herculaneum. Only a few private individuals could afford to sink a well and before long the local authorities had public wells dug and municipal cisterns built (Maiuri 1973, Eschebach 1979). Inside their houses the inhabitants built enormous cisterns. The water was not only used as drinking-water as was probably the case in Herculaneum, but also for domestic use. Considering that the citizens of Pompeii had to fetch part of the indispensable water outdoors or to collect it in a system (which demanded a lot of maintenance), it is easy to imagine that they were eager to be connected to the piped water supply system. This way they made sure they could enjoy the luxury of having lots of water at their disposal within doors. The enthusiasm with which Pompeii welcomed the arrival of the piped water supply, is not only an indication of the riches of the Pompeiani (Maiuri 1958 p.51-52), but is probably also an indication of the poor means of water supply that existed before. It is beyond doubt, however, that it resulted in a richness of both urban and private waterworks.

From this comparison between the two cities it can be concluded that the shallowness of the groundwater in Herculaneum and the possibilities to sink many wells

had the following consequences:
1. The cisterns, probably only serving for drinking-water, could remain small.
2. For a long time private individuals were able to take care of their own water supply and there was no need for the local authorities to interfere. It was not until the introduction of the piped water supply system that their interference was called for.
3. Piped water supply was not as vital as in Pompeii, because the private wells provided a continual water supply.

## FURTHER RESEARCH

Al these data have been gathered by observing the elements which have already been excavated. To extend this research and to come to statistical statements about water supply- and sanitation systems of the excavated part of Herculaneum, it is necessary to fill in the gaps mentioned at the beginning of this article.
In the first place the undefinable shafts should be emptied. This way reliable information about the number of cisterns and wells, their location and the possible combinations of the two could be obtained. Moreover, one could come to some well-founded hypotheses of the contents and the capacity of the cisterns, in connection with the specific purposes the water they contained was used for.
Secondly, the excavation of the drain-pipes of the latrines could also yield valuable information. It might be possible to discover whether these pipes were connected to cesspits or to sewers. Cleaning these cesspits one could gather data concerning capacity, coating and traces of use. This way a useful contribution could be made to Roman latrine research.
In the third place, a more complete picture of the system of water pipes both inside and outside the houses of Herculaneum could be developed tracing the underground pipes.
It would be a pity to let any of these opportunities to gather useful information pass by . Herculaneum is one of the few Roman towns so well preserved and such a treasure of archeological data.

Gemma C.M. Jansen
Regentesseplantsoen 4
2801 CK GOUDA

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## NOTES

* This article deals with some aspects of research carried out from April 1988 till August 1989 under supervision of prof. J.A.K.E. de Waele (Catholic University of Nijmegen), dr. Th.L. Heres (Istituto Olandese, Rome), drs. L.J.F. Swinkels (Provincial Museum G.M. Kam, Nijmegen) and ir. R.J.A.M. Kragting (Technical University of Delft). This research included an extensive inventarisation of all elements and systems.

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[1] For this research -as for all researches being done on Herculaneum- the publication of Maiuri (1958) proved to be of great value and it is used as a starting point. This does not imply, however, that the writer does not want to make a few remarks on his publication with regard to the description of water supply- and sanitation systems. Though Maiuri discusses some aspects of water supply (p.51-53) and

sewarage (p.49-51,467469), he does not look at the systems as a whole. Treating the individual houses he gives arbitrary information about the presence of cisterns, wells and latrines. Other elements, such as waterspouts, are not mentioned at all.

[2] To my knowledge no research has been done into the geology and hydro-geology of Herculaneum. This passage is based on Maiuri (1958) and Wallèn C., Climates of Central and Southern Europe, Amsterdam, 1977, table XV, p.180.

[3] This passage is also based on Maiuri (1958).

[4] Deiss (1985, p.33) gives this number, which is based on the number of seats in the theater and the bounded space on the promontory.

[5] Maiuri (1958) reports occasionally about the presence of a cistern or a well in a house. Only once (p.246) he mentions the excavation of a private well to the bottom. Unfortunately this well and most wells and cisterns reported by him are no longer recognizable as such. This was brought about on purpose partly by filling up the shafts after excavation and partly by tourists, who think these shafts are garbish bins, piling up the rubish.

[6] In some of the houses the overground elements of the system of rainwatercollection are still visible: (with waterspouts) casa del tramezzo di legno III,4-12; casa dell'erma di bronzo III,16; casa sannitica V,1-2; casa del bel cortile V,8; (without waterspouts) casa dell'atrio a mosaico IV,1-2; casa del bicentenario V,13-18.

[7] This simple cortile system can be found in casa dello scheletro III,3; casa a graticcio III, 13-15; casa dell'alcova, IV, 3-4; casa del gran portale V,35.

[8] Completely excavated cisterns are in casa del mosaico di Nettuno e Anfitrite V,6-7; casa del gran portale V,35. Not completely excavated cisterns are in casa a graticcio III,13-15; casa dell'atrio a mosaico IV,1-2; casa del salone nero VI,11 (two cisterns); casa del colonnato tuscanico VI,17 (two cisterns).

[9] Well situated in the atrium of casa V,9-12; casa dei due atri VI,1; casa del rilievo di Telefo Ins. Orient.I,2-3. Well in peristyle in casa del tramezzo di legno III,4-12; casa dei cervi IV,21. Well in a cortile in casa a graticcio III,13-15; casa dell'alcova IV,3-4; casa del bel cortile V,8. Well in a covered space in casa dell'erma di bronzo III,16; casa IV,13 (two wells in the passage); casa V,9-11 (one well in the shop and one well in the passage).

[10] Puteals can be found in casa di Aristide II,1; casa dell'atrio a mosaico III,1-2; casa dell'alcova IV,3-4; casa IV,10-11; casa dei cervi IV,21; casa V,9-12; casa del sacello di legno V,31; casa dei due atri VI,1; casa del salone nero VI,11; casa del colonnato tuscanico VI,17; casa del rilievo di Telefo Ins. Orient. I,2-3.

[11] Well and cisternheads constructed in masonry have been found in casa dell'albergo III,1-2 18-19 (three); casa dello scheletro III,3 (two); casa a graticcio III,13-15; casa dell'atrio corinzio V,30; casa del gran portale V,35; casa del salone nero VI,11; casa del relievo di Telefo Ins.Orient. I,2-3. Well-houses have been found in casa dell'erma di bronzo III,16; casa del bel cortile V,8.

[12] Two windlasses have been found in Herculaneum: one in casa a graticcio III,13-15 (Maiuri 1958 p.413-414). The rope, which is still turned on the windlass, measures more than nine metres. The other windlass has been found in casa IV,13 (Maiuri 1958 p.435-436).

[13] Maiuri (1958 p.52) supposes that Herculaneum was connected with a branch of the so-called aquaduct of Serino, which supplied the greater part of Campania with water. This hypothesis has not yet been verified. See also Sgobbo (1938).

[14] Both water-towers of Herculaneum are situated on Cardo IV, one at the crossing with the Decumanus Inferior, the other at the crossing with the Decumanus Maximus (Maiuri 1958 p.53). For more general information about water-towers see Dybkjaer-Larsen (1982).

[15] The three public fountains of Herculaneum are named after the figures portraied on these fountains. Both the fountain of Venus and the one of Hercules are situated on the Decumanus Maximus. The fountain of Neptune is situated at the crossing of Cardo V and the Decumanus Inferior (Maiuri 1958 p.53). For more general information about public fountains see Eschebach (1982).

[16] Not many enough water-conduits have been found in Herculaneum to make some useful statements about the destinations of these conduits and of the use of tap water. Comparitive research needs to be done on the water-conduits in the houses of Pompeii in orde to shed more light on their possible destinations.

[17] Still visible connected to the tap water system are casa dello scheletro III,3; casa dell'atrio a mosaico IV,1-2; casa del mosaico di Nettuno e Anfitrite V,6-7; casa V,9-12; casa del colonnato tuscanico VI,11. Maiuri (1958) mentions several houses where during his excavation conduit-pipes have been found: casa dell'albergo III,1-2 18-19 (pipe now in the storage rooms of Herculaneum); casa sannitica V,1-2; casa dell'atrio a corinzio V,30; casa dei due atri VI,1; casa della gemma Ins.Orient. I,1; casa di Galba VII,2. In one of the storage rooms of Herculaneum is a conduit-pipe from casa del salone nero VI,11.

[18] In total 62 private toilets and one public toilet in the Forum thermae.

[19] Houses with more than one latrine are casa dell'albergo III,1-2 18-19; casa del telaio V,3-4; pistrinum Ins.Orient. II,1a; pistrinum Ins.Orient. II,8.

[20] A two-seater has been found in casa del tramezzo di legno III,9; casa IV,15-16; casa sannitica V,1-2; casa del salone nero VI,11; casa della gemma Ins.Orient. I,1. A four-seater has been found in casa dello scheletro III,3-4; pistrinum Ins.Orient. II,1a. A six-seater has been found in casa dell'albergo III,1-2 18-19; pistrinum Ins.Orient. II,1a. Compare those with the public toilet at the Forum thermae, which was an eight-seater.

[21] Latrines in kitchens have been found in casa dello scheletro III,3; casa del tramezzo di legno III,4-12; casa dell'albergo III,1-2 18-19; casa dell'alcova IV,3-4; casa sannitica V,1-2; casa del mosaico di Nettuno e Anfitrite V,6-7 (both in the kitchen on the ground floor as well as in the kitchen on the upper floor); casa dei due atri VI,1; casa dell'atrio corinzio V,30; casa del gran portale V,35; casa del colonnato tuscanico VI,17. Latrines near kitchens in casa dei cervi IV,21; casa della gemma Ins.Orient. I,1. Latrines in shops and workshops in taberna vasaria IV,14; casa IV,15-16; casa V,19-20; pistrinum Ins.Orient. II,1a (two latrines) and further in the following workshops of Ins-.Orient. II 5,6,9,10,11,12,14,25. Latrines situated near courtyards in casa del tramezzo di legno III,9; casa a graticcio III,13-15; casa IV,10-11; casa sannitica V,1-2; casa del sacello di legno V,31; casa del gran portale V,35. Latrines situated under staircases in casa del papiro dipinto IV,8-9; casa con giardino V,33; casa del gran portale V,35; casa del salone nero VI,11; pistrinum Ins.Orient. II,8; casa Ins.Orient. II,18. Some latrines have been mentioned two times in this enumeration because sometimes a kitchen is situated near a courtyard, or provided with a staircase.

[22] CILIV Suppl.3.4.10606. This inscription has been found in casa del salone nero VI,11.

[23] Casa dello scheletro III,3 and casa dei due atri VI,1 are still visible connected to this sewer. Moreover, Ruggiero (1885 p.XLVI) mentions a connection to this sewer of casa dell'albergo III,2 , Maiuri (1958 p.50) of casa di Galba VII,2 and Deiss (1985 p.115) of casa del colonnato tuscanico VI,17.

[24] Martialis Ep.XII.48.4; Seneca Ep.70.

[25] This can clearly be seen in the kitchens of casa dell'atrio a mosaico III,1-2 and of casa della gemma Ins.Orient.I.1. For more information see Salza Prina Ricotti E., Cucine e quartieri servili, in Epoca Romana LI-LII (1978-79 and 1979-80) p. 237-294.

[26] One of the main sewers is situated under Cardo III into which the minor sewer from the Decumanus Inferior discharged. Another main sewer is situated under the row of shops and workshops on the west side of Cardo V. During the Convegno Internationale di Studi, Ercolano 1738-1988, 250 anni di ricerca archeologica, held at Herculaneum, Pompeii and Ravello in November 1988, dott. T. Budetta mentioned the discovery of a third main sewer under Cardo IV.

[27] The overflow of the fountain of Hercules and the fountain of Venus, both situated on the Decumanus Maximus, was directed by way of a specially constructed gutter to the sewer under Cardo III. The overflow of the Neptune fountain, situated on Cardo V, streamed trough the street for some metres and flowed by a rising in the road surface and an opening in the kerb into the sewer of this Cardo.

[28] The phases presented here are hypothetical and will be taken into account in future research. The facts used for these phases are based on Maiuri (1958) who dates the Forum thermae and the connected sewer back to the early Augustean period (p.91-112), the introduction of tapwater to the Augustean period (p.52) and the Palaestra with shops, appartments and underlying sewer to the post-Augustean period (p.113-143).

[29] A rich house: big in size with beautiful decorations.

[30] In particular the shops and appartments at Cardo V, probably constructed by the local authorities.