Streets and streams : health conditions and city planning in the Graeco-Roman world

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II. CITY AND BODY FLUIDS

Greek and Roman Ideas about Healthy Drinking-water in Theory and Practice

Context

There is a large number of ancient treatises that discuss drinking water, some written by medical authors (e.g. the Hippocratic treatise *De aëre aquis et locis* (*Airs Waters Places*), and others written by practical men (scientists and 'engineers' like Varro, Vitruvius and Frontinus).

Besides that, a lot has been written about the construction of aqueducts, both famous and less well-known; a look-a-like Pont-du-Gard (a Roman aqueduct in southern France) is even depicted on the € 5 banknote. Over recent decades, many volumes (proceedings of conferences) have been published that discuss hydraulic and archaeological aspects of the supply of drinking water, as well as research results concerning the quality of drinking water in the Graeco-Roman world.[1] Publications discussing philosophical and medical aspects of drinking water, however, are scarcer and are mainly embedded within general works about ancient medicine. The main work in this field is that by A. Bollen, in Dutch and written in 1943.[2]

The English is slightly changed and a few references are added. The references to the Hippocratic Corpus and Galen have been modified in line with all other ancient authors, titles and abbreviations in this volume as mentioned in the Index Locorum.

1 Esp. Réparaz, A. de (ed.). 1987. *L'eau et les hommes en Méditerranée*, Paris; Frontinus-Gesellschaft (ed.). 1987^2. *Die Wasserversorgung antiker Städte: Mensch und Wasser, MittelEuropa, Thermen, Bau/Materialien, Hygiene*, Mainz; Argoud, G. et al. (eds). 1992. *L'Eau et les hommes en méditerranée et en mer noire dans l'antiquité de l'époque mycénienne au règne de Justinien: Actes du Congrès International Athènes, 20-24 mai 1988*, Athens; Ginouvès, R. (ed.). 1994. *L'eau, la santé et la maladie dans le monde grec*, Athens/Paris and Wiplinger, G. (ed.). 2006. *Cura Aquarum in Ephesus: Proceedings of the* 12th *International Congress on the history of water management and hydraulic engineering in the Mediterranean region, Ephesus/Selçuk, October 2-10, 2004*, Louvain/Paris/Dudley MA.

2 Bollen, A. 1943 (see Bibliography).

Greek and Roman Ideas about Healthy Drinking-water in Theory and Practice

Abstract [1]

Healthy drinking-water is one of the basic conditions to survive, in all times and all places. So the presence of healthy drinking-water is a must to found a city.

Ancient medical writers such as the authors of the Hippocratic Corpus, Galen and others expressed their opinions on the question which qualities of drinking-water are the best. There are different types of water: warm and cold, clear and unclear, light and heavy. Also the sources of water are important. There were, roughly, five origins of drinking-water: rain water, source water, well water, surface water (river water, lake water) and marsh water. Even the orientation of the water source was, according to some authors, a factor: to the west, to the east etc. Did their opinions correspond to the opinions of non-medical ancient authors like Aristotle, Pliny the Elder and Frontinus? And did the opinions of ancient authors correspond to the situation in practice? Which type of drinking-water did the city governments prefer to distribute to the citizens?

In my paper, I hope to show that opinions concerning drinking-water in cities, stated by ancient medical authors are (amongst them) roughly the same, but that they sometimes differ from the views of non-medical authors, having different argumentations; in practice, the urban drinking-water supply was completely dependent on local circumstances.

Introduction

The Roman architect Vitruvius acknowledges the crucial importance of water to mankind. In his work *De architectura* (*On Architecture*) 8.3.28 he states: *Nulla enim*

ex omnibus rebus tantas habere videtur ad usum necessitates, quantas aqua, 'For of all things, not one seems to be as necessary for use as water'.[1] Just as today, in the Graeco-Roman world drinking-water was considered as a crucial factor for human survival. Where drinking-water is absent, human life is impossible.

But which type of drinking-water was the best one for consumption? In Graeco-Roman literature, several qualitative distinctions were made: warm and cold water, soft and hard water, light and heavy water, and different types like rain water, spring water and well water. All these types of water were discussed in detail, within the context of ancient medicine and elsewhere.[2]

Some waters were judged healthy, others not.[3] Is, for example, rain water considered as healthier than spring water, and why?

This chapter is divided into three parts. In the first (theoretical) part, I will discuss the different qualities (heavy, light, hot, cold etcetera) and types (rain water, spring water etcetera); in the second part, the situation in practice and, finally, the relation between theory and practice. This chapter will be concerned with drinking-water only; the use of water for other purposes like bathing or irrigation is not at issue here. To stress the continuity in these theories during twelve centuries I have chosen for a thematic approach. I will draw attention to variants and historical develop-
[4] ments whenever necessary.

1. Theory

1.1. Qualities of water

1.1.1. Light and heavy water

In Antiquity, 'heavy water'[4] is supposed to contain more weight, more elements, than 'light' water. Light water is considered as healthy water: it warms up and cools off quickly, it is cold in summer and warmer in winter; since it contains only a few elements, it has no smell or taste and passes through the intestines quickly. Light water is also good for the balance of the four humours inside the human body.[5] According

1 Cf. Vitr. 8.1.1 [sc. *aqua*] *Est enim maxime necessaria et ad vitam*.

2 The cited authors are, chronologically, the following: the authors of the Hippocratic Corpus (5th -1st century BC), Aristotle (384-322 BC), Theophrastus (371-287 BC), Erasistratus (3rd century BC), Varro (116-27 BC), Vitruvius (85-20 BC), Celsus (± 25 BC-50 AD), Columella (4-±70 AD), Pliny the Elder (23-79 AD), Frontinus (30-104 AD), Galen (131-± 210 AD), Plutarch (1st-2nd century AD), Antyllus (2nd century AD), Rufus (2nd century AD), Athenaeus (2nd-3rd century AD), Oribasius (4th century AD), Aëtius (6th century AD) and Paul of Aegina (7th century AD). Although these authors span a period of twelve centuries, in ancient medicine there is so much continuity on the subject of drinking water that, in spite of occasional differences, they can be considered as part of one and the same living tradition. Wherever necessary I will highlight differences.

3 Ruf. 63-72; Haak 2013, 56-58 and 74-78.

4 Nowadays, 'heavy water' refers to the chemical property dideuteriumoxide (D_2O).

5 Hipp. *Aph.* 5.26 (164 Jones = 4.542 L.); Hipp. *Epid.* 2.2.11 (32 Smith = 5.88 L.); Jouanna 1994, 30; Arist. *Pr.* 873b27; Thphr. *Fr.* 214A; Vitr. 8.4.2; Cels. 2.18.12; Plin. *Nat.* 31.37; Bollen 1943, 85-91; Gal. *Ptis.* 1 (6.818-819 K.); Gal. *Hipp. Epid. VI* 4.10 (17b.156 K.); Gal. *Hipp. Aph.* 5.26 (17b.814 K.). Cf. Gal. apud

to ancient medical authors, a healthy man can drink every type of water, but is heavy water as fit for consumption as light water? According to Paul of Aegina, a Byzantine follower of the Hippocratics, all authors consider heavy water as more noxious than light water, because heavy water would have more weight, containing more material or elements and warms up and cools off less quickly than light water.[6] The Hippocratic treatise *De victu* mentions that water must contain as few elements as possible. People having light waters in their bodies react more quickly to season changes; the quantity of particles of water (the element) in their bodies have not yet reached the maximal capacity (πλησμονή); they are more flexible and for this reason, people can reach the age of 40, or more.[7] So, light water is better for human consumption than heavy water, but what is exactly the definition of light and heavy water? There appears to be no agreement on this topic. [5]

According to the author of the Hippocratic treatise *De aëre aquis et locis* (*Airs Waters Places*, in Greek: Περὶ ἀέρων ὑδάτων τόπων; ὑδάτων is plural) rain water is a light type, and therefore healthy. Some authors, especially Celsus (*Nam levis pondere apparet*, 'For by weighing, the lightness of water becomes evident') agree. The heaviest water is sea water.[8] Other authors have a different opinion. The Alexandrian physician Erasistratus, well-known for his experiments, has a surprisingly rational view: he is doubtful concerning the statement that heavy water is worse than light water. There is good and bad drinking-water, but this cannot be deduced from its weight; he states that unhealthy water has the same weight as healthy water.[9] Pliny the Elder radically rejects the importance of the weight of water; it does not matter at all,[10] so his opinion is diametrically opposed to that of Celsus. This raises the question whether the 'weight' of water was a purely theoretical qualification or was really put to test.

A fragment of Erasistratus' work sheds some light on this problem. After a discussion concerning potable water, Erasistratus states: δοκιμάζουσί τινες τὰ ὕδατα σταθμῷ ἀνεξετάστως. There are, in my opinion, three possible interpretations of this sentence.

- Firstly, σταθμῷ ἀνεξετάστως may be interpreted as a word group, independent of δοκιμάζουσι: 'some people evaluate water, without inspection of its weight'. In this context, τινες are right: they consider weight of such little importance that they do not examine it (ἀνεξετάστως), confirmed by γάρ in the following

Orib. *Med. Coll.* 5.1.2; Aët. 11.15.23; Paul. Aeg. 1.50; Garzya 1994, 109; Rogers 2013, 7. For a list of authors and their statements concerning light (healthy) water see Bollen (1943, 140-142). She does not mention Aristotle, Vitruvius and Galen, but they have the same opinions.

6 Paul. Aeg. 1.50.1.

7 Hipp. *Vict.* 1.32 (272-278 Jones = 6.506-510 L.).

8 Hipp. *Aer.* 8; Arist. *EN* 1142a21; Cels. 2.18.12. According to Aristotle, light water has a better taste, passes the stomach quickly and does not cause intestinal diseases. He uses the word λεπτός, not only meaning 'light-weighted' but also 'with a fine structure': Arist. *Pr.* 873b27. Cf. Thphr. *Fr.* 214A vol. 1, 384-385; vol. 3.1, 204-205; Von Staden 1994, 80-81; Vitr. 8.4.2; Bollen 1943, 47; Sen. *Nat.* 3.2.2. Sea water: Arist. *Pr.* 932b8-10.

9 Erasistr. apud Ath. 2.46c; Erasistr. *Fr.* 159, 117; Von Staden 1994, 81-83.

10 Plin. *Nat.* 31.32; cf. 31.38; Von Staden 1994, 82-84.

sentence (ἰδοὺ γὰρ τοῦ ἐξ Ἀμφιαράου ὕδατος καὶ ἐξ Ἐρετρίας συμβαλλομένων, τοῦ μὲν φαύλου τοῦ δὲ χρηστοῦ ὄντος, οὐ δή τίς ἐστὶ διαφορὰ κατὰ τὸν σταθμόν ('Witness that, when water from the Amphiaraus spring and from Eretria is compared, although one of them is bad and the other good; there is no difference in weight whatsoever').[11]

[6] • Secondly, the word σταθμός can mean 'weight' (τό), but also 'balance' (ὁ). So another translation of these words would be: 'some people evaluate water without inspection, by means of a balance'. This interpretation does not make much sense; moreover, in this interpretation, there is no coherence between the two sentences connected by γάρ. Furthermore, it seems illogical to measure a weight without the use of a balance. Pliny translates Erasistratus' quotation roughly: *quidam statera iudicant de salubritate frustrante diligentia,* 'some people evaluate (sc. waters) by means of a balance; but their efforts are senseless'.[12] He continues stating that weight is not important.

• Thirdly, σταθμῷ specifies δοκιμάζουσι ('some people evaluate water by its weight, without [critical] inspection'). In this case, τινες are researchers who are wrong; according to the next sentence, weight is not of any importance at all. I prefer this last possibility: this is the clearest explanation (more stressed if οὐ δή τίς is used),[13] there is a coherence between the two sentences doing justice to γάρ and the use of τινες suggests that some people evaluate water by its weight.

In the second option, balances were mentioned. There are three authors who discuss the use of balances explicitly: Plutarch (who describes people using and even constructing balances for measuring the weight of water; Pliny the Elder and even Galen (mentioning that who wants to know the weight of water has to use a balance).[14] Moreover, Theophrastus claims that he has weighed water at Mount Panggaion; in winter, the water weight is 96 units, in summer 46; water clocks would be inaccurate due to the changing density of water. This story seems to be doubtful. There is no evidence for a change of weight of water in summer and winter (in winter more than twice as much!). Theophrastus' use of the word *gnomon* (ἐν τοῖς γνώμοισι) provides another puzzle since a *gnomon* is a sundial which does not contain water. The exact
[7] numbers suggest that he has weighed water by means of a balance, but the incredible elements of this story make it hard to believe.[15] The notion of practical experiments by Erasistratus and, moreover, by Galen is striking.

11 In Garofalo's edition, οὐ δή τίς is mentioned; this gives the statement a more stressed signification than the one of Erasistr. apud Ath. 2.46c οὐδ' ἥτις, 'although one of them is is bad and the other good, and there is no difference in weight.' There are two springs called Amphiaraos: one in the Amphiareion in Oropos, a good one; the other in Lerna, a bad one. See for this discussion concerning the Amphiaraos springs compared with the spring of Eretria Bollen (1943, 108-111). According to Nutton (1998, 226), Evenor refers to the Amphareion water in Oropos.

12 Plin. *Nat.* 31.38.

13 See note 11.

14 Plu. *Fr.* 81; Plin. *Nat.* 31.38; Gal. *Hipp. Aph.* 5.26 (17b.815 K.). Cf. Ruf. apud Orib. *Med. Coll.* 5.3.26.

15 Thphr. apud Ath. 2.42a-b; Fortenbaugh 1992, 382-383 (= 214A). The translator of the Loeb text (ed. 1927) justly adds in a footnote: 'This is the only passage in which γνώμων = κλεψύδρα, "water-clock".'

Some authors mention the possibility that the weight of heavy water might be reduced by boiling. Galen states that water has to be boiled and later cooled off: at first, it must be put down in an open jar or barrel and the next day one has to sprinkle the barrel. During the boiling process, the water elements are divided and when the water is cooling, heavier elements like salt or bitumen sink down to the bottom and the lighter elements remain in the upper part of the barrel.[16] This process testifies to the view that added elements deteriorate the quality of water.

Airs Waters Places speaks of 'hard' (σκληρός), roughly comparable with 'heavy' water. 'Hard' water is not water containing lime or calcium, like nowadays, but water containing particles of rock, sometimes with added metals or bitumen. People with a 'hard digestion' are advised to drink 'soft' water and people with a soft digestion to drink 'hard' water, *contraria contrariis*.[17]

In short, waters containing a lot of elements were supposed to be heavy, and therefore unhealthy. Some authors were convinced of the fact that waters have different weights from place to place and that therefore the salubriousness of waters differs too. Other authors, however, were doubtful concerning this topic; salubriousness of water was, in their view, independent from its weight.

1.1.2. Hot and cold water

Ancient authors distinguish hot (heated) and cold water. There are two types of hot water: water, hot by nature, from hot springs; and water, artificially heated by fire. Lukewarm water is heated artificially. All other water is cold: rain water, cold spring water, well water and cistern water (cisterns are bricked underground water cellars for storage of water). 'Hot', 'lukewarm' and 'cold' are, of course, relative notions, also in Graeco-Roman times; cold for the one, fresh for the other. So, 'cold' can mean 'fresh', 'cool', and even 'icy cold'.

In *Airs Waters Places*, hot water contains elements (a.o. sulphur, alum and bitumen), making it heavy and therefore unhealthy. Here, Vitruvius is an adherent of *Airs Waters Places*: he states that water, by its nature, is cold; if hot, it contains elements like sulphur, alum or bitumen. In some cases, however, hot springs produce healthy water and cold springs unhealthy water. Nevertheless, in view of his use of words like *autem* in 8.3.1, *sunt autem etiam nonnulli fontes calidi, ex quibus profluit aqua sapore optimo*, 'there are, however, also some hot springs from which water flows of excellent flavour' and *etiam* in 8.3.2, *sunt etiam odore et sapore non bono frigidi fontes*, 'on the other hand, there are cold springs of unpleasant smell and taste', it may be inferred that, according [8]

What follows is uncertain in text and meaning'. In ed. 2006: '*gnōmōn* has this sense nowhere else, but it is difficult to see what else the text could be referring to'.

16 Gal. *Hipp. Epid. VI* 4.10 (17b.153-166 K.); Bollen 1943, 86. Boiling, cooling and reheating of water: Ruf. apud Orib. *Med. Coll.* 5.3.36; Haak 2013, 75; apud Aët. 3.165; cf. Paul. Aeg. 1.50; Winkelmann 1994, 167.

17 Hipp. *Aer.* 7 (88 Jones = 2.32 L.); Bollen 1943, 29; Crouch 1993, 50; López Férez 1992, 538; Jouanna 1996, 37. Cf. Ath. 2.42c; Wellmann 1900, 357.

to Vitruvius, hot springs produce mainly more noxious waters than cold springs.[18]

Galen permits sick people to drink cold water if they used to do so while they were healthy; this suggests that Galen does not advise drinking water to be cold. He gives a list of cases concerning the use of cold water. Cold water (as medicament) is wholesome against fever (*contraria contrariis*), to restore the temperature of the body, but sometimes, it is better not to use cold water.[19] Hot water – I suppose heated water – was also used as medicament, especially as emetic.[20]

In general, cold water was supposed to be more healthy for consumption, because this is a natural phenomenon; hot water should contain more (noxious) elements – but there are some exceptions. Hot water, however, is recommended as emetic.

[9] ***1.2. Types of water***

Now I will discuss the several types of water (precipitation water and water on earth). There are, roughly, four types of water: rain water, spring water, well water and surface water. The last type can be subdivided into marsh water, river water and lake water. Which type of water was recommended by ancient authors for consumption and which was not?

1.2.1. Rain water

According to the majority of all ancient authors, rain water is considered as the best type of water. *Airs Waters Places* states that rain water from the highest parts of the sky, close to the sun, is the best, because the sun makes it sweet; rain water from the lowest parts of the sky is less healthy, because rain water deteriorates quickly and close to earth, it is a dense fog. For the best result, it must be boiled before consumption preventing afflictions of the throat.[21] The Hippocratic author does not make clear whether rain water is better than spring water (discussed below).[22] Nearly all

18 Hipp. *Aer.* 7 (86 Jones = 2.30 L.); Thphr. apud Ath. 2.42a-b; Fortenbaugh 1992, 384-385 (= 214A); Sharples 1998, 205-206; Steinmetz 1964, 264; Campbell 2012, 343; Vitr. 8.2.8-9. Sulphur, alum and bitumen: see *infra*. Temperature and taste: Vitr. 8.3; Winkelmann 1994, 167; Campbell 2012, 339.

19 Gal. *Hipp. Epid. VI* 8 (ed. Pfaff, CMG V 10.2.2, 489-490); Horstmanshoff 1999, 138. List and fever: Gal. apud Orib. *Med. Coll.* 5.2.1-9.

20 Recommending cold water: Hipp. *Morb.* 2.40 (226 Potter = 7.56 L.) (against fever, *contraria contrariis*); Cels. 1.3.23; Gal. *MM* 11.9 (10.757 and 10.759 K.); Gal. *Comp. Med. Loc.* 8.4 (13.170 K.); Paul. Aeg. 1.40.1. Cold water as emetic: Cels. 3.9.3; Rejection of cold water: Diocl. *Fr.* 182 line 207; Gal. *San. Tu.* 1.11 (6.56 K.); Orib. *inc.* 40.52. Recommending hot water: Hipp. *Loc. Hom.* 27 (66 Potter = 6.318 L.); López Férez 1992, 536. Warm water as emetic: Hipp. *Epid.* 2.5.19 (74 Smith = 5.132 L.); Ruf. apud Orib. *Med. Coll.* 7.26.167; Antyll. apud Orib. *Med. Coll.* 5.29.1-4; Gal. *Ant.* 2.7 (14.144 K.); Aët. 5.108.

21 Hipp. *Aer.* 8 (90 Jones = 2.36 L.); Crouch 1993, 50; Bollen 1943, 40; Winkelmann 1994, 163-164; Von Brunn 1946, 166; Von Brunn 1947, 12; López Férez 1992, 538.

22 Bollen 1943, 42 'rain water is the best of all'; *contra* Bollen 1943, 112 'Hippocrates prefers spring water to rain water'. In *Airs Waters Places*, there are two main groups of water: precipitation water (rain water, falling down with force or not, ice and snow water) and water on earth (spring water from rocks, earthen hills, and surface water).

other authors prefer rain water.[23] In addition, the physician Rufus divides rain water into rain water falling with a north wind – this type is softer and colder – and falling with a south wind – this type is harder and warmer. Rainfall in winter and spring is better than in summer and autumn, because in these seasons there are noxious vapours emitting from the earth.[24] Pliny the Elder is an adherent of the same view concerning rain water pollution. He mentions that some physicians prefer rain water [10] (*hi* [sc. *medici*] *rationem adferunt, quoniam levissima sit imbrium, ut quae subire potuerit ac pendere in aere*, 'the physicians adduce that the lightest water is rain water, seeing that it has been able to rise and to be suspended in the air'), but, according to him, rain water deteriorates quickly, due to noxious vapours from the earth. Rain water warms up quickly, because it is polluted; so he is in disagreement with nearly all medical authors who state that light water with only a few or no elements is warming up quickly. The same opinion concerning pollution of rain water caused by other elements in the atmosphere is found, however, in *Airs Waters Places* 8; maybe, Pliny derived his view from this treatise.[25] Nowadays, we know that 'acid rain' is caused by pollution.

In *Airs Waters Places* other types of rainfall are distinguished: rain water falling in a calm shower is preferred to rain water falling during a storm. However, if rain falls accompanied by lightning, it is even better; lightning is associated with ether, the furthest remoted from earth with its noxious vapours, and thus as pure as possible.[26]

Concerning the question as to whether snow, hail and ice water are better than rain water, there is discussion amongst the different authors. Some medical authors answer this question in the negative; the light and sweet particles of these waters (λαμπρὸν καὶ κοῦφον καὶ γλυκύ) would have been diminished and the heavier ones (θολωδέστατον καὶ σταθμωδέστατον, added elements) are left behind.[27] Pliny, on the other hand, states that according to some authors, snow- and ice water is better than rain water, because it is lighter, but hail water, only mentioned by him, is the worst of all, due to the absence of fine particles (*exactum sit inde quod tenuissimum fuerit*).[28]

23 Thphr. *HP* 7.5.2; Vitr. 8.2.1; Gros 1997, 1157; Winkelmann 1994, 167; Cels. 2.18.12; Col. 1.5.2; cf. Palladius 1.17.4; Plu. *Aetia physica* 912b-d; Gal. *Hipp. Epid. VI* 4.19 (17b.184 K.); cf. Gal. apud Orib. *Med. Coll.* 5.1.5; Gal. apud Orib. *Med. Coll.* 5.1.9-10; Ruf. apud Aët. 3.165; Haak 2013, 74-75; Paul. Aeg. 1.50. An enumeration of all rain water adherents and Pliny as opponent is given by Bollen 1943, 46-47.

24 Ruf. apud Orib. *Med. Coll.* 5.3.7-11; Bollen 1943, 131-133; Haak 2013, 75. For the exhalations from the earth into rain water see Plin. *Nat.* 31.32.

25 Plin. *Nat.* 31.31-34. Pollution of rain water: Gal. apud Orib. *Med. Coll.* 5.1.8.

26 Hipp. *Epid.* 6.4.17 (238 Smith = 5.310 L.); Gal. *Hipp. Epid. VI* 4.19 (17b.187.7-188.11 K.); Paul. Aeg. 1.50.

27 Hipp. *Aer.* 8 (92 Jones = 2.36 L.); Jouanna 1996, 31; Crouch 1993, 50; Bollen 1943, 18 and 26; López Férez 1992, 535; Gal. *Hipp. Aph.* 5.24 (17b.813 K.); Gal. apud Orib. *Med. Coll.* 5.1.10; Bollen 1943, 91-92; Paul. Aeg. 1.50.

28 Plin. *Nat.* 31.33. See for the discussion concerning the quality of snow and ice water Bollen 1943, 74-76. Cf. Ath. 2.42c; Thphr. *Fr.* 214A vol. 1, 384-385; vol. 3.1, 206; Wellmann 1900, 354-355.

1.2.2. Spring water

The Hippocratic ideas concerning rain water survived throughout the classical period, until the Byzantine era; according to Paul of Aegina, spring water is good, but rain water is better; the author cites *Airs Waters Places*: rain water contains the finest elements.[29] *Airs Waters Places* mentions two types of spring water. Firstly water from
[11] springs rising out of rocks; they deliver hard water, containing small pieces of rock. Secondly, spring water from soil producing better water.[30] According to Aristotle, some salty (and, inevitably, according to ancient theory 'heavy') springs can produce drinking-water. According to him, all hot water springs produce salt water. But is this really salt water? Probably, this is mineral water containing elements producing a certain taste; in hot (mineral) water, elements dissolve easier than in cold water. On the other hand, Diodorus Siculus mentions some hot springs producing sweet and healthy water.[31]

A positive aspect of spring water is the property that it flows. Varro agrees, stating that an estate must enclose a spring, or nearby.[32] Vitruvius' opinion concerning spring water is less strict: Springs at the foot of mountains (including siliceous earth) produce more and better water than springs in a flat area, because flat areas receive more sunlight and heath; the sun pulls up the finest elements of the water, leaving behind the less tasteful part of the water. Here he disagrees with the author of *Airs Waters Places*, who has a negative opinion on springs rising out of rocks.[33] When spring water is passing an earth layer containing sulphur, alum or bitumen, this water will produce stench and a bad taste; it does not matter whether it is hot or cold. Later, however, Vitruvius discusses the (wholesome) curative aspects of water containing sulphur, alum or bitumen; suitable for bathing, but not for consumption.[34] He prefers, on behalf of cities and settlements, spring waters to well waters.[35]

The only non-medical author who divides water into different types is Columella. His sequence is as follows: the best water is flowing water (spring water), next well water and, third, cistern water (subdivided into, the best, rain water, second water from rocks and third water from hills) and, finally, marsh water. Flowing spring water is better than well water and stagnant water.[36] But is spring water better than rain water? Columella calls rain water *salubritati corporis accommodatissima*, 'most suitable to the body's health' (1.5.2), but this refers to cistern water, so it can be stated that, for consumption, rain water is as good as spring water. A remarkable point is that Columella prefers spring water rising out of rocks to spring water rising out of hills and valleys, in contrast to *Airs Waters Places*. Here we see, maybe, the practical man

29 Paul. Aeg. 1.50; Hipp. *Aer.* 8 (90 Jones = 2.32 L.); Jouanna 1996, 39.

30 Hipp. *Aer.* 7 (86 Jones = 2.30 L.).

31 Arist. *Pr.* 937b18; cf. Sen. *Nat.* 3.2.1; Rogers 2013, 7; D.S. 2.59.9; Hipp. *Aer.* 3 (74 Jones = 2.16 L.) mentions brackish water in cities exposed to the south winds, but it is unclear if this is also drinking-water.

32 Thphr. apud Ath. 2.42c; Hellmann 1994, 274; Var. *R.* 1.11.2.

33 Vitr. 8.1.2 and 8.1.7. Cf. Thphr. *Fr.* 214A vol. 1, 384-385; vol. 3.1, 206; Col. 1.5.2; Palladius 9.8; Callebat 1973, 55.

34 Vitr. 8.2.8. Curative waters: Vitr. 8.3.4; Callebat 1973, 91; Gros 1997, 1166; Yegül 1992, 92-93.

35 Vitr. 8.6.12.

36 Col. 1.5.1.

Columella, in opposition to the more speculative views of the Hippocratics. Perhaps, in Columella's view, water from hills is less clear, due to layers of clay and sand. [12]

Concerning springs, Pliny the Elder pays attention mainly to curative springs for bathing, mainly hot ones, containing sulphur, alum and bitumen – the similarity of Vitruvius' opinion on this topic (discussed above) is striking. Pliny (a critic of Greek medicine)[37] – gives the place and situation of water a central role: rain water is not good (due to its pollution), and water is considered as good neither owing to its containing particles of sand or rock nor by the question if it is flowing or not; therefore only the place is important.[38]

Whence the different opinions concerning the quality of waters from rocks, sandy hills or valleys? As said above, the author of *Airs Waters Places* argues that water from rocks is 'heavy', probably because rocks are heavy; sand is lighter of weight, so healthier. Particles of rock, however, make water less turbid than particles of finer material like sand; therefore, Vitruvius and Columella prefer water from rocks.

The majority of the authors state that, discussing spring waters, neither their temperature, nor their origin, nor their contents do actually matter. Some of these authors, mentioning that it depends on the places, whether a source is good or bad, are Plutarch (water from Arethusa, although light, is bad); Rufus (agreeing with Plutarch on the case of Arethusa: this water causes, according to him, gout) and Athenaeus. The latter sometimes follows the Hippocratic tradition (heavy and hard water is worse than light water warming up quickly; flowing water is better than stagnant water, and water from mountains is better than water from plains). He goes on, however, to enumerate a list of healthy and unhealthy springs, e.g. in the environment of Baiae, producing unhealthy waters; Strabo, however, states that these are very wholesome. Maybe, Strabo refers to a different spring, or water from these springs is unfit for consumption, although maybe suitable for bathing purposes.[39] Authors discussing individual springs have, in contrast to authors following Hippocrates, a less speculative and less generalising approach. The importance of cardinal directions with spring water is also mentioned by *Airs Waters Places*: a spring situated to the east is the best, next a spring to the north, next a spring to the west and, finally, a spring to the south. In case of southern springs, it does matter whether there is north wind or south wind; south wind is worse than north wind.[40] Cities exposed to the south have plentiful and brackish waters; cities to the north have cold and hard waters, and cities to the west unclear ones. Cities to the east have the best waters; sweet-smelling, soft and delightful.[41] [13]

37 Hahn 2005, 715.

38 Plin. *Nat.* 31.4-5. In the next paragraphs, he discusses a large number of springs and their properties. According to Pliny the Elder (*Nat.* 31.59), sulphur is good for the sinews, alum against paralysis and collapse and asphalt and bitumen are good for drinking and as a purge, following Vitr. 8.3.4; Bonnin 1984, 90. Crucial place and situation: Plin. *Nat.* 31.35; Campbell 2012, 340.

39 Hot and cold springs, healthy and unhealthy: Ath. 2.42e-2.43e. Baiae: Ath. 2.43b; Thphr. *Fr.* 214A vol. 1, 386-387; vol. 3.1, 208; Str. 5.4.5. According to Campbell, also Galen judges each spring separately: Gal. *SMT* 1.6 (11.392 K.); Campbell 2012, 343.

40 Hipp. *Aer.* 7 (88 Jones = 2.30 L.); Jouanna 1996, 33-34. Cf. the colder and softer north wind during rainfall mentioned by Rufus above.

41 South: Hipp. *Aer.* 3 (74 Jones = 2.16 L.); north: Hipp. *Aer.* 4 (76 Jones = 2.18 L.); east: Hipp. *Aer.* 5 (80

Other authors also prefer springs in the north and the east. Vitruvius is an adherent of *Airs Waters Places* concerning situations to cardinal directions and states that the best springs are situated in the north. It is uncertain whether Galen prefers spring water to rain water, but an important factor is the direction of the stream from the spring. Rufus prefers both north and east.[42] But what is meant by, for example, 'to the south'? Does the author mean that the water flows to the south, so the spring is, inevitably, situated in the north? Or is the spring in the south and does the water flow to the north? According to Paul of Aegina, spring water flowing to the north is bad;[43] inevitably, this spring is situated in the south, where, according to *Airs Waters Places* and other authors, the water is bad. Maybe, it is meant that 'a spring to the south' is a spring in the south, from where the stream flows to the north. For an explanation for preferring the east and the north, see pp. 162-166 in this volume.

1.2.3. Well water

In respect to well water, the Hippocratic Corpus is less clear. According to *Airs Waters Places*, good water must be cold in summer and warm in winter (*contraria contrariis*); well water coming from a great depth is such water. A disadvantage is that a well contains stagnant water in the upper part, warm in summer and cold in winter.
[14] Vitruvius prefers spring water to well water; he recommends digging wells if there are no springs. Varro and Columella recommend respectively a reservoir and a well if a spring is not present.[44]

Some authors state that the quality of well water is worse than spring water. In the water order of Celsus, well water comes after rain water, spring water and river water.[45] The fact that well water is placed after river water is astonishing, because surface water is usually estimated as an unhealthy type of water. Probably, Celsus prefers river water because it is flowing, like rain and spring water.[46]

Only Pliny is an adherent of well water, on condition that it is continuously flowing, and that the location provides fresh air and shadow. Another advantage is the

Jones = 2.22 L.); west: Hipp. *Aer.* 6 (82 Jones = 2.24 L.); Bollen 1943, 32-33; Lo Presti 2012, 178-179.

42 For his education in architecture, knowledge of medicine was needed: Vitr. 1.1.10; 1.1.13; Mazzini 2014, 89. It is remarkable that he uses the words *aeris et locorum* […] *aquarumque*, possibly a reference to *De aëre aquis et locis* (*Airs Waters Places*). Best springs in the north: Vitr. 8.1.6 (cf. Callebat 1973, 60-61); 8.2.6 and 8.2.8; Gal. *San. Tu.* 1.11 (6.57 K.); Bollen 1943, 90-91; Gal. apud Orib. *Med. Coll.* 5.1.4; Ruf. apud Orib. *Med. Coll.* 5.3.12-16; Bollen 1943, 133-134 (directions of streams); cf. Ruf. apud Aët. 3.165 and Ruf. apud Orib. *Syn.* 4.41.1-12; Wellmann 1900, 352.

43 Paul. Aeg. 1.50.

44 Hipp. *Aer.* 7 (86 Jones = 2.30 L.); Hipp. *Morb.* 4.25 (70-74 Potter = 7.522-526 L.); López Férez 1992, 535; Vitr. 8.6.12; Guillaume 1877-1919, 1209; Var. *R.* 1.11.2. Varro writes *sub tectis* when he discusses drinking-water. This expression can refer to a roofed well or underground storage. I suppose that the latter is meant, because Columella writes *cisternae hominibus, piscinaeque pecoribus* (1.5.1-4) describing the polarisation between men and animals; Morley 2005, 197. Cf. Col. 11.3.8.

45 Cels. 2.18.12; Jouanna 1996, 39; Hellmann 1994, 275; Bollen 1943, 46; cf. Wellmann 1900, 352.

46 There are slowly flowing rivers with turbid waters and rapidly flowing brooks; probably, Celsus refers to the last ones. Rufus is negative about well water, but it can be improved by moving it: Ruf. apud Orib. *Med. Coll.* 5.3.1.

fact that it has been filtered through earth layers.[47] But well water usually does not flow, except after tapping; why, nevertheless, his preference for well water? Maybe this may be explained by his disdain for theoretical Greek doctors (who prefer rain water and spring water) and his preference for simple medicine. Well water was used on a large scale in the Vesuvius area where he lived.[48] So we can conclude that well water is usually less in favour than rain water and spring water. Apart from the fact that it contains more elements, it is not clearly flowing.

1.2.4. Cistern water

Cistern water is rain water, stored in cisterns. On the one hand, it is rain water, according to the majority of the authors the best type of water. On the other hand, it is stagnant water, the worst type.

The only author who mentions cistern water is Evenor, a 4th century BC physician. He recommends cistern water and, according to the same discussion in Athenaeus' book, Praxagoras recommends rain water.[49] Aristotle states one should drink cistern water only in case of emergency, if no other water is available.[50] For water supply at an estate, Varro recommends a cistern if there is no flowing water and Columella recommends it if there is no spring or well. This cistern must be filled with rain water; if this is lacking, with water from rocks; if this is lacking too, with water from hills. Pliny's opinion concerning cistern water is very negative. He states that some physicians recommend cistern water (maybe Evenor is one of them), but that is unhealthy: it contains slime (*limus*, maybe a reference to algae, covering the masonry of a half-filled cistern) and other noxious creatures.[51] Due to the fact that cistern water is stagnant water, containing a lot of elements (added during the storage), it must have been usually considered as a relatively unhealthy type of water. [15]

1.2.5. Surface water

Surface water is water from slow-flowing rivers, lakes and marshes. Particularly marsh water is discussed and condemned by nearly all authors as the worst type.[52] Galen dissuades the consumption of water from pools or puddles, stench-producing,

47 Plin. *Nat.* 31.38-39; Bollen 1943, 71. Filtering: Plin. *Nat.* 31-38.

48 For Pliny's attitude towards Greek medicine see the article of Hahn, 1991, *passim*.

49 Ath. 2.46d; Hellmann 1994, 274; Bollen 1943, 73; Wellmann 1900, 356; Nutton 1998, 226. It is remarkable that cistern water is considered as different from rain water. Probably, the taste has changed during the storage, or cisterns were filled with other types of water.

50 Actually, the situation in practice (see *infra*).

51 Arist. *Pol.* 1330b; Hellmann 1994, 274; Var. *R.* 1.11.2. Col. 1.5.2; Plin. *Nat.* 31.34; Oleson 2008, 290; Rogers 2013, 7.

52 Hipp. *Aer.* 7 (84-86 Jones = 2.26-28 L.); Bollen 1943, 18-25; Jouanna 1996, 33-36; López Férez 1992, 537; Arist. *Pr.* 884a32-34; Argoud 1987, 209; Cels. 2.18.12; Jouanna 1996, 39; Bollen 1943, 46. Varro does not discuss explicitly stinking marsh water, but the bad reputations of marshes in general: Var. *R.* 1.12.2; Col. 1.5.3; Ruf. apud Aët. 3.165; Garzya 1994, 109; Bollen 1943, 149; cf. Paul. Aeg. 1.50.

muddy and salt water, so also marsh water.[53] Rufus states that beside marsh water also lake water is unhealthy; in summer- and wintertime, it causes diseases like dysentery and dropsy. Only a marsh in Egypt is not unhealthy, because there are less season influences and Nile water is refreshing the marsh from time to time.[54] Other
[16] authors are, however, sometimes less negative.[55]

It is clear that standing water, involving such properties as smell, taste, colour and even mud is, actually, the worst type and unfit for consumption. The poor quality of surface water is also recognised by Frontinus, the author of *De aquis urbis Romae* (*Aqueducts of Rome*). Water has to be clear and turbid water is unhealthy. The best aqueducts of Rome are the Aqua Marcia and Aqua Claudia, containing spring water, better than rain water;[56] but the worst water for consumption comes from the river Anio aqueducts. Galen praises the excellent quality of the water of Rome (better than Pergamum),[57] but unfortunately he does not mention the name of the aqueduct. As has been said, there were good and bad aqueducts.

Regarding the different types of water, sometimes summed up by authors, rain water and spring water were considered as the most healthy ones; surface water, however, as the most unhealthy. The other types of water, well water and cistern water, were considered as moderate.

1.2.6. Conclusion

In literature, therefore, we see roughly the same preferences of water types. Light water is better than heavy water, because it contains no (or nearly no) added elements; the best drinking-water is clear, without any smell or taste. As to the preference for cold or hot water, there is a clear preference for cold water for consumption. Discussing the types of water, we found that rain water was favourite, preferred by the majority of all authors, and especially by medical authors. Sometimes, other types of drinking water were preferred by authors, like Pliny the Elder and Columella. But what was the situation in practice? Did people really consume mainly rain water? Or another type of water, maybe considered as less suitable for consumption than rain water but available in a larger quantity and easier to supply by local or regional authorities? Was there, in practice, a preference for 'light' or cold water? In the next paragraph, I hope to answer these questions.

53 Gal. *San. Tu.* 1.11 (6.56-58 K.). According to Galen, the quality of fish depends on the corresponding water quality: fish living in muddy water is more unhealthy for consumption than fish living in clear water. The most unpleasant fish is fish living in water polluted by city sewers: Gal. *Alim. Fac.* 3.24-31 (6.708-730 K.); Grant 2000, 174-183.

54 Ruf. apud Orib. *Med. Coll.* 5.3.3-6; Haak 2013, 75; apud Aët. 3.165; Garzya 1994, 110; Bollen 1943, 128-130. Rufus mentions a disease called 'ophis' in Egypt, caused by worms after the consumption of water (Ruf. 65-69); Haak 2013, 57 and 76-77. If Nile water is drunk, this water is not healthy, contradicting his statement concerning Nile water.

55 X. *HG* 3.2.19 (Leucophrys); Plin. *Nat.* 31.31. Surface water can be relatively good, but it must flow; cf. Var. *R.* 1.11.2 and Col. 1.5.2.

56 Fron. *Aq.* 2.91, 1.12-13 and 2.89.

57 Gal. *Hipp. Epid. VI* 4.10 (17b.159 K.).

2. Practice [17]

2.1. Wells, springs, cisterns and aqueducts

Once more: people cannot survive without water. This statement was also recognised in the Graeco-Roman world. So governments had to distribute water of high quality to the citizens.

Which type of water was, in daily life, supplied to the citizens? Did the theoretical and even speculative qualities of water play a role of any significance for water supply in practice? I have argued that, according to the literary sources, 'soft' and 'light' water, cold water, rain water and spring water were considered as the best types of water. In practice, however, all water types have advantages and disadvantages. A spring can dry up due to an earthquake or a change in climate. If there is the wish to remain in the same place, one is forced to look for another water type. Rain water is an alternative. The disadvantages of rain water, however, are the flat taste (caused by the absence of minerals) and the fact that rain does not always fall, and not everywhere. The Mediterranean area has hot, dry summers and one has to collect and save rain water in other seasons as much as possible for dry periods. This was accomplished by the construction of cisterns: bricked underground water cellars for saving water. A disadvantage of the cistern is that water is stagnant like marsh water, as we have seen in the first part of this chapter, considered as the worst water type. Cisterns had to be cleaned and maintained regularly, and one had to check that there were no cracks, caused by earthquakes or wearing of the building material. Mortar which covered the interior part of the cistern was especially vulnerable. We know that people were severely punished if they did not maintain their cisterns meticulously.[58] Finally, well water is actually always available, but sometimes one is forced to dig deep to reach it; the level can change or the well may even dry up.

When cities arose, we see a change from individual water supply to communal water supply, constructed and maintained by the city government or local authority. The construction of cisterns, wells and sometimes a spring for water supply for their own property in the countryside could be done by individuals, but water supply for a city needed more investment. One had to look for the most suitable tap points and means of transport for water supply. Water tapping from the spring was important for the whole community – which had to pay for it, by means of taxes – and it was crucial that water supply was not hampered. To achieve this, it was preferable to construct underground water pipes or aqueducts. According to Vitruvius, water must remain cold and, moreover, be inaccessible to unauthorised people who could tamper [18] with the water supply, pollute or poison the water, a suggestion mentioned for exam-

58 Maintenance of cisterns: Brinker 1990, 71-73; Oleson 2008, 288-289; Reinholdt 2009, 204-206. Punishments: Bonnin 1984, 36.

ple by Frontinus, or destruct aqueducts.[59] So it is crucial that only in the fountain house water is accessible to the public.

Some cities had a large quantity of aqueducts at their disposal, like Pergamum, Syracuse and Rome, but if springs were lacking, cisterns remained in use (also urban cisterns), for example in Carthage. So the number of inhabitants was not a crucial factor to construct more and longer aqueducts. Also, the best type of water was not always available. In Rome, spring water supply was insufficient, so here even river water was in use. The invention of the arch construction and the unity of the Roman Empire made it possible for the Romans to construct their famous long arched aqueducts.

2.2. Drinking-water in the Greek world

Greek settlements were usually founded, in the first instance, in the neighbourhood of springs, but later wells were dug out and underground water pipes were constructed. Spring water remained the preferred water type. Sometimes well water remained in use, e.g. at the Asklepieion of Cos. Here was a continuous flow of underground water,[60] apparently considered as better than rain and spring water – in contrast to the discussion above, where rain water is considered as the best.

Around 400 BC, we see a change from spring and well water into cistern (rain) water. The reason of this is a point of discussion. According to Camp and Crouch the climate became drier (especially in the years 335-325), so water became scarcer and rain water had to be stored in cisterns. The drought is mentioned by Aristotle in his *Meteorologica*.[61] According to Thommen and Maise, however, while the climate between 850 and 600 BC was cooler and wetter and in the 6th and 5th century it was hotter and drier, the 4th century and 3rd century were cooler and wetter again. The
[19] information given by the C14 level in ice cores corroborates the latter supposition. Maybe, the Greek drought was local, caused by deforestation?[62] The quotation that, according to Brinker, cisterns were already in use in Athens in the 6th century BC, can refer to the dry period between the 6th and 5th century.[63] But what about the use of cisterns in the cooler and wetter 4th and 3rd century? Maybe, an increase of rainfall was just a reason to build them, or a better taste than well water or a larger demand by population growth. For larger demands, aqueducts supplying spring water were built. Only at places where spring water was not available, cisterns were used, e.g. in Rhodiapolis and Sagalassos (Asia Minor).[64] Sometimes, after the construction

59 Unaccessible water: Eck 1987, 60 and 88-89; Fahlbusch 1982, 22-23. Pollution of water: Fron. *Str.* 3.7.6; Crouch 1993, 22-24 and 123-126. Poisoning of water in wartime: Th. 2.48.2 (in Piraeus, 429 BC); Grmek 1979, 146-147. Destructions of aqueducts: Th. 6.100.1; Höcker 2002, 414; Procop. *Goth.* 5.19.13.

60 Reinholdt 2009, 192.

61 Arist. *Mete.* 352a; Crouch 1993, 66 and 109; Camp 1982, 9-17.

62 Thommen 2009, 27; Maise 1998, 219 and 224-233. Maise's research area is Central Europe.

63 Crouch 1993, 262. According to Camp (1977, 22 and 145) the drier period started at the beginning of the 4th century BC; according to Argoud (1987, 210) at the end of the 5th century. Cisterns in Athens: Brinker 1990, 11.

64 Wiplinger 2006, vol. 1 *passim*, e.g. the contributions of Murphy, 159-164 (Rhodiapolis) and Mar-

of an aqueduct, cisterns were filled up with spring water, so there is some evidence that the storage method of cisterns was considered as good. Metropolises like Alexandria and Carthage had the disposal of many and large cisterns, due to the absence of sufficient spring water in the neighbourhood. Climate change and population growth stimulated the use of cisterns in Carthage, replacing wells from the 3rd century BC onwards.[65]

2.2.1. Casus: Corinth

Pausanias mentions that in Corinth drinking-water was tapped out from some springs, and rain water was used for baths.[66] The most famous spring was the Peirene.[67] In addition, a large number of cisterns were found at the Acrocorinth, probably constructed as military or emergency accommodation. Outside Corinth, there were other acropolises containing cisterns.[68] So spring water was preferred to rain (cistern) water; cistern water (at the acropolises) was only in use if spring water was insufficient or even lacking.

2.3. Drinking-water in the Roman world [20]

When Rome was still a small town, the local water supply was not a problem. Frontinus mentions that the first Romans drank out of the Tiber, so in these times, river (surface) water was sufficient. When Rome became a metropolis, the quality of the Tiber water decreased by pollution, other water types were used and aqueducts were constructed.[69] In addition, the Romans used cisterns and in cases of large demand for water (as was the case in Rome), surface water was improved by filtering. As compared to the Greeks, the Romans used more surface water.[70] Galen, who was familiar with the situation in Rome very well, describes that the citizens drank water from wells, springs (via aqueducts and lakes), rivers and also rain water out of cisterns. He praises the excellent quality of the water of Rome.[71] Probably, filtering was a success. Everywhere in the Empire, city governments could choose their own water supply: wells, cisterns and aqueducts.[72] In Constantinople, more than 70 cisterns were found.[73]

tens, 168-169 (Sagalassos). Cf. Spagnolo 2012, 359-370 (wells and cisterns in Gela, Sicily).

65 Storage of spring water in cisterns: Bildirici 2006, 148-149 (Keramos). Guillaume 1877-1919, 1209-1210; Euzennat 1992, 75; Oleson 2008, 288-289.

66 Paus. 7.27.4; Oleson 2008, 295-296.

67 Hdt. 5.92b.21; Ath. 2.43b.

68 Other springs: Crouch 1993, 85-88, 126-132 and 319. 80 cisterns were found at the Lindos acropolis (Crouch 1993, 90) and also 80 at the Pergamum acropolis (in the entire city of Pergamum 107); Garbrecht 1987, 13-47.

69 Fron. *Aq.* 1.4; Fahlbusch 1987, 145; De Kleijn-Eijkelestam 2001.

70 Fahlbusch 1987, 147-148. Examples are Rome, Trier and Aix-en-Provence; Labisch & Koppitz 2005, col. 916.

71 Gal. *Hipp. Epid. VI* 4.19 (17b.183 K.). Quality: Gal. *Hipp. Epid. VI* 4.10 (17b.159 K.).

72 Nijmegen (Netherlands): Koster, Peterse & Swinkels 2002, 12 and 17. England: Rogers 2013, 187.

73 Höcker 2002, 413; Mays, Sklivaniotis & Angelakis 2012, 33-34.

2.3.1. Casus: Pompeii

There were no springs within the boundaries of Pompeii. For a continuous water supply, wells were dug out. The wells had a depth of ± 30 metres. Excavations and further research indicate that it was very difficult to construct these wells; one had to dig through lava layers before ground water was reached. Apparently, there was a sufficient supply of water, but on its quality opinions differ.[74]

One of the most significant features of Pompeii houses are the ones with an atrium, compluvium and impluvium, containing cisterns. This way of water management was probably more sufficient and satisfying than digging wells. When the eastern part of Pompeii was built (second half 4th century),[75] the cistern system was in use on a large scale. Nevertheless, the inhabitants were, ultimately, not satisfied with rain and well water and built aqueducts; cisterns were filled with spring water from
[21] this aqueduct and street fountains replaced the wells. Probably, ± 80 BC there was already a water pipe system in the city.[76] In Herculaneum, more wells and less cisterns were found (wells are less deep here) and in Ostia, mainly well water was consumed; it was easy to reach.[77]

2.4. Conclusion

In practice, the drinking-water supply was based on the availability of drinking-water. In its most primitive way, surface water like river water (or spring water) was in use: prehistoric man was forced to drink this type of water. When cities arose, well water and spring water became the most usual types of drinking-water. Cisterns were realised at a later time, in the Mediterranean area from the 6th century onwards. It is unclear if they were used due to scarcity of water (period of drought) or due to a large quantity of rain. Both in Greek and Roman cities, we see that rain water was mainly in use in times of emergency, when another type of water was not available. The Romans consumed usually spring water, delivered by their famous aqueducts, spending a lot of energy and money to construct, maintain and protect them. Nevertheless, the use of rain water remained in use, even when other water supply was in use, like in Pompeii. Surface water was usually considered as unfit for consumption.

Final Conclusion

Theories on the qualities of drinking-water were formed within the intellectual framework of the medical authors. In most cases, these theories were not based upon empirical perceptions and proofs, but on axioms. Qualifications of water as 'heavy'

74 Jansen 2002, 20-22, 75 n. 67 and 68.
75 In a few cases, cisterns are lacking: Jansen 2002, 77 n. 92.
76 Ohlig 2001, 271; Jansen 2002, 17-18, 26 and 56-57; Eschebach 1979, 3-25. Eschebach mentions (p. 7) some dates of the construction of the aqueduct 201-90 BC (citing Mau) and mid 2nd century (Maiuri). Some fountains are older: Jansen 2002, 56 and 85-86 (n. 257).
77 Jansen 2006, 175-176; Camardo, Martelli Castaldi & Thompson 2006, 183.

and processes like 'keeping humours in balance' were classified according to their contribution to human health. All such theories show a preference for rain water; sometimes, they mention spring water as a good type of water. The fact that these views on water quality remained unchanged – without evolution – up to the Byzantine era, even to the year 1000 (according to Avicenna's notation in his *Canon* 361-392) is striking. The ideas of medical authors are sometimes contested by other authors; their views are more diverse, using experiences and perceptions; for example, they [22] state that spring water is sometimes good and sometimes bad. Nevertheless, all authors, both medical and non-medical, observe that flowing water is preferable to stagnant water and they – sensibly – condemn the consumption of marsh water.

In practice, all qualities and types of water – 'heavy' and 'light' water, hot and cold water, rain water, spring water and well water, sometimes even surface water – were in use (hot water did, actually, not play a role for the regular drinking-water supply, but was only in use for curative purposes); one was aware of the crucial importance of water in general and the advantages and disadvantages of the different types. In the first settlements, river water, wells and springs were in use. After ± 400 BC, however, a climate change took place and people began to collect rain water in cisterns, beside their wells. But the Greeks and Romans preferred spring water and constructed aqueducts, spending a lot of money and effort. Thus, rain water was consumed only at dry times when water was scarce and spring and well water were not available. So, the real situation in practice is in sharp contrast to the opinions of the medical authors, who all have a strong preference for rain water. Theory and speculation had little impact on water supply in practice.

The page numbers [23], [24] and [25] are absent. They refer to the list of Ancient Sources in the Eä article.

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Opinions concerning Faeces and Urine in the Graeco-Roman World

Context

'Opinions concerning Faeces and Urine in the Graeco-Roman World' is under review for an international journal.

In addition to my research on the supply of drinking water, I have investigated the closely related subject of waste discharge of both human bodies and cities. As in the previous chapter that discusses the supply of drinking water, there is a long tradition of information about sewers, toilets and excrements. Here also there is no dearth of literature on the subject (see also the following chapter), such as the volume of G. Jansen, A.O. Koloski-Ostrow and E. Moormann (2011).[1] This volume discusses various aspects of toilets – from an archaeological, a palaeobotanical and a historical point of view. However, a medical approach, based on ancient medicine is, however, still lacking. The same goes for M. Bradley (2012).[2]

Roman cities – in contrast to their medieval counterparts – have for a long time been considered as clean and healthy, due to the strict separation of drinking water and waste water. This image was called in question in 1986 by A. Scobie and in 2001 by G.E. Thüry.[3] Graeco-Roman cities were full of human and animal excrement and urine. But these matters were not considered as dangerous, rather they were deemed at the worst annoying; moreover, they were in use as medicaments. The following publications appeared after the closing of this manuscript: O. Wagener (2014), M. Dekkers (2014), M. Blonski (2014), M. Bradley (2015) and P.D. Mitchell (2015).[4]

In the following chapter, I will try to fill the above-mentioned gap in the volume of Jansen, Koloski-Ostrow and Moormann. It is a revision of my paper 'To Remove or Not to Remove? Opinions concerning human excrements in the Graeco-Roman World', presented during the 'Third West Coast Symposium' in the History of Medicine, 30-31 March at Texas A & M University, College Station TX, USA and at the conference on 'Approaches to Ancient Medicine' at Cardiff University, 21 August, both in 2012.

1 Jansen, G., Koloski-Ostrow, A.O. & Moormann, E. (eds). 2011. *Roman Toilets: Their archaeology and cultural history*, Louvain/Paris/Walpole MA.

2 Bradley, M. (ed.). 2012. *Rome, Pollution and Propriety: Dirt, disease and hygiene in the Eternal City from Antiquity to Modernity*, Cambridge etc.

3 Scobie, A. 1986 (see Bibliography); Thüry, G.E. 2001 (see Bibliography).

4 Wagener, O. (ed.). 2014. *Aborte im Mittelalter und frühe Neuzeit: Bauforschung – Archäologie – Kulturgeschichte*, Petersberg; Dekkers, M. 2014. *De kleine verlossing of de lust van ontlasten*, Amsterdam/Antwerp; Blonski, M. 2014. *Se nettoyer à Rome IIe s. avant J.-C. –IIe s. après J.-C.: Pratiques et enjeux*. Paris; Bradley, M. (ed.). 2015. *Smell and the Ancient Senses*, London/New York and Mitchell, P.D. (ed.). 2015. *Sanitation, Latrines and Intestinal Parasites in Past Populations*. Farnham/Burlington VT.

Opinions concerning Faeces and Urine in the Graeco-Roman World

Abstract
In our days, human urine and excrement are considered to be dirty substances, creating unhealthy situations and even diseases. In this chapter, I examine the different opinions on this topic in Graeco-Roman medicine. Ancient medical authors, for example, considered excrement as transformed food. The unpleasant odour, however, was seen as dangerous for public health; negative opinions usually criticise the smell of urine and excrement. Other ancient authors show a different point of view, valuing excrement as dung for agriculture.

It is a general misunderstanding that the famous Roman sewers were constructed for the removal of urine and excrement. Their main purpose was the removal of rain water and waste water coming from public baths. It was not always possible to connect a public toilet with the sewer system. The streets were generally filled with animal dung, so in daily life removing human excrement from the streets for purposes of hygiene may not have been felt as an urgent matter.

Introduction

In Pompeii, the following graffito was found on the external wall of a house: *Cacator, sic valeas, ut tu hoc locum trasea* ('Shitter, may you feel well, if you go past this place') (**fig. 1**).[1] May we therefore infer that human faeces were considered as unhygienic and dangerous, infectious matters? Or is this, on the contrary, an indication that it was normal behaviour to leave human excrement in public areas?

In a broader context there is a lot of discussion concerning the concepts of 'dirt'

1 *CIL* IV 6641, located near the Vesuvian gate. Other interdictions concerning defecating and urinating: *SEG* 45 (1995) 1174 (Samos, Tunnel of Eupalinos); *SEG* 46 (1996) 1157 (Andros); *SEG* 49 (1999) 1461 (Ephesus); *CIL* VI 13740 = *ILS* 8202 (Rome); *CIL* VI 29848b (Nero's Golden House); *AE* 1949, 48 (Thigibba); Panciera 2000, 98 for more references; Potter 2015, 125.

Fig. 1. *Graffito in Pompeii (photo G. Jansen).*

and 'hygiene'. The famous anthropologist Mary Douglas stated that 'dirt' (e.g. faeces) is a 'by-product of a systematic ordering and classification of matter, insofar as ordering involves rejecting inappropriate elements', depending on culture, time, etc. The epidemiologist Valerie Curtis, however, states that the concept of 'dirt' is connected with 'the set of behaviours that animals, including humans, use to avoid infection' […] since 'they are motivated by the emotion of disgust'.[2]

An innovative volume, entitled: *Roman Toilets: Their archaeology and cultural history*[3] (2011) deals with almost every conceivable aspect of the subject; arguments from ancient medicine and hygiene, however, have received little attention.[4] In this chapter, I will try to fill this lacuna. From our modern point of view, Roman (and Greek) toilets were not hygienic. But what about ancient notions of hygiene and infection? To what extent was human excrement considered as noxious, unhealthy, even dangerous in ancient Greek and Roman medicine? Is there any evidence that the predominant ideas on physical hygiene in ancient medical theory influenced behaviour in daily life? If so, in what way? One might think of personal hygiene, how one dealt with bodily secretions such as faeces and urine, but also of hygiene on a larger scale, in household (architecture) and town (town planning). Did any medical knowledge 'trickle down' into other strata of society?

To answer these questions, using documentary evidence, I will first of all consider general ideas on public hygiene and infectious diseases in Graeco-Roman Antiqui-

2 The citations are mentioned in Jansen 2011, 157, referring to Douglas 1966, 35 (cf. Van der Geest 2007, 80) and Curtis 2007, 660 (cf. Gal. *San. Tu.* 1.8 (6.44-45 K.), where a baby in a wet bed was crying; after cleaning sheets, he stopped crying). For these and more theories about pollution in anthropology see Bradley 2012, 11-18; for the ancient context 18-28.

3 Jansen, Koloski-Ostrow and Moormann, 2011. It has been well received (some reviews: *AJA* 116 (2012), http://www.ajaonline.org/online-review-book/1196 and *JRA* 26 (2013) 723-726, http://journals.cambridge.org/download.php?file=%2FJRO%2FJRO26%2FS1047759413000664a.pdf&code=d2cdc4caf7ca2f8283c2e95bce65491e). Cf. also my review in Van Hee, B. & Tilburg, C. van (eds). 2014. *Heelmeesters: Befaamde artsen en figuren uit de geschiedenis van de geneeskunde*, 108-109. Antwerp/Apeldoorn.

4 Jansen 2011, 157-164.

ty (1), subsequently theories on digestion and the digestive tract (2), the excretion system (3), urine and faeces as diagnostic instruments (4) and urine and faeces as medicament (5). Then I will pose the question: (6) are urine and faeces considered dirty and unhealthy, or not? After that I will discuss in some case studies how the ancients coped in practice with pollution caused by discharge of urine and faeces in the Greek (7a) and the Roman world (7b) and whether or not daily life was influenced by medical theories. I will end with a conclusion.

1. The ancient definition of ὑγιής: a body in a good condition

The fact that the English word 'hygiene' derives from the Greek adjective ὑγιής[5] (= healthy, also connected with the name of the goddess Hygieia), is generally known. What is less known, however, is that the notion ὑγιής (and ὑγιεινός, 'good for the health' or 'relating to health') did not have the same meaning as our modern word 'hygiene'. In the Graeco-Roman world, opinions concerning the idea of 'hygiene' were totally different from those in modern times. In our time, 'hygiene' means: 'Conditions or practices conducive to maintaining health and preventing disease, especially through cleanliness'.[6] The Greek word ὑγιής, however, refers to balance in the human body.[7]

According to the 5th century BC philosopher Alcmaeon of Croton, one of the first authors to mention humours and qualities, disease occurs when one humour or quality is dominant.[8] After Alcmaeon, ancient medical authors like the Hippocratics, Celsus and Galen followed this view;[9] the idea of hygiene, that is being ὑγιής, was restricted to the individual (*idiosyncrasy*). It follows from this that our modern notions of hygiene were foreign to the Graeco-Roman world.

In the Hippocratic Corpus, we find the following opinion that health is based on balance between the individual and his surroundings: 'And the habitude, things from which we are healthy: in diet, covering, exercise, sleep, sexual activity, mental activity'.[10]

According to the Galenic tradition, the following things had to be in balance: (1) the *res naturales*, 'natural things': the elements, the humours (blood, phlegm, yellow and black bile), the parts of the body, the bodily functions, and (2) the *sex res non naturales*, 'six non-natural things': *aer* (air), *cibus et potus* (food and drink), *motus*

5 According to Beekes, the original significance of ὑγιής is: 'having eternal life', $h_2iug^wih_3$-es-, Lat. *iugis*, 'eternal'; Beekes 2010, 1525.

6 Definition of 'hygiene' according to the *Oxford Dictionary of English*. Origin late 16th century: via French from modern Latin hygieina, from Greek hugieinē (tekhnē) '(art) of health', from hugiēs 'healthy'. Cf. Jansen 2011, 157.

7 Cf. Kudlien 1941-, 904: 'Im Griechischen fehlt es an Wörtern, die 'gesund' oder 'normal' in rein klinischem Sinn bedeuten'. In Kudlien 1941-, 904-906 are more words referring to 'good health'.

8 Alcmaeon, DK VS 24 B 4; Wöhrle 1990, 48; Horstmanshoff 1993, 213; Bergdolt 1999, 29-30; Schultz 2002, 175; Rothschuh 1973, 3; Kudlien 1941-, 906; Marketos 1994, 268.

9 Blood: e.g. Gal. *Hipp. Epid. I* 2.36 (17a.132 K.). Phlegm: e.g. Gal. *Cris.* 3.3 (9.709 K.). Yellow bile: e.g. Hipp. *Prorrh.* 1.53 (180 Potter = 5.24 L.). Black bile does not occur in excretions; Gal. *Hipp. Aph.* 4.21 (17b.681 K.).

10 Hipp. *Epid.* 6.8.23 (270 Smith = 5.352 L.).

et quies (moving and resting), *somnus et vigilia* (being asleep and awake), *excreta et secreta* (excretions and secretions) and *affectus animi* (emotions).[11] The *res contra naturales* or *res praeter naturales*, 'contra-natural things' (pathological signs) were considered as consequences of a disturbed balance.[12]

Our emotions of disgust are based not only on dirtiness, but also on knowledge of pathogens (bacilli, viruses, etc.) in faeces and urine: we are aware, therefore, that faeces and urine threaten public health. In Antiquity, this notion was absent. Diseases were thought to afflict the individual and people tried to adjust their own life or, if possible, to escape to another place.

Due to the unawareness of the real causes of diseases, the idea that diseases were caused by supernatural powers was widespread, so religion (including superstition and magic) was an important factor in improving health.[13] When people found a rational explanation, they blamed diseases on poor surroundings or on the climate. Ideas of infection and contagion did exist, but were, obviously, not based on microbiological science and were as such ineffective.[14] Diseases were private matters, not-ὑγιής proportions of humours and qualities in individual bodies, to be cured by means of individual dietetics. Therefore, they saw no reason to consider faeces and urine as dangerous,[15] so that there was no need for prevention by cleaning streets and other public places.[16]

2. Digestion and the digestive tract

First, I will discuss the so-called *excreta et secreta*, digestion and excretion. For a healthy body these things must be, of course, ὑγιής. Were the contents of the bowels, changing from tasteful food in the mouth into less tasteful faeces, considered as ὑγιής or not-ὑγιής, and was excrement – outside the body – and the bowels' contents – inside the body – considered as ὑγιής? Different opinions about the digestive tract were circulating. What was the ideal, ὑγιής digestive tract? A description of the digestive tract is given in the Hippocratic Corpus, in the treatise *De anatomia* ('On Anatomy', date uncertain, plausibly 4th century, maybe late 5th century BC):[17] the oesophagus starts

11 Gal. *Ars med.* 23 (1.367 K.); Wöhrle 1990, 13-14, 66 and 190; Lindeboom 1993, 49; Horstmanshoff 1993, 214; Horstmanshoff 2002, 32; Bergdolt 1999, 103-104; for more information see Jarcho 1970, 372-377; García Ballester 2002, 105-115.

12 This categorisation, used in the medieval *Regimina Sanitatis* literature, is ascribed to Galen, but via him, it goes back to the Hippocratic authors; Horstmanshoff 1993, 214.

13 Cf. Apollo's arrows causing a 'pestilence' at the beginning of the *Iliad* (Hom. *Il.* 1): Lloyd 2003, 14-17; Wershub 1970, 44-45. More references to supernatural powers: Lloyd 2003, 43-49 (cf. the 'Sacred Disease') and, more elaborately, Horstmanshoff 1989, *passim*, esp. 291-295 (summary in English).

14 Leven 2005, cols 54-56.

15 Jansen 2011, 157-158. For more information about pollution in cities and military camps see Nutton 2000, 65-73. For city hygiene, cf. my article 'A "Healthy Mistake": The Excrement Problem from Ancient Greece to Nineteenth Century Holland' in this volume, pp. 137-157.

16 In short, citing Labisch & Koppitz 2005, col. 446, and Jansen 2011, 158, citing Labisch & Koppitz: 'Die Menschen der Antike dachten nicht hygienisch (und schon gar nicht bakteriologisch)'.

17 Craik 2015, 29; according to Jouanna (1992, 530), however, probably dating from the Hellenistic or Roman period.

after the tongue; it ends in the stomach. Food starts its digestion in the lower part of the stomach. Beyond the stomach come the intestines, ending at the anus.[18]

Celsus summarises the following theories: According to Erasistratus (3rd century BC), food is pulverised in the intestines; according to Praxagoras (4th century BC) and Plistonicus (his pupil, 4th-3rd century BC), food is rotted down and according to Hippocrates, it is boiled, producing heat.[19]

The Hippocratic treatise *De carnibus* (*Fleshes*), (5th-4th century BC),[20] describes the digestion process in this way: after the passage of the intestines, foodstuffs are transported to the other parts of the body; the remaining material is pressed together as κόπρος (excrements),[21] and leaves the body through the anus. Veins, taking foodstuffs from the intestines' contents, transport them to the different body parts and organs, thus maintaining the body.[22] The actual digestion process takes place in the stomach and the upper part of the small intestines; after the passage through the ieiunum, in the last and lowest parts of the intestines, excrement is created.[23]

Another explanation of digestion can be found in the Hippocratic treatise *De morbis* (*Diseases*) 4 (± 400 BC).[24] According to this theory, there is a cycle of three days.[25] Sometimes, however, excretion takes place the same day.[26]

According to Aristotle, the digestive process is as follows: material is concocted, caused by heat in the body. In the first instance, the body is cooled by the eaten food, but in a later stage, the food is cooked because of its moisture. Due to this heat, faeces are hot, compact and salty, because the moisture has disappeared due to the cooking process. Producing urine and faeces is a sign of health, because it shows that the source of heat is functioning properly. Unfortunately, Aristotle's exact theory is not clear: he also states that foodstuffs are, in the first instance, transformed into blood and only later into other body fluids.[27]

Asclepiades of Bithynia (2nd-1st century BC), the teacher of Themison of Laodi-

18 Hipp. *Anat.* 1 (4-6 Potter = 8.538-540 L.); Oser-Grote 2004, 216.

19 Cels. *Pr.* 19-22; Stamatu 2005d, col. 893. For the boiling processes in the Hippocratic writings see Brunn 1946, 165-168. According to Schulze, 'boiling' is a metaphor for 'digesting': Schulze 2005, col. 611. According to Galen, Erasistratus shares the idea that food is boiled: *Nat. Fac.* 3.7 (2.166-168 K.).

20 Jouanna 1992, 532; according to Craik (2015, 48) second half 5th century BC.

21 Besides the word κόπρος, ancient medical authors use the word διαχώρημα, 'passing-through material', 'bowel contents'. Galen gives this name also to the oesophagus' content: *Caus. Symp.* 3.7 (7.243 K.). The only non-medical author and non-lexicographer using this word is Strabo: 14.5.14. According to the Hippocratic Corpus: intestinal contents from which foodstuffs are extracted to fulfil the needs of the body. In many cases, this word is (like κόπρος) mentioned in combination with οὖρον, 'urine'. A third word, especially used by Galen, is ἔκκρισις, referring, more generally, to 'excretion'. This excretion can take place both inside (Gal. *At. Bil.* 4 [5.115 K.]) and leaving (Gal. *Ars med.* 19 [1.353 K.]) the body.

22 Hipp. *Carn.* 13 (146-148 Potter = 8.600 L.); Oser-Grote 2004, 216-217; Wilkins & Hill 2006, 229.

23 Oser-Grote 2004, 216-217.

24 Jouanna 1992, 547; according to Craik (2015, 190) early to mid 4th century BC.

25 Hipp. *Morb.* 4.42 (124-126 Potter = 7.562 L.); Gundert 2005, col. 508.

26 Hipp. *Morb.* 4.42-44 (126-130 Potter = 7.562-568 L.).

27 Arist. *Mete.* 379b12-380a11; Orland 2012, 462-463 ('But Aristotle's concoction could also mean the opposite, a kind of inconcoction'). Transformation of foodstuffs into blood: Orland 2012, 462; Van 't Land 2012, 370; Lloyd 1966, 369-370 n. 2.

cea – the founder of the (Hellenistic) Methodists sect[28] – states, very differently, that the body is composed of invisible particles. According to him, food changes into blood immediately after entering the body. The particles move to finely structured and hot places in the body (πρὸς τὸ λεπτομερὲς φορά). During this process, faeces are formed and urine is expelled. Excretions are thus formerly invisible particles, that have now become visible.[29]

According to, finally, Galen (in his treatise *De Naturalibus Facultatibus*, *Natural Capacities*), the digestive process is as follows: digestion already starts in the mouth. When a person is hungry, his stomach gurgles (via the oesophagus, i.e. peristalsis); after nutrition, peristalsis ends. In the stomach, there is a sequence of faculties (δυνάμεις, see *infra*): attraction (of food); retention (during which alteration of foodstuffs by means of phlegm, bile – gastric juices –, πνεῦμα [see *infra*] and internal heat [see *infra*] takes place) and, finally, expulsion of transformed foodstuffs (due to irritation), moving to the pylorus, liver and intestines. The transport of foodstuffs can be compared with the irrigation of a garden.[30]

In his treatise *De Methodo Medendi (The Therapeutic Method)* Galen enumerates three types of πνεῦμα (*spiritus*): πνεῦμα ζωτικόν (*spiritus vitalis*, vital spirit), the active agent in respiration and vital combustion in the heart and blood; πνεῦμα ψυχικόν (*spiritus animalis*, animal spirit), the active principle of the central nervous system in the head; and πνεῦμα φυσικόν (*spiritus naturalis*, natural spirit), confined to the liver and the veins. The first two he mentions explicitly; the latter only casually. After Galen, however, this passage was interpreted as a reference to a full tripartite system, in accordance with the tendency to systematisation prevalent at the time (extending to the Renaissance). The view that Galen would have adopted a tripartite system is still surviving. Other modern authors, however, share the opinion that Galen distinguishes only two types of πνεῦμα: the vital (ζωτικόν) and the animal (ψυχικόν). In his *Ars Medica* (*The Art of Medicine*), only these two types are mentioned.[31] I suppose that the πνεῦμα involved in digestion belongs to the πνεῦμα ζωτικόν, because the πνεῦμα ψυχικόν is restricted to the brain and the nervous system. Where digestion is concerned, Debru speaks just of πνεῦμα.[32]

In this treatise as well as in *De Bonis Malisque Sucis* (*Good Humour and Bad Humour*) Galen describes the digestive process in three stages: in the first stage, food is

28 Wershub 63. He calls him, wrongly, Asclepiadus.

29 Gal. *Hipp. Epid. III* 1.4 (17a.506 K.); Ihm 2005, cols 107-108.

30 Gal. *Nat. Fac.* 3, *passim*. Peristalsis: Stamatu 2005a, col. 208-209. Garden: Gal. *Nat. Fac.* 3.15 (2.210-211 K.). Cf. Hipp. *Cord.* 7 (62-64 Potter = 9.84 L.); Pl. *Ti.* 77C.

31 Gal. *MM* 12.5 (10.839-840 K.). Three πνεύματα: Singer 1957, 58-61; Lindeboom 1993, 71-72; Rothschuh does mention the πνεῦμα φυσικόν in his text (1973, 17), but not in his scheme (1973, 19 fig. 3); King (2012) is speaking still of 'the three Galenic spirits' (p. 20). These authors do not cite Galen's passage in *MM*. Two πνεύματα: Gal. *Ars Med*. 37 (1.406 K.); Siegel 183-192 (referring to other authors, like Verbeke, who state that there were only two πνεύματα in Galen's physiology); Oser-Grote 2005, col. 718; Debru (2008, 272) states that the tripartite pneumatology is a doctrine of later Galenism, not of Galen himself. For an overview of the history of the interpretation of the number of πνεύματα see the elaborate article of Rocca (2012); for the tripartite system during Renaissance see the articles of Kodera (p. 143 n. 14), Kalff (p. 179), Brömer (p. 347) and Santing (p. 426) in the same volume as Rocca's.

32 Debru 2008, 272-273.

concocted quickly in the stomach; gastric juices are produced as a starting point for the second and third stages. In the second stage, foodstuffs are digested in the liver and veins (as blood) and in the third stage, the foodstuffs spread out into the other parts of the body.[33] Digestion itself (πέψις, *coctio*) is accomplished by so-called innate heat (ἔμφυτον θερμόν, *calor innatus*)[34] close to the heart.

In contrast to Hippocrates' opinion (cited by Celsus), Galen states that this heat is not the result, but the cause of digestion.[35] He distinguishes four faculties in the human body: attraction (ἑλκτική), retention (καθεκτική), alteration (ἀλλοιωτική) and expulsion (ἀποκριτική). In addition, digestion has its own faculties; in this case a nutritive (θρεπτική) faculty and a haematopoietic (αἱματοποιητική) faculty.[36] The foodstuffs pass the stomach and the intestines, and via the portal vein to the liver; the faculty of alteration transforms them into blood, and the gall bladder and spleen, respectively, into yellow and black bile. Finally, the kidneys (*renes*) extract the moisture from the foodstuffs.[37] Thus faeces remain.

After the digestive process, the remaining materials leave the body in three ways: as urine via the veins, as faeces via the stomach and as spit via the breathing organs.[38] If the body does not extract foodstuffs from the food, it becomes ill; this results in undigested food in the excrement (λειεντερία).[39]

In brief: different views were posed by several medical authors, disagreeing amongst each other,[40] but there is no indication that any of them was aware that body waste could cause infectious diseases and that public health was at stake (**fig. 2**).[41]

3. The excretion system

In respect to the excretion system, the Hippocratic treatise *De anatomia* (*Anatomy*) states that there a vein is running from the liver to the kidneys; from here, two slant-

33 Gal. *Nat. Fac.* 3.13 (2.200-201 K.); Gal. *Bon. Mal. Suc.* 5 (6.786 K.). Gundert 2005, cols 508-509; Schultz 2002, 176. Cf. Gal. *PHP* 6.8 (5.567-568 K.); Diamandopoulos 1997, 224; Wilkins & Hill 2006, 230. One must realise that the blood circulation system was not yet discovered in Antiquity. See 'Interaction between Anatomical and Civil Engineering Terminology' in this volume, pp. 1-22.

34 For a more extensive description of heat as source of the digestion system see Gundert 2005 (with references); Arist. *Mete.* 379b12-34; Orland 2012, 462; Bergdolt 1999, 40; Moreau 2011, 144; Debru 2008, 265; 269-273; Schäfer 2012, 250-253; Rocca 2012, 637-638. The *calor innatus* would be valid until Harvey; Sennett 1994, 255; 257.

35 Cf. Gal. *Alim. Fac.* 1.1 (6.459-560 K.); Grant 2000, 7-8; cf. Dsc. *De Materia Medica* 2.110.1. On the other hand, food is necessary as fuel to this heat: Gal. *Temp.* 3.2 (1.659 K.); 3.4 (1.683 K.).

36 Gal. *Hipp. Epid. VI* 5.1 (17b.232-233 K.); Debru 2008, 267. See for the attractive faculty and faculties in general also McVaugh 2012, 110; Musitelli 2010, 17.

37 Debru 2008, 266-275; Moreau 2011, 142-143; Grant 2000, 33 (bile). For the kidneys, see *infra*.

38 Gal. *Cris.* 1.7 (9.577 K.), citing Hippocrates, probably referring to Hipp. *Coac.* 387 (196 Potter = 5.668 L.); Gundert 2005, col. 509.

39 Hipp. *Vict.* 3.80 (406-408 Jones = 6.626 L.); Stamatu 2005d, col. 893. For λειεντερία see e.g. Hipp. *Vict.* 3.79 (404 Jones = 6.624 L.).

40 Vallance 1993, 699; Debru 2008, 271. Galen rejects Asclepiades' theory: *Nat. Fac.* 3.7 (2.166 K.).

41 Eggs of parasites have been found in Carnuntum: Jones 2011, 16-18; Jansen 2011, 162 (roundworm *Ascaris lumbricoides*).

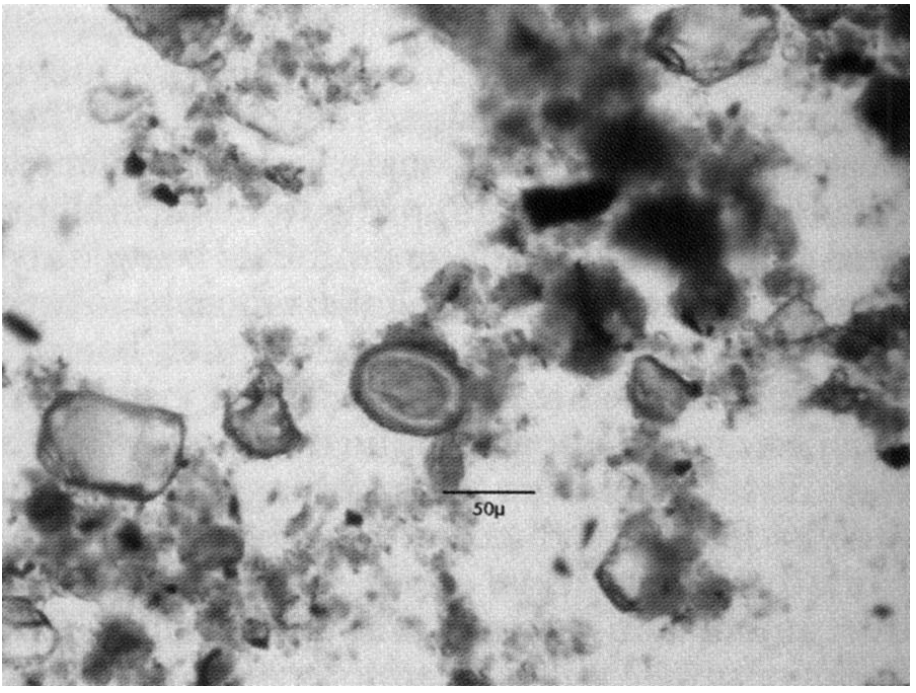

Fig. 2. *Eggs of* Ascaris lumbricoides *in Carnuntum (photo I. Feuereis; Jansen, Koloski-Ostrow & Moormann 2011, 162).*

ing ducts, the ureters (ὀχετοὶ σκαληνοειδεῖς) run to the upper side of the bladder.[42] These ureters are also mentioned in the treatise *De ossibus* (*Nature of Bones*) where they are called φλέβες (veins).[43] According to Musitelli, the Hippocratic Corpus describes how urine is formed in the kidneys and flows into the bladder through the ureters.[44] The fluid flowing from the kidneys to the bladder is spongy; it is only in the bladder that urine and blood are separated. This explains why urine is reddish in colour.[45] Aristotle distinguishes three stages in the excretion process: first, blood flows to the kidneys, second, the kidneys extract the moisture from the blood and transform it into urine, and, finally, the urine leaves the body.[46]

According to Galen, after drinking, fluid passes at first to the liver, then arrives in the hollow vein and, finally, reaches the kidneys which attract the fluid by a par-

42 Hipp. *Anat.* 1 (4 Potter = 8.538 L.); Oser-Grote 2004, 230 and 237; Craik 2006, 124-127; for a detailed commentary on this text see Craik 2006, 142-144.

43 Hipp. *Oss.* 4 (18 Potter = 9.170 L.); Oser-Grote 2004, 231.

44 Musitelli 2010, 4; Stamatu 2005c, col. 379. According to Stamatu, however, ureters are not mentioned in the Hippocratic Corpus. I suppose that Stamatu means that they are not called, actually, οὐρητῆρες. Nevertheless, in *Aer.* 9 an οὐρητήρ is mentioned, where sufferers from stones are discussed. The female οὐρητήρ is shorter than the male one; I suppose that here the urethra is meant.

45 Hipp. *Oss.* 4 (20 Potter = 9.170 L.); Oser-Grote 2004, 231 and 237.

46 McVaugh 2012, 105.

ticular force (δύναμις).[47] The final division between blood and urine takes place in the kidneys; the fluid leaves the body via the ureters (οὐρητῆρες)[48] and the bladder.[49] McVaugh observes that this tripartite system is adapted from Aristotle.[50] Another correct observation made by Galen is that there is one-way traffic: urine cannot flow back from the bladder to the kidneys.[51]

Not only does the process of digestion and secretion have to be in balance, the same applies to the proportions of bodily material.[52] A physician may therefore prescribe a patient not only to do something, but also *not* to do something; of course, this might cause aggravation of the disease, or even death. To tackle digestive problems, one has usually to eat or to drink, but sometimes one should not. According to a prescription of the Asklepieion of Pergamum, P. Aelius Theon had to fast 120 days, which he did; afterwards he dedicated a gift to Asclepius.[53]

4. Urine and faeces as diagnostic instruments

Ancient medical authors used to apply their knowledge concerning faeces and urine to investigate the patient's health.[54] The importance of urine and faeces research is described in many writings, because, by using this knowledge, the physician was able to make a prognosis and diagnosis. Galen describes extensively how diagnosis and prognosis of a disease can be determined through studying urine and faeces.[55] Due to the fact that the digestive process not only operates through the veins and the stomach, but also via the breathing organs (see above), one has to examine all excretions in the event of disease.[56]

Ideal faeces are soft, solid, leaving the body regularly and corresponding to the quantity of eaten food. Another point is that faeces must not produce too much stench; here medical authors confess that faeces produce stench (see *infra*).[57] The ide-

47 Beside use of δύναμις as 'attracting power', the term may refer to something like a 'food value', modifying the state of the humours in the body: Wilkins & Hill 2006, 215-216; Hipp. *Vict.* 2.56 (336-338 Jones = 6.566 L.); Wilkins & Hill 2006, 219.

48 Gal. *Nat. Fac.* 1.6 (2.14 K.); Stamatu 2005c, col. 379; Rothschuh 1973, 17.

49 Gal. *UP* 4.5 (3.362-363 K.); Kurz 2005, col. 379; Rothschuh 1973, 20; Moreau 2011, 144; McVaugh 2012, 105-106; Musitelli 2010, 17. For the entire excretion process according to Galen see Siegel 1968, 126-132 and Wershub 1970, 63-71, where Galen discusses the excretion system, rejecting Asclepiades (*Nat. Fac.* 1.13 [2.30-38 K.] and 1.15 [2.56-60 K.]).

50 McVaugh 2012, 106-110.

51 Gal. *Nat. Fac.* 1.6 (2.36-37 K.); Stamatu 2005c, col. 379.

52 Lindeboom 1993, 49; Schultz 2002, 175.

53 Hipp. *De Arte* 5 (196 Jones = 6.8 L.). Theon: Steger 2004, 160-165; Steger 2005, 41 and Müller's article.

54 Kurz 2005, cols 378-379; Riha 2005, col. 520.

55 There are many examples, e.g. Gal. *Loc. Aff.* 5.8 (8.374 K.); *Cris.* 1.5 (9.569 K.); *Opt. Corp. Const.* 3 (4.742-744 K.), where Galen considers unhealthy excrements as causes of diseases. Wöhrle (1990, 229) mentions *San. Tu.* 2.2 (6.88 K.). For a diagnosis using urine in the Hippocratic Corpus see Hipp. *Epid.* 2.3.11 (54-56 Smith = 5.112-114 L.).

56 Gal. *Cris.* 1.7 (9.579-580 K.); Gal. *MM* 8.7 (10.583 K.).

57 Hipp. *Prog.* 11 (22 Jones = 2.136 L.) (= Gal. *Cris.* 1.11 [9.587 K.]); Hipp. *Coac.* 589 (256 Potter =

al urine is colourless or light yellow, with a white sediment.[58] If faeces and urine deviate from these rules – for example, the colour may be different – this can be seen as an indication that the bodily condition of the patient is not good. In the Hippocratic Corpus and other writings, we find references to reddish faeces, slightly black faeces and urine, yellow urine (apparently unhealthy) and pale or green excretions.[59] In addition, one has to investigate the quantity and composition[60] of faeces and urine meticulously. If one of the four humours (blood, phlegm, yellow bile and black bile) or qualities (hot, cold, moist and dry) is dominant, the body is not ὑγιής and the patient is sick. And, finally, the physician has to consider the smell of the excrement and excretions.[61]

When investigating faeces and urine, touch, sight and smell were used as well. But was taste also a research item? The earliest reference to the consumption of faeces can be found in one of Aristophanes' comedies. In his *Plutus* (*Wealth*), the protagonist's slave Carion calls Asclepius a σκατοφάγος, 'faeces-eater'.[62] This word occurs mainly in comedies, connected with animals or as general invective.[63] Aristophanes Grammaticus calls Cleon, a populist politician at the beginning of the Peloponnesian War, a σκατοφάγος.[64] Here no medical notions concerning digestion are involved; it simply is a matter of verbal abuse. Therefore this is not a reliable testimony for medical practice.

A second possibility is the following: although every physician and doctor in history, just as today, must surmount horrible sights and smells of patients, including their excretions,[65] it must have been disgusting for a physician to taste them. To know the taste of faeces and urine, a physician, maybe, did not taste the excrement

5.720 L.); Cels. 2.3.5. For the colon as regulator of the digestion tract see also Pl. *Ti.* 72E-73A; Bergdolt 1999, 50.

58 Hipp. *Prog.* 12 (24 Jones = 2.138-140 L.); Gal. *At. Bil.* 8 (5.141 K.); (Ps.)Gal. *De urin.* (19.616 K.); Cels. 2.3.4; Stolberg 2009, 69.

59 Light reddish faeces: Hipp. *Prog.* 11 (22 Jones = 2.136 L.) (= *Judic.* 2 [276 Potter = 9.276 L.]). Blackish faeces and urine: Hipp. *Epid.* 1.3.13 (188 Jones = 2.684-686 L.) (= Gal. *Hipp. Epid. I* 1.3 [17a.259 K.]). Reddish urine: Cels. 2.4.8. Yellow urine: Anonymi Medici, *De morbis acutis et chroniis* 33.2. Pale or green excretions: Gal. *Cris.* 1.12 (9.604 K.); cf. *Cris.* 1.12 (9.595 K.). For different colours of urine see also Schlesinger 1999, 97; Stolberg 2009, 43-44. I restrict myself here to the classical period. Only in the Byzantine era uroscopy was systematised, theoretically and practically. From there it was introduced in Western Europe and brought to perfection. One example may suffice: the urine flask and basket referred to in Horstmanshoff (2002) 58. For more examples from various periods in history see the books by Vieillard (1903), Werschub (1970) and Stolberg (2009), and the articles by Muth (1968, cols 1299-1300), Neuburger (1937), Stettler (1988), Marketos (1994) and Diamandopoulos (1997).

60 Quantity of faeces: e.g. Hipp. *Epid.* 1.3.13 (188 Jones = 2.686 L.); quantity of urine: e.g. Hipp. *Epid.* 3.3.17 (276-278 Jones = 3.136 L.); Ruf. *Quaestiones Medicinales* 27; Haak 2013, 48 and 67. Composition (ποικίλως): Hipp. *Epid.* 3.3.17 (280 Jones = 3.14 L.). Hard faeces: Gal. *Hipp. Epid. VI* 5.27 (17b.292 K.). For good and bad faeces see also Brunn 1946, 161-164.

61 Gal. *Hipp. Off. Med.* 1.3 (18b.654 K.); Totelin 2015, 22-24.

62 Ar. *Pl.* 706.

63 Animals: e.g. Ath. 107 (boar). General invective: Men. *Pk.* 394.

64 Aristophanes Grammaticus, *Argumenta fabularum Aristophani tributa* fr. 6. He mentions a list of increasingly more offending invectives: Paphlagonian, tanner, garlic-sausage-seller, faeces-eater (in Aristophanes' *Equites*, *Knights*, concerning Cleon's reputation, this word does not occur).

65 Hipp. *Flat.* 1 (226-228 Jones = 6.90 L.); Manetti 2013, 160.

by himself, but asked the patient to do it. In the Hippocratic Corpus, this is said of a phlegm.[66] No clear evidence has been found that physicians actually tasted faeces and urine.

Finally, a third possibility is that the word σκατοφάγος refers to the use of urine and faeces as medicament.

5. Urine and faeces as medicament

Galen and later ancient medical authors mention excrement as medicament or part of medicament (in German: 'Dreckapotheke'). In general, this is the excrement of birds and animals; the references to human faeces are scarcer. In his work *De Simplicium Medicamentorum [Temperamentis ac] Facultatibus* (*The Capacities [and Mixtures] of Simple Drugs*) 11.18-29 (12.284-309 K.), Galen describes the applications of human and animal excrement in medicaments.[67] Although he gives an extensive account, he rejects the application of excrement as medicament, including menstrual blood, urine and cerumen, if another medicament is available.[68]

Nevertheless, faeces and urine were not unusual in medicine. In Egypt (under King Re-Ser-Ka, ± 1700 BC), donkey dung was used against an erysipelas-like disease ('Hmaou'); in the Hippocratic Corpus, women's urine (possibly older urine) and bovine urine are applied as a medicament;[69] the Roman politician Cato mentions human urine as medicament, especially for bathing purposes;[70] Celsus describes a case of a man who drank his own urine (without this having the desired effect); Dioscorides enumerates, like Galen, many applications of urine of humans and animals, both for internal as external use, and Pliny the Elder recommends boar urine against ear pain.[71] Galen, however, is doubtful whether (human) urine is salubrious.[72]

Concerning dung and faeces: Celsus prescribes goat dung, Dioscurides mentions

66 Hipp. *Morb.* 2.47 (236 Potter = 7.66 L.).

67 Cf. Jansen 2011, 158. Galen, Oribasius, Paulus of Aegina and Aëtius mention many examples where excrements of mainly doves, dogs, sheep, cattle, goats, pigs, asses, ibises, crocodiles and lizards are recommended for medical usage, especially dried up (κόπρος ξηρά) and both for internal and external use. Before Galen's time, the Hippocratic Corpus mentions two passages, recommending excrements as medicaments: *Mul.* 1.75 (8.164 L.) λύκου κόπρον (woolf dung) and 2.189 (8.370 L.) πελιάδων κόπρον (dove dung). Recommendations by Galen: *SMT* 11.18 (12.284-288 K. and 12.290-309 K.); Stamatu 2005b, col. 235-236; Mattern 2008, 116; 243-244. For medical and cosmetical use in Antiquity, Middle Ages and Early modern period see Laporte 1993, 100-107.

68 Gal. *SMT* 10.1 (12.248-249 K.); Von Staden 1991, 43-44 (n. 4); Stamatu 2005b, col. 235-236.

69 Hipp. *Mul.* 3.221 (350 Potter = 8.426 L.); for more Hippocratic references to womens' diseases see Von Staden 1991, 44-48. Cf. Mattern 2008, 250 n. 16. Man's, woman's and bovine urine are looking similar: Stolberg 2009, 178-179 with references.

70 Egypt: Zinsser 1937, 108 (Papyrus Ebers); Van der Kroon 1998, 39. There are more references to the internal and external use of urine and dried-up excrements (*ḥs*) in Egyptian papyri: Sijpesteijn 1972, 81 (Papyrus Ebers 792-794 col. 94, l. 2-7, fumigation); on p. 83, Sijpesteijn refers to Papyrus Hearst 208 (donkey dung), Papyrus Ebers 326 (bird's dung) and 782 (dung of flies) for internal use. Cato, *Agr.* 157.10-11; Muth 1968, 1298; Laporte 1993, 98; Stamatu 2005b, col. 236.

71 Cels. 3.21.4; Dsc. *De Materia Medica* 2.81; Kurz 2005, col. 379; Plin. *Nat.* 28.173.

72 Gal. *SMT* 11.27 (12.305-306 K.). His doubts are expressed in his chapter concerning urine (ιε΄. Περὶ οὔρου, 12.284-288 K.).

many applications of excrement[73] and Pliny the Elder also devotes several books (28, 29 and 30) to the application of human and animal excrement as medicaments. He advises goat's dung against bites of scorpions, cat's dung (not mentioned by Galen) and mice excrement against bladder stones.[74] In the introduction to *The Capacities [and Mixtures] of Simple Drugs*, Galen prefers bovine dung and dung of goats, lizards[75] and dogs above human faeces. On the other hand, in the same introduction, he states that the use of excrement as a medicament can be effective, referring to Asclepiades, who apparently claimed that he used it successfully,[76] while Galen rejects human faeces as medicament, its stench being too bad, compared with the stench of other excrements. This is also one of the few passages where he admits that human faeces do stink; he does so in a comparison of excrement in other medicaments, producing less or no stench when they are dried up.

Unfortunately, these texts neither give information about quantities, nor is it clear if these applications are used with or without tasteful additions like wine, honey, etc. Dioscurides, for example, writes: 'Urine of a harmless child is to be drunk against dyspnoea; added with honey […] against scars […]'.[77] If child urine has to be drunk purely, without additions, this contradicts Curtis' hypothesis that people have an instinctive disgust against faeces and urine. Another fact, however, is that it is unclear whether patients knew of the use, smell and visibility of urine and/or excrement in their medicaments, especially for internal use, so to be eaten or drunk. There is, of course, a difference between a cupful of urine to be drunk, or a cup of wine containing one drop of urine, where the person drinking it is not aware of the drop.

In short, we can state that ancient medical authors considered the ideal, ὑγιής digestive and excretion tracts as tripartite processes in which tasteful food is transformed into faeces and urine. The stomach is the first organ in which food is changed into the content of the bowels. If the tracts are working well, the proportions of material are in balance, and the appearances and smells of faeces and urine are normal, the person and his excrements and urine are healthy, so ὑγιής. If the smell of faeces and urine smell is absent or not too unpleasant, they can be used as medicament.

6. Urine and faeces: dirty and unhealthy, or not?

In ancient times, in medical treatises, a great deal of attention was paid to the production of faeces and urine and how these were treated. Is there evidence that they were considered as noxious and dirty in Graeco-Roman medicine?

In ancient Greek, there was not a single specific word for 'dirty'. The Greeks used

73 Cels. 5.27.8; Dsc. *De Materia Medica* 2.80. Cf. Plin. *Nat.* 28.153.

74 Goat's dung: e.g. Plin. *Nat.* 28.155; cat's dung: Plin. *Nat.* 28.165; mice excrements: Plin. *Nat.* 30.65; Laporte 1993, 98-100.

75 Galen and Dioscorides speak of χερσαῖος κροκόδειλος, 'land crocodile'; I suppose that a lizard is meant.

76 Gal. *SMT* 11.18 (12.290-291 K.).

77 Dsc. *De Materia Medica* 2.81.2; Muth 1968, col. 1298; according to Muth (col. 1297), urine of a young man (παῖς ἄφθορος, *puer impubis*) was often used as medicament; Cels. 5.22.4.

various words like ἄλουτος (unwashed), αὐχμήεις (squalid), αὐχμηρός (squalid), αὐχμώδης (arid, squalid),[78] βορβορώδης (muddy), δυσπίνης (squalid), θολερός (turbid), πηλώδης (clayey), πιναρός (squalid), πινόεις (= πιναρός, squalid),[79] πινώδης (foul), πολυπινές (very squalid), ῥυπαρός (foul), ῥυπώδης (filthy), σαπρός (putrid).[80] Also δυσώδης (stinking) is an important word in this context.

These words, in combination with the Greek words for faeces and the bowel's contents – κόπρος, διαχώρημα and ἔκκρισις – do not have a clear match in the works of Greek medical authors.[81] The word δυσώδης, stinking, however, does occur in this context. If medical authors use this word in combination with κόπρος, they are referring to the faeces of an animal or a human being, someone other than the patient.[82] If the patient's faeces is meant, the word διαχώρημα is used. The physicians refer, however, to diseases; the only passage where the usual stench of faeces is mentioned is discussed above.[83] We observe roughly the same situation for urine, but the majority of medical authors use apart from δυσώδης, θολερός (turbid), referring to a disease.[84] They also use the words 'stinking urine', when they refer, as in the case of κόπρος and διαχώρημα, to a condition that is not-ὑγιής, and not to the situation that urine is producing its normal stench. For example, the Hippocratic Corpus and Galen describe stinking urine as deadly![85] Galen says also that sewers produce stench;[86] this will be discussed below.

In Latin, the following words for 'dirty' occur: *sordidus, squalidus, lutosus, lutulentus, caenosus* (*coenosus*), *immundus, impurus,*[87] *luteus, illotus*[88] and *foedus*.[89] As far as we know, they are never used in combination with *excrementum*, *stercus, fimus* and *merda*. Like the Greeks, the Romans generally did not have a negative opinion concerning urine and faeces; unless they did not consider it worthwhile to write it down.

In brief, in their treatises, ancient medical authors do not show an aversion to

78 Woodhouse 1910 s.v. 'dirty'.

79 Pape & Sengebusch 1905 s.v. 'schmutzig'; he also mentions αὐχμηρός and αὐχμώδης.

80 Halsberghe 1962 s.v. 'vuil'.

81 I have used TLG. There are matches θολερός and κόπρος, θολερός and διαχώρημα, and θολερός and οὖρον: Hipp. *Epid.* 2.3.11 (54 Smith = 5.114 L.) and Gal. *Hipp. Epid. I* 3.11 (17a.260 and 293 K.); these matches refer to turbid urine, observed on behalf of uroscopy. The match ῥυπαρός and ἔκκρισις (Aët. 11.29.5 and Anonymi Medici, *De morbis acutis et chroniis* 39.2.3) refers to foul pus in wounds. Cf. Kudlien 1941-, 904 (*supra* n. 7).

82 Aetius states that human excrements are usually stinking more, compared with animal dung: *Iatrica* 110 Περὶ κόπρου. Galen mentions 'stinking faeces' especially in his work *De simplicium medicamentorum temperamentis ac facultatibus*, where he compares the (bad) smells of different animal excrements and human faeces with each other.

83 E.g. Gal. *Hipp. Aph.* 3.26 (17b.635 K.); Hipp. *Epid.* 1.3.13 (210 Jones = 2.716 L.); Cels. 2.8.32. For the normal stench of διαχώρημα: Hipp. *Coac.* 589 (256 Potter = 5.720 L.) (see n. 54). Cf. Laporte 1993, 82.

84 Gal. *San. Tu.* 4.4 (6.252 K.); Hipp. *Epid.* 1.3.13 (188 Jones = 2.686 L.); Cels. 2.8.24.

85 Hipp. *Prog.* 12 (26 Jones = 2.142 L.); Gal. *Hipp. Prog.* 2.32 (18b.157 K. = Gal. *At. Bil.* 8 [5.142 K.]). Other features of diseases and diagnoses: Gal. *Def. Med.* 194 (19.400 K.); Aët. 5.4; diagnosis: Aët. 5.43.

86 Gal. *Hipp. Epid. III* 1.14 (17a.563 K.).

87 Georges 1869 s.v. 'schmutzig'.

88 Smith & Hall 2000 s.v. 'dirty'.

89 *Foedus* occurs nowhere as 'dirty', but has this meaning when stench is discussed.

faeces and urine. They even give definitions of ideal (ὑγιής) faeces and urine. Faeces and urine were considered as transformed food and drink, that could be useful for medication. They are only considered as stinking in case of deviating smell; in that case, there is disharmony in the body, so that the situation is not ὑγιής and the patient is sick. In one case Galen mentions, amongst other things like animals and beans, the stench of κόπρος, apparently in a non-medical context.[90]

The presence or absence of smell of faeces, urine and dung plays a crucial role in the various opinions. The stench of urine in particular was considered unpleasant, even more than faeces' stench.[91] In the *Problemata* (*Problems*), in the *Corpus Aristotelicum*, chapter IΓ Ὅσα περὶ τὰ δυσώδη ('On Stench') the smell of urine is observed to be worse than the smell of faeces, because faeces dry up, producing less smell, whereas urine becomes thicker after a while.[92] This chapter also discusses other stenches and other aspects of stenches. The author, probably Aristotle, states that the smell of eaten food evaporates; this is the reason that the smell of faeces differs from the smell of food. Garlic is an exception.[93] Strabo, too, mentions 'urine and other malorodous liquids'.[94] In the Roman world, Plautus creates in his *Miles Gloriosus* (*The Braggart Soldier*) the image of a soldier with the stench of faeces and Catullus considers Volusius' annals as *carta cacata*, 'papers full of shit'. Toilets and sewers were considered as dirty and negative, according to Cicero and Apuleius. Finally, in Late Antiquity, some theologians speak, metaphorically, about stinking κόπρος and dirty *stercus*.[95]

Agronomists like Varro acknowledge the importance of faeces and dung as manure, to be brought to the countryside.[96] Urine was used in industries.[97] Mud from sewers and baths was also used for manure,[98] probably for gardens in cities and villages (where sewers and baths were in use) and their hinterland.

The reason that information concerning this topic is scarce, is probably that after the rise of cities in the Greek world, from 800 BC onwards, dung was a common feature in street scenery. Hellenistic and Roman cities had the same street scenery, but they had more inhabitants, which made it necessary to install special constructions

90 Gal. *San. Tu.* 1.11 (6.58 K.).

91 According to Meijer, divers (*urinatores*) were incontinent as a result of their work and this phenomenon caused their low reputation; Meijer 1997, 118-119.

92 Arist. *Pr.* 907b.

93 Arist. *Pr.* 908a; Totelin 2015, 22 n. 33.

94 Str. 16.2.43 (= Posidonius *Fr.* 60.21). Strabo tells us that, according to Posidonius, sorcerers living in an asphalt lake in Judea use urine and other malorodous liquids; they harden it, looking for elements in them.

95 Pl. *Mil.* 88-90; Catul. 36; Cic. *N.D.* 2.141; Apul. *Met.* 1.17; Eusebius, *Commentarius in Isaiam* 1.99; August. *Sermones* 254. A papyrus, Papyrus Enteux. 79 (found in Crocodilopolis, English tr. N. Lewis, *Greeks in Ptolemaic Egypt*, Oxford 1986, 61) tells us about a woman throwing a pot full of urine over a man; Ulp. *dig.* 21.1.14.4 discusses the value of bed-wetting slaves.

96 Var. *R.* 1.13.4. Col. 1.6.24; 10.84-85; 11.3.12; cf. X. *Eq.* 2.2.5; *Oec.* 20.10.1; Scobie 1986, 413-414; Jones 2012, 2-3; 8; Shiel 2012, 19-20; Bull & Evershed 2012, 70-72; Wilson 2011, 147-148 and Flohr 2011, 148-149.

97 See Flohr 2011, 150-154, including a reference to Vespasian's famous tax on urine; Bradley 2012, 23; Davies 2012, 69; Flohr 2013, 103-104; 170-171 (crocks in the street for fullers).

98 Gal. *Hipp. Epid. III* 1.14 (17a.563 K.); Col. 10.85 (gardener).

and facilities to remove the whole or a part of the dung, faeces and urine. So-called κοπρολόγοι (dung and waste collectors) removed faeces and dung out of the cities.[99]

It is remarkable that there was considerably less aversion to dried-up excrement than to fresh excrement. As we have seen, Galen used dried excrement in his medicaments. Varro mentions older manure to be brought to the field. Apparently, annoying faeces (or dung) is transformed into useful manure; when it is dried-up and produces no or almost no stench anymore.[100] People were accustomed to dirt and its smell, so that faeces and dung were not so much experienced as nuisance.

7. Discharge of faeces and urine

According to the above-mentioned medical theories, human excrement and urine were considered as transformed food, the results of digestion and secretion. In practice, however, human excrement and urine, and animal dung caused a great deal of soil pollution. Before the founding of actual cities, this would not have been a major problem; people dumped their faeces into a cesspit or on a dungheap, and urine dried up in the soil if it was not used as material for fulleries or other industries. With the growth of cities, population increased and, inevitably, the quantity of faeces and dung in the streets of these densely inhabitated nuclei. One was forced to remove it, but the question is whether this was done to improve hygiene or for other reasons? In this paragraph, I will discuss these aspects of urine and faeces in some case studies.

7.1. The Greek world

In the Greek cities, at first chamber pots or mobile toilets (**fig. 3**) were quite common. The contents were emptied in a cesspit, a collective dung heap or open sewer, in the first instance used as rain water drainage. Cesspits had certain advantages: they were cheap to construct and easy to empty, and there was no need for intervention by authorities. Only in case of large quantities of faeces and waste water, like public toilets and baths, were connections to sewers constructed.[101]

The more Greek cities constructed sewers, the more fixed toilets came to be used. The advantage of fixed toilets is that there is less stench and it is no longer necessary to transport full pots to dungheaps. A disadvantage is that a well-functioning sewer needs a flowing stream and there was always the danger of congestion of faeces.

At the beginning of the 5th century BC, in Athens the Great Drain was constructed to drain the Agora.[102] Before the end of the 5th century BC, cesspits were replaced

99 Arist. *Ath.* 50.2; Owens 1983, 44-50; Scobie 1986, 414; Owens 2011, 29; Wilson 2011, 147-148. Κόπρος has to be translated, in this context, also with 'waste' in general. See also *infra*.

100 Var. *R.* 1.13.4; cf. Laporte 1993, 37; 66. He mentions that the Byzantine author Constantinus Porphyrogenes (10th century) states that excrements must be spread out 3 to 4 years on the field for transforming from faeces into manure.

101 Jansen 2002, *passim*.

102 Guillaume 1877-1919, 1260; Wilson 2000, 164; Owens 1983, 49; Young 1951, 151.

Fig. 3. *Hamis or amis (Sparkes, Talcott & Frantz 1958, fig. 22).*

by sewers. There is evidence that excrement was discharged by a sewer system. We see the same development in Carthage, Priene, Delos and Thera. From 320 BC onwards, in Piraeus the use of cesspits was even forbidden.[103] On the other hand, the fact that κοπρολόγοι were not only active in the 5th but also in the 4th century BC indicates that not all faeces were removed through sewers, even if they were present. Doubtless, in the Greek world, excrement and other kinds of waste were dumped by these κοπρολόγοι outside the city, at a fixed distance from the city walls.[104] Also elsewhere, an interdiction on dumping waste could be valid, for example on the Acropolis.[105] Outside Athens, interdictions on dumping excrement to prevent the fouling of temples and shrines, were imposed in Delos, Epidaurus and Paros.[106]

At a later stage, we see the same development as in Athens: open sewers were transformed into covered ones; a variety of sewer systems is also seen in Hellenistic

103 Carthage: Telmini 2011, 62. Priene, Delos and Thera: Thompson 1959, 102. Interdiction of cesspits in Piraeus: *IG* II^2 380.

104 Arist. *Ath.* 50.2; Owens 2011, 29; Wilson 2011, 147.

105 *IG* I^3.4; Jordan 1979, 45; Liebeschuetz 2000, 56.

106 Owens 1983, 46.

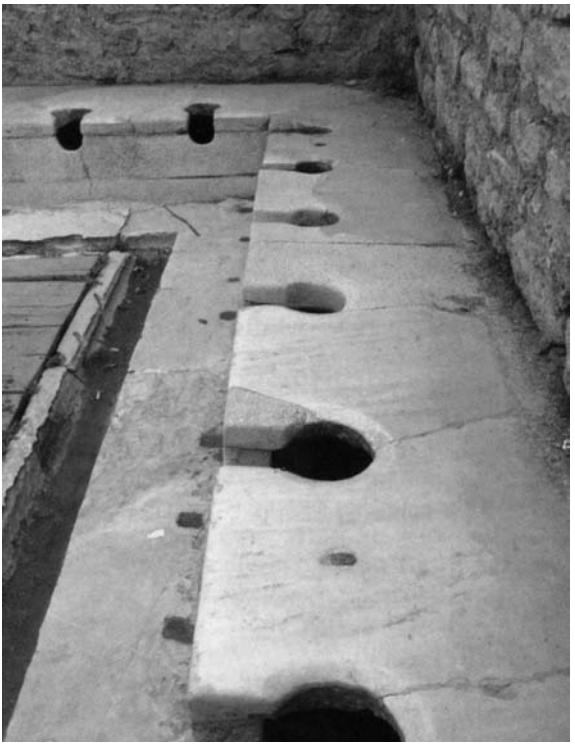

Fig. 4. *Roman public toilet in Ephesus (photo G. Wiplinger; Jansen, Koloski-Ostrow & Moormann 2011, 102).*

cities.[107] Citing Liebeschuetz: 'Keeping public spaces public had a greater priority than keeping them clean'.[108]

7.2. The Roman world

The Romans, too, used both mobile and fixed toilets (*latrinae*). They adapted their toilet accommodations from the Greeks[109] and toilets are found in houses and public complexes everywhere in the Roman Empire (**fig. 4**). Again, archaeological surveys give most information; neither Greek nor Latin literature offers very much information on toilets and stools, and this scarce information is mainly found in comedies and satires,[110] and also in street texts (see Introduction).

To remove excrement more easily, the Romans connected public toilets to existing drain canals. The best known is the Cloaca Maxima (Main Sewer),[111] constructed to drain the area among the hills, the Forum Romanum. In Plautus's time (± 200 BC) it

107 E.g. Smyrna had no sewer at all: Str. 14.1.37; Liebeschuetz 2000, 57-59.
108 Liebeschuetz 2000, 59.
109 Thédenat 1877-1919, 987; Trümper 2011, 33; Koloski-Ostrow 2011, 51.
110 E.g. Pl. *Cur.* 577; Lucil. *fr.* 400.
111 Hughes 2014, 177; Koloski-Ostrow 2015, 91-92.

was still an open sewer (*canalis*). So we see the same development as in Athens. The importance of the Cloaca Maxima is evident from the fact that even in the 6th century AD, Theodoric's time, the sewer was still in good condition.[112] It was, however, impossible to connect all Rome's toilets to it, so that a vast quantity of faeces and dung was still left in the streets, and many cesspits remained in use.[113] In Rome, removing dung was supervised by the *IVviri viis in urbe purgandis* and *IIviri viis extra urbem purgandis*; the actual removal was done by *stercorarii*, who also removed other garbage (like the κοπρολόγοι).[114] Before that time, there was an edict by L. Sentius, prescribing that faeces and other waste had to be removed far from the city's boundaries.[115] An inscription found in Pompeii also refers to *stercorarii*.[116]

Emptying and maintaining cesspits was a private matter. In Herculaneum, it was possible to pay someone to do it.[117] The porous volcanic soil type of Pompeii was more suitable for constructing cesspits than the more compact soil type of Herculaneum. Here the construction of an underground sewer system was more suitable.[118]

Beside underground sewers in the Roman world, there were also open sewers, and cities with no sewer at all, even during the Empire. Local authorities chose the system of removing waste, excrement and dung. In Amastris (in present-day Turkey), an open sewer produced a horrible stench. Pliny the Younger wrote a complaining letter to Emperor Trajan.[119] According to Gülbay, in the province of Asia, good sanitation was at the bottom of the list.[120]

One reason not to construct an underground sewer could be that a soil type was not suitable to construct such a structure. It was very expensive to construct and maintain a sewer.[121] Sewers had to be cleaned and repaired from time to time. Due to the gases and the noxious vermin that were to be found there, it was dangerous

112 There is a disagreement whether the sewer system is realised under the reign of Tarquinius Priscus (Liv. 1.38.6 and 1.56.2) or Tarquinius Superbus (D.H. *Antiquitates Romanae* 3.67.5 and 4.44.1); see Bauer 1993, 288 for more information. Bianchi and Antognoli state in their articles that drainage started under Tarquinius Priscus and that the sewer, equipped with stone slabs, was finished under Tarquinius Superbus (Antognoli & Bianchi 2009, 92; Bianchi 2010, 5-8 and 20; Bianchi & Antognoli 2013, 130). Davies (p. 70) mentions the 6th or 5th century BC; Hopkins (p. 85) the 5th century, so after the kingdom. Covering: Pl. *Cur.* 476; Davies 2012, 78. Bianchi and Antognoli discuss the hypothesis that covering took place under Agrippa (Antognoli & Bianchi 2009, 94; Bianchi & Antognoli 2013, 126-127). Theodoric's time: Cassiodorus, *Variae* 3.30.1. For a general overview of the Cloaca Maxima see the articles of Davies, Bauer, Bianchi and Antognoli.

113 Thüry 2001, 10; Davies 2012, 68.

114 Scobie 1986, 413-414. He restricts the significance of *stercorarii* to 'those who emptied cesspits'; Davies 2012, 69. For more information of the street cleaning organisation of Rome see Panciera's article.

115 *CIL* I^2 838 = 839; Panciera 2000, 100.

116 *CIL* IV 7038. For discussion concerning this inscription see Bodel 1986/1994, 32 and 104 n. 126; Panciera 2000, 100; Thüry 2001, 17; Wilson 2011, 148.

117 Schubring 1962, 243 n. 3; *CIL* IV Supp. 3.4.10606; Jansen 2002, 110 and 120; Wilson 2011, 147.

118 Jansen 2002, 62 and 110. The soil type of Herculaneum made it possible to dig shafts and tunnels for exploration; Camardo 2013, 329-337; Koloski-Ostrow 2015, 92-93.

119 Plin. *Ep.Tra.* 10.98. In Tra. Plin. *Ep.* 10.99, Trajan agrees with the proposal to cover the sewer.

120 Gülbay 2006, 461.

121 D.H. *Antiquitates Romanae* 3.67.5.

to go down into the sewers; they were usually cleaned by slaves or as a form of punishment.[122] Open sewers were easier to clean and repair, but here the stench was the problem.

Conclusion

Our word 'hygiene' is derived from the Greek word ὑγιής, but its meaning is very different. In modern English, it means: to avoid everything that can be threatening our health, like dirt, faeces and urine. In the ancient Greek and Roman world, it means: a situation of balance of humours and other elements inside the body, and external factors which influence the body. The attitude of ancient medical authors towards faeces was usually neutral or positive; faeces and urine were considered as transformed food, and not as annoying factor or even as a cause of infectious diseases – there were ideas concerning infection, but these were only ideas; they were not properly developed. If the smell of faeces and urine was normal, the man or woman was healthy. Deviating smell was unhealthy, not ὑγιής. Faeces and urine were even in use as medicament; faeces mainly in dry substance, with little or no stench.

Outside ancient medicine, the attitude of ancient authors was more negative (apart from agronomists, who were professionally interested in dung and manure). They considered faeces (especially fresh faeces) and urine as stench-producing material, not as transformed food as the medical authors did. Although animal dung was a common feature in street scenery, so that common people were accustomed to stench, there were interdictions on dumping faeces at special places, as the graffito in Pompeii shows. Large amounts of dung had to be removed from the streets; this, however, was done more for the purpose of keeping access and removing stench. To reduce the stench of human excrement in the case of a growing population, governments decided to connect public baths and public toilets to the sewer system. The most well-known sewers – the Great Drain in Athens and the Cloaca Maxima in Rome – were built, in the first instance, to drain low areas; only later were toilets and baths connected to them. Ancient physicians did not play a role of any significance in keeping cities healthy. Thus the idea that sewers were built to remove faeces and urine as in our modern times was a misunderstanding.[123]

With regard to the graffito in Pompeii, we are now able to answer the question formulated above: the aim of the graffito is not to avoid health danger – there was no notion of any relation at all between dirt (faeces) and contagious diseases, since diseases were ascribed to supernatural powers, bad surroundings and not-ὑγιής proportions of humours and qualities in individuals, – but to prohibit annoyance and and to keep the place in order. This may be viewed as a confirmation of Douglas' theory. Excrement and urine were not considered as dirty as such.

122 Ulp. *dig.* 7.1.15.1; Labeo *dig.* 19.1.54 pr.; August. *De libero arbitrio* 3.9; August. *Enarrationes in Psalmos* 103.4.10; Jansen 2011, 161; Koloski-Ostrow 2015, 94-95. Punishment: Tra. Plin. *Ep.* 10.32.

123 For information concerning the history of urban sewers in Europe see the following chapter. On the misunderstandings of ancient street cleanliness see especially the articles of Scobie and Thüry, and Jansen 2011, 157.

Nowadays, however, studies indicate disgust toward faeces,[124] and so we also see, in a way, a confirmation of Curtis' theory: fresh stinking faeces and urine were considered as disgusting, but not as dangerous. When these were older and dried-up, there was less stench and less aversion. Citing Von Staden: 'Les excréments passaient aux yeux des poètes, des philosophes, des savants, des prêtres, des législateurs et des médecins pour l'exemple même de la souillure détestable. Néanmoins, depuis les premiers auteurs hippocratiques jusqu'à l'antiquité tardive, les médecins grecs les prescrivirent'.[125]

124 Miller 2004, 26; 50; 57. She refers, amongst others, to Douglas and Curtis. Miller mentions an interesting aspect concerning faeces: school-age children like talking about 'poop' (p. 61-63). Thus, there is a development of disgust towards faeces after the baby-age, when a child is crying in a wet bed (see Galen's reference); cf. p. 88.

125 Von Staden 1991, 44.

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