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

Tilburg, C.R. van

Streets and Streams

Health Conditions and City Planning in the Graeco-Roman World

Cornelis van Tilburg

Parentibus

Streets and Streams
Health Conditions and City Planning in the Graeco-Roman World

PROEFSCHRIFT

ter verkrijging van
de graad van Doctor aan de Universiteit Leiden,
op gezag van Rector Magnificus prof.mr. C.J.J.M. Stolker,
volgens besluit van het College voor Promoties
te verdedigen op woensdag 14 oktober 2015
klokke 13.45

door

Cornelis Richard van Tilburg

geboren te Waddinxveen,
in 1965

Promotiecommissie

Promotor:
Prof. dr. H.F.J. Horstmanshoff

Tweede promotor:
Prof. dr. E.M. Moormann

Copromotor:
Dr. M. van Raalte

Overige leden:
Prof. dr. H. Beukers
Dr. G.C.M. Jansen

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Acknowledgements

Most of the chapters in this book have been published as articles in journals or edited volumes. They are republished here, sometimes slightly modified; major changes will be accounted for in the Contexts preceding each chapter. I want to thank the various publishers for their kind permission to reprint them here.

1. 'Traffic Policy and Circulation in Roman Cities', was originally published in *Acta Classica* 54 (2011) 149-171.

2. 'Gates, Suburbs and Traffic in the Roman Empire', was published in *BABesch* 83 (2008) 133-147. I am grateful to the late Dr Arie van Heck for his help and for his translation of the Italian sources.

3. 'Greek and Roman Ideas about Healthy Drinking-water in Theory and Practice' is reprinted here from *Eä Journal of Medical Humanities & Social Studies of Science and Technology/Revista de Humanidades Médicas & Estudios Sociales de la Ciencia y la Tecnología* 5 (Junio 2014) 1: 1-30.

4. 'Opinions concerning Faeces and Urine in the Graeco-Roman World' is under review for an international journal. I am grateful to Marilyn Hedges MA (Universiteit Leiden) for correcting the English and to Dr Cisca Hoogendijk (Universiteit Leiden) for her help with the papyrological sources.

5. 'A "Healthy Mistake": The Excrement Problem from Ancient Greece to Nineteenth Century Holland' is published in A. Karenberg, D. Groß and M. Schmidt (eds), *Forschungen zur Medizingeschichte. Beiträge des 'Rheinischen Kreises der Medizinhistoriker'*. Kassel 2013, 103-117 [Schriften des Rheinischen Kreises der Medizinhistoriker 3].

A Dutch version of this article 'Een heilzame vergissing: Het urine- en fecaliën-probleem van Grieken tot Gouwenaars', appeared in *Studium* 5 (2012) 1: 34–52. I am grateful to Prof. Eddy Houwaart and the staff members of the MA course Medical History VU University Amsterdam/Leiden University for their role in the publication of the latter version.

In the present chapter the illustrations from the Dutch article have been added again.

6. 'A Good Place to Be: Meteorological and Medical Conditions in Ancient Cities' is released for publication online ahead of a forthcoming issue of *Mnemosyne* (January 2015). It is reprinted here with the kind permission of Koninklijke Brill NV. I would like to thank Dr Paul Scade (İstanbul Şehir Üniversitesi) for his help to correct the English.

The page numbers refer to the numbers of the last electronic edition.

I thank my supervisors Prof. Manfred Horstmanshoff, Prof. Eric Moormann and Dr Marlein van Raalte for their advice and encouragement, and Professor Horstmanshoff in particular for suggesting this field of study to me and for his supervision for many years.

I also want to express my profound gratitude to Dr Hans Haak and Lisette Demmers MA for their support throughout the years, and to the staff of the Leiden University Centre for the Arts in Society (LUCAS): Dr Korrie Korevaart, Lia ten Brink and Viola Stoop MA for their friendly and efficient help in many fields. I am grateful both to LUCAS and to the Leiden University Fund (LUF) for financial support, and to Leiden University, including Leiden University Library, for its institutional support.

For assistance with translation, I would like to thank Jane van Klaveren for her efficient and sensitive work.

This book would not have been published without the fruitful cooperation with Evelyn de Regt MA, publisher of Primavera Pers, Leiden.

Aids to the Reader

The abbreviations used in the Index Locorum are those of the following dictionaries and bibliographies:

Greek authors and their works:
Liddell, H.G., Scott, R. & Jones, H.S. (LSJ). 1996. *A Greek-English Lexicon*. Oxford.
E.g. Ar. *Lys.* 88 → Aristophanes, *Lysistrata* 88.
If abbreviations are lacking, I have written the author and/or title in full:
E.g. Eusebius, *Commentarius in Isaiam* 1.99.
I have added the abbreviation *Med. Coll.* referring to Oribasius' *Collectiones Medicinae*. This abbreviation is lacking in LSJ.
E.g. Ruf. apud Orib. *Med. Coll.* 5.3.12-16.

Latin authors and their works:
Glare, P.G.W. 1982. *Oxford Latin Dictionary*. Oxford.
E.g. Pl. *Cur.* 123 → Plautus, *Curculio* 123.

Hippocratic Corpus:
http://cmg.bbaw.de/online-publikationen/hippokrates-und-galenbibliographie-fichtner
Between brackets, the pages of the Loeb editions are mentioned, followed by a L. quotation, referring to the edition of Littré, É. 1961-1982. *Oeuvres complètes d'Hippocrate etc.* Amsterdam.
E.g. Hipp. *Aph.* 3.22 (130 Jones = 4.496 L.) → Hippocratic Corpus, *Aphorismi* 3.22 (p. 130 of the Loeb series edited by W.H.S. Jones = vol. 4, p. 496 of the edition of É. Littré).

Galen and Galenic Corpus:
Singer, P.N. (ed.). 2014. *Psychological Writings: Avoiding Distress, Character Traits,*

The Diagnosis and Treatment of the Affections and Errors Peculiar to Each Person's Soul, The Capacities of the Soul Depend on the Mixtures of the Body. Cambridge.

Between brackets, the pages of the Kühn edition (K.) are mentioned, referring to the edition of Kühn, C.G. 1821-1833. *Claudii Galeni Opera omnia*. Hildesheim.

E.g. Gal. *Nat. Fac.* 1.6 (2.14 K.) → Galen, *De Naturalibus Facultatibus* 1.6 (vol. 2, p. 14 of the edition of C.G. Kühn).

I have harmonised, corrected and completed the references in the chapters in this volume in accordance with these rules.

In this volume, the page numbers of the original publications are mentioned in bold, between square bold brackets.

E.g. **[37]** refers to page 37 in the original publication.

INTRODUCTION

Interaction between Anatomical and Civil Engineering Terminology

Introduction

Medicine[1] and city planning are disciplines which are, at first sight, far removed from each other. Medicine is a science thousands of years old – medical treatises were already written in the Graeco-Roman world – but city planning and traffic studies are modern sciences that constitute a common part of social and technical sciences. We have no information on the education of Greek or Roman city planners; we do not even know if there were traffic experts in Antiquity. On the one hand we know that knowledge of medicine was required for studying architecture, as stated by Vitruvius, the famous Roman architect and engineer, but on the other hand, the aspect of civil engineering or architecture did not play a role of any significance in medical education. In this volume I will set out to prove that there were, however, correlations between the sciences of medicine and civil engineering; their mutual terminologies were in use in both sciences just as they are today.

Medical concepts and words play an important role as 'gesunkenes Kulturgut' (the process whereby customs and words, in the first instance used by the upper classes, become more and more common amongst ordinary people) in social life and in literature.[2] In 1965, the Dutch traffic expert Henk Goudappel (1930-2007) described traffic problems in the following way:

> 'Many words describing traffic problems are derived from medical terminology: congestion, artery, circulation, sanitation, 'recovery'. On the one hand, all these terms acknowledge traffic as a vital urban function; on the other hand, they show that the city is not quite in a healthy state. Obstruction of the veins and arteries can

1 In this introduction, anatomy and physiology (I use their modern definitions, as used from the 16th century onwards; see Nutton 2012) are considered as parts of medicine.

2 See Elias 1980 *passim*, esp. part 1, 5-10, 43-50; part 2, 336-351 and 409-454.

> be lethal for a human being. This is also the case with cities: parts of a city can die, caused by interruptions or total blockages of traffic […]. As with a sick body, a sick city cannot be revived by a simple prescription. Traffic needs a more determined treatment. Observation, diagnosis, prognosis and therapy, the correct route towards recovery, all these are elements of traffic regulation'.[3]

Goudappel published these observations at a time when traffic congestion was still a relatively minor problem, in comparison to traffic congestion in the 21th century. Nevertheless he did state that a city with traffic congestion was 'sick'.

The problem is not a recent one; in the Graeco-Roman world[4] traffic congestion was also a problem and it is an interesting theme to research socio-economic values of traffic congestion at that time. Did people compare medicine (the human body) with traffic science, architecture and technology?

Metaphors, analogies and comparisons concerning the human body are used in almost all sciences and throughout history – and the Graeco-Roman world was no exception. The following famous statement is ascribed to the Greek sophist and philosopher Protagoras (490-420 BC): πάντων χρημάτων μέτρον ἐστὶν ἄνθρωπος, τῶν μὲν ὄντων ὡς ἔστιν, τῶν δὲ οὐκ ὄντων ὡς οὐκ ἔστιν, 'Man is the measure of all things; of what is, that it is; of what is not, that it is not', i.e. he explores the world, choosing his own body and parts of it as a point of departure.[5] By way of introduction to this volume, I will point out to what extent anatomic nomenclature and the description of physiological processes are used for traffic and architectural terminology – and the reverse. In other words, I will show which terms from the field of anatomy and physiology were used, with reference to landscape, city planning and traffic, and in reverse order; and in which field of science they were first used – as far as we are able to ascertain. An important question is how far these processes were known, comparing the terms of one-way, return and circulation, when describing the movements of both the human body and traffic.

To what extent did both sciences, civil engineering on the one hand and anatomy and medicine on the other, influence each other in the Graeco-Roman world? I will consider both sciences separately and in comparison and I will also discuss the historical development of each term. In seeking the answers, I have used lexicographic sources.[6]

3 Steÿn 2010, 17; translated by the author.

4 When I use the words 'Graeco-Roman world', I refer to the Greek-speaking area around the Mediterranean Sea and the Roman Empire, in the period between 800 BC and 700 AD.

5 DK 80 B 1 (DK II.263.9-10). Cf. Van Berkel 2013, 37-65, esp. 56-60. She refers to (p. 56-57): δάκτυλος (finger), πούς (foot), παλαμή (palm), πῆχυς (elbow), κόνδυλος (knuckle) and ὄργυια (length of spread arms).

6 Behm, Hyrtl, Scarborough and Skoda; for the etymology see Beekes, Chantraine, Masson & Lejeune, LSJ and C.T. Lewis & C. Short, *A Latin Dictionary* (Oxford 1993).

1. Metaphor and analogy

First, let me give a short explanation of the term 'metaphor'. 'Metaphor' and 'analogy' are terms for related concepts. A metaphor is a figure of speech where a concept is replaced by an image (e.g. 'a ship of the desert' instead of 'a camel'). An analogy is a comparison: a camel crosses the desert like a ship crosses the sea. Throughout history, a vast amount of literature is published about the concepts 'metaphor' and 'analogy', including metaphors and analogies in Graeco-Roman literature. In his *Poetica* (*Poetics*), Aristotle gives a clear definition of these concepts.

A metaphor, on the one hand, contains two components: the word or concept itself, and on the other hand, the word that refers to something else, which is adapted.

An analogy,[7] on the other hand, contains four components: A, B, C and D. A and B have a distinct and usually functional relation to each other, like C and D. Then A is compared with C, and B with D. For example: Old age (A) is to life (B), as evening (C) is to day (D). This creates the following formula: A:B = C:D.[8] Of course the reader or listener to whom the metaphor or analogy is directed, has to know the meaning and connotations of the words involved; otherwise the message is not clear and the metaphor or analogy loses its function. Metaphors and analogies are thus subject to time, person and culture. E.g. the metaphor 'Time is money' can only be comprehended in a situation where the phenomenon 'money' is important, and 'time' is scarce, as in our modern Western society. For a text to be translated which is written in a particular period in a particular country or region, the translator has to be aware that not only the text, but also the context, has to be translated.[9] This culture-related aspect creates the possibility of using metaphors as comparisons for historical research.

7 Bartha (2013) describes an analogy as follows: 'An *analogy* is a comparison between two objects, or systems of objects, that highlights respects in which they are thought to be similar. *Analogical reasoning* is any type of thinking that relies upon an analogy. An *analogical argument* is an explicit representation of a form of analogical reasoning that cites accepted similarities between two systems to support the conclusion that some further similarity exists'.

8 Arist. *Po.* 1457b7-30; Stutterheim 1941, 65; 69-81; Taub 2012, 45-46; Fojt 2009, 112-113; Oosterhuis 1982, 40. Sometimes an analogy contains three components: Empedocles, DK 31 B 55 writes that 'the sea is the sweat of the earth', which is, according to Aristotle (*Mete.* 357a25-29), important in a poetical context, but not in a scientific context; Lloyd 2002, 116 n. 32; Lloyd 2012, 73-74. Cf. for other references and metaphors in the Graeco-Roman world Arist. *Rh.* 1406b, Arist. *Rh.* 1410b16-19 and Quint. *Inst.* 8.6.8-9. For Galen's use of metaphors see H. Von Staden, 'Science as text, science as history: Galen on metaphor', in Eijk, Ph.J. van der, Horstmanshoff, H.F.J. & Schrijvers, P.H. (eds), *Ancient Medicine in its Socio-Cultural Context*. Amsterdam/Atlanta 1995, 499-518.

9 Examples of culture-subjected metaphors and types of metaphors are to be found in Lakoff & Johnson 1980, *passim*. Translations: Heeßel 2010, 175-177; Høyrup 2010, 398 (both referring to the translations of Babylonian texts). Cf. Craik 2009, 108; 111 (translation of φλέψ into 'channel').

2. City, body and metaphors

Metaphors referring to civil engineering and architecture on the one hand (macrocosm) and the human body on the other hand (microcosm),[10] as Goudappel describes, were also in use in the Graeco-Roman world.

In this introduction, I will discuss the following words: *dorsum*, ἔξοδος, κιών, κοιλία, κυκλοφορία, ὀχετός, πεδίον, πύλαι and πυλωρός and their Latin counterparts (*dorsum* and πεδίον have no counterpart, as far as we know, in Greek and Latin respectively). These words can be divided into two categories: words which in the first instance are mentioned in a medical context and later in a civil engineering context; and the reverse: words which in the first instance are mentioned in a civil engineering context and later in a medical context. Three of them are already cited in the works of Homer: κιών, πεδίον and πύλαι. The other Greek words (both civil engineering and medical) can be dated to the late 5th century BC, when Greek literature had reached a peak; the time when medical literature had made its entry. Their Latin counterparts date mainly from the 1st century BC when they are used by Vitruvius and Celsus.

Within the dichotomy of words in which the use in civil engineering is older than the medical use, and words where the medical use is older than that in civil engineering, there arises a second dichotomy: words having a 'static' and a 'dynamic' sense. The group of concepts with a 'static' sense is the largest: both groups refer to parts of the body and artefacts being at rest. Only after the rise of medicine did people observe the internal parts of the body and they not only observed, but also named, these parts, as is shown in the Hippocratic Corpus from the 5th century BC onwards. E.g. the name of the πυλωρός, pylorus, the circular muscle between the stomach and the duodenum, is derived from the fact that this muscle resembles a Graeco-Roman city gate at that period, which could be opened and closed. In this case, the civil engineering meaning is older than the medical meaning.

2.1. City planning, traffic and architectural terms, used in anatomy and physiology

The terms κιών, πεδίον and πύλαι are used by Homer; the civil engineering term is older than its medical counterpart.

Let us start with πεδίον, in the geographical sense 'plain', but in the medical sense 'metatarsus'.[11] This word refers to a 'plain' in the geographical sense, a phenomenon which we see in nature. This word has its roots in the Hittite language. Michler states that the word is used by many authors signifying 'ploughed field'. We find this meaning throughout the entire Greek literature.[12]

10 Macrocosm and microcosm: Holmes 2010, 99.

11 Hitt. peda- Beekes 2010, 1161; see Michler's article (1961) for an extended etymology; Poll. 2.179; 4.196. In Latin there is no equivalent; Celsus only describes the metatarsus in 8.1.27 (*Cetera pedis ossa ad eorum, quae in manu sunt, similitudinem structa sunt: planta palmae, digiti digitis, ungues unguibus respondent*).

12 Hom. *Il.* 5.222; Skoda 1988, 49-50, who refers in n. 181 to the female genitals, mentioned by Aristophanes: *Lys.* 88; *Av.* 507; LSJ.

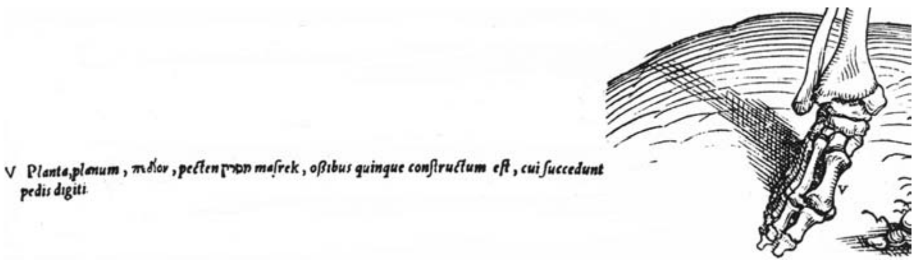

Fig. 1. *Πεδίον, still in use in Vesalius'* Tabulae anatomicae sex *(Saunders & O'Malley 1973, 243, plate 90; Vesalius' first edition 1538, plate IV; modified by C. van Tilburg).*[13]

In its medical sense we meet the word first in the works of Rufus of Ephesus (2nd century AD). Galen states in his work *De usu partium* (*The Function of the Parts of the Body*) that the word πεδίον (**fig. 1**) acquired its name because the metatarsus touches the earth, 'plain' or 'field' (according to Michler).[14] There are two other synonyms for the metatarsus: ὄρος (mountain) as stated by Pollux (2nd century AD)[15] and the more common ταρσός or ταρρός.[16]

The shape of the metatarsus can indeed evoke certain associations: plain, mountain and a ploughed field: the toes are very close to each other, evoking the image of furrows, ending at the metatarsus. Ταρσός or ταρρός evokes (in contrast to ὄρος) the association with a flat structure like the flat side of an oar or the palm of a hand.[17] Galen and Rufus indicate in their treatises on medical terminology that there were more names and terms for parts of the human body which were created by physicians who were trying to make a name for themselves.[18]

The other Homeric words of which the civil engineering meaning is older than the medical use, κιών and πύλαι, do not refer to a phenomenon found in nature but to artificial structures. Κιών (Lat. *columna*), civil engineering: 'column'[19] is cited, as already said, by Homer in an architectural context.[20] In the medical sense, κίων refers to four parts of the human body: uvula (**fig. 2**),[21] internasal septum,[22] wart[23] and penis.[24] In all senses, the word apparently refers to a vertical structure. Already in prehistory, vertical elements (poles) were used for tents and cabins to support their

13 Translation: The *planta, planum,* pedion, *pecten*, MASREQ, masrek is formed of five bones. After it come the digits of the foot (Singer & Rabin 1946, 28). The medieval Latin word *pecten*, the Hebrew MASREQ and Arabic masrek mean 'comb' (Singer & Rabin 1946, 26 nn. 155-156).

14 Rufus: Ruf. *Onom.* 125; Galen: Gal. *UP* 3.8 (3.201-203 K.); Michler 1961, 218-221.

15 Poll. 2.197.

16 From Homer onwards (*Il.* 11.377) up to now; Hyrtl 1880, 526-529.

17 Cf. Cels. 8.1.27; Beekes 2010, 1453-1454.

18 Galen: Gal. *Med. Nom.* 85r (translated from Arabic by Meyerhof & Schacht, see the bibliography) p. 9 r. 16-31; Rufus: *Onom.* 10; Haak 2013, 82 and 203; Lloyd 2002, 102-105.

19 IE (Indo-European) ḱīwōn, Beekes 2010, 707; Ruf. *Onom.* 60; Poll. 2.79; 2.99 (uvula).

20 Hom. *Od.* 8.66.

21 Hipp. *Epid.* 1.3.13 (196 Jones = 2.696 L.); Ruf. *Onom.* 60. For more synonyms of 'uvula' see *infra.*

22 Ruf. *Onom.* 37. For synonyms cited by Rufus see *infra.* In Latin: Isid. *Orig.* 11.1.48.

23 Hipp. *Nat. Mul.* 65 (290 Potter = 7.400 L.).

24 Only in Latin: Mart. 6.49.3. Cf. English 'pole'.

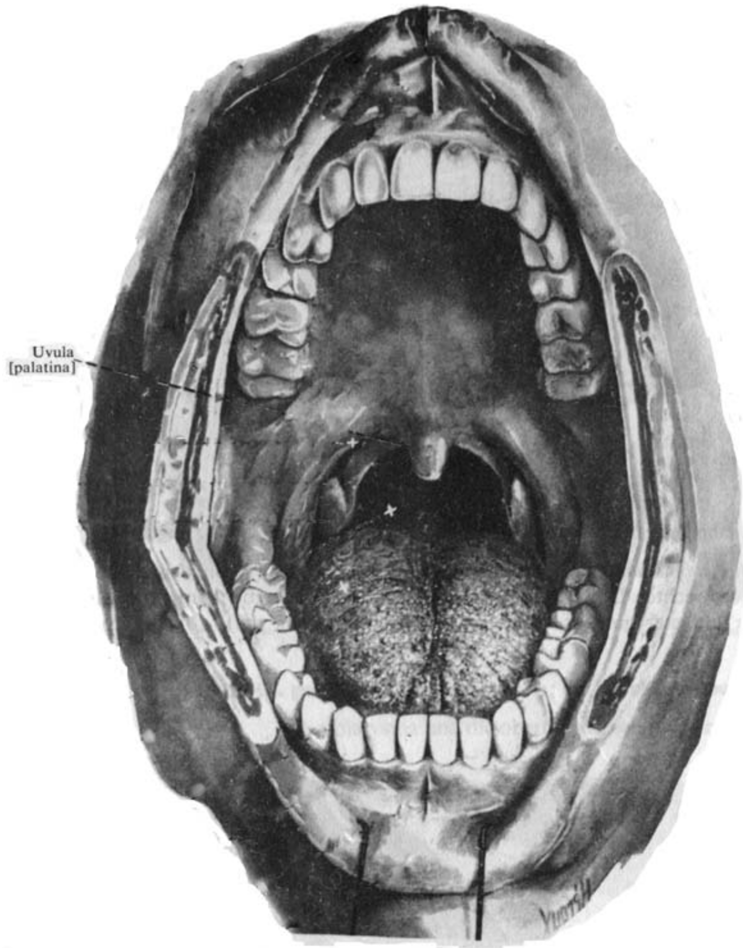

Fig. 2. *Uvula (Spalteholz & Spanner 1951-1961, 186, fig. 1049; modified by C. van Tilburg).*

roofs. Looking at the Indo-European origin of the word, it must indeed be very ancient. The parts of the human body to which the word refers are visible from the outside, but in (medical) literature we meet the word only from the 5th century BC onwards.

Roughly the same situation is found in the case of πύλαι (Lat. *iocineris*) *portae*, civil engineering: 'gate', medical: 'portal vein'.[25] Homer uses the plural form referring to the Skaiian Gate of Troy.[26] Like poles, gates can be considered as the basic elements of human dwellings; Beekes describes the word as 'pre-Greek'. The Minoans and Myceneans erected gates, such as the famous 'Lion's Gate' of Mycene. The image of the

25 Unknown etymology, probably pre-Greek, like many other words concerning architecture; Beekes 2010, 1257; Ruf. *Onom.* 179-180; Poll. 2.215.
26 Hom. *Il.* 3.145 (The Skaiian Gate of Troy).

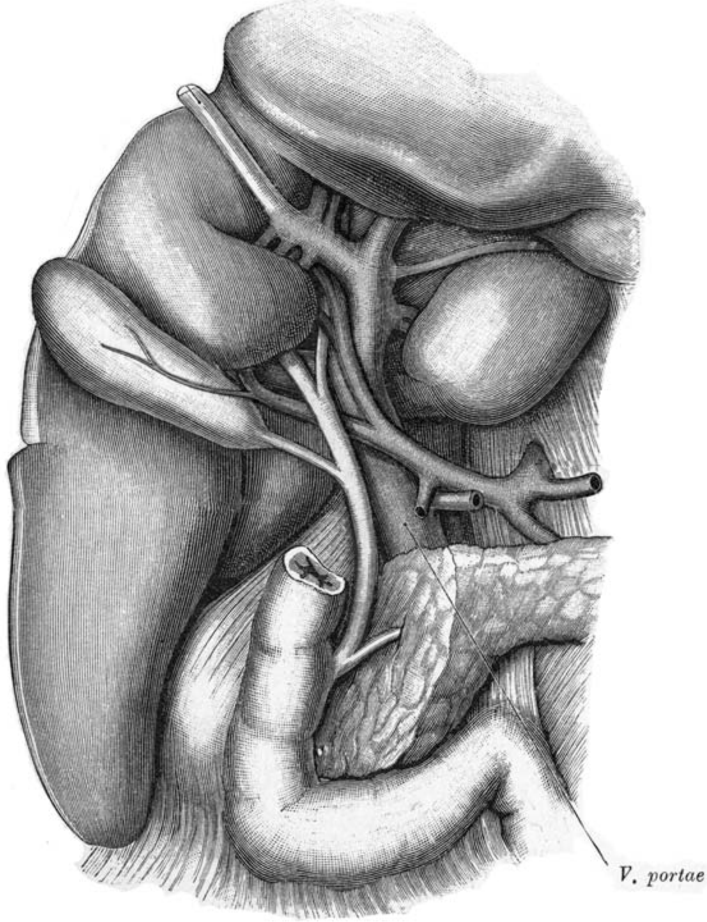

Fig. 3. *Portal vein (Heitzmann 1905, 359, fig. 429; modified by C. van Tilburg).*

portal vein, accompanied by the liver artery and bile ducts, corresponds with a busy forecourt of a city gate (**fig. 3**).

The portal vein is the only vein running from the digestive system to the liver, transporting blood. In a medical sense, too, this vein is called πύλαι (plural) because it splits up into several branches.[27] In this sense, we find the oldest reference (as far as we know) in Euripides' *Electra* (5th century BC). Here the portal vein of a calf is mentioned; the first reference to a human portal vein we find in the Hippocratic Corpus. Later references are found in Plato, Aristotle, Celsus and Galen.[28] The portal vein is the entrance to the liver. It is doubtful whether this vein was known before the first

27 Singular πύλη only cited by Ruf. *Onom.* 179; in *Onom.* 1.29 (Daremberg Ruelle 176), on the other hand, plural (πύλαι).

28 E. *El.* 828 (calf's liver); Hipp. *Epid.* 2.4.1 (64 Smith = 5.122 L.) (end 5th century-beginning 4th century BC; Jouanna 1992, 537; Craik 2015, 90-91); Pl. *Ti.* 71C; Arist. *HA* 496b32; Cels. 5.26.2 (also in Latin plural); Gal. *HNH* 2.6 (15.145 K.); Leven 2005, col. 560.

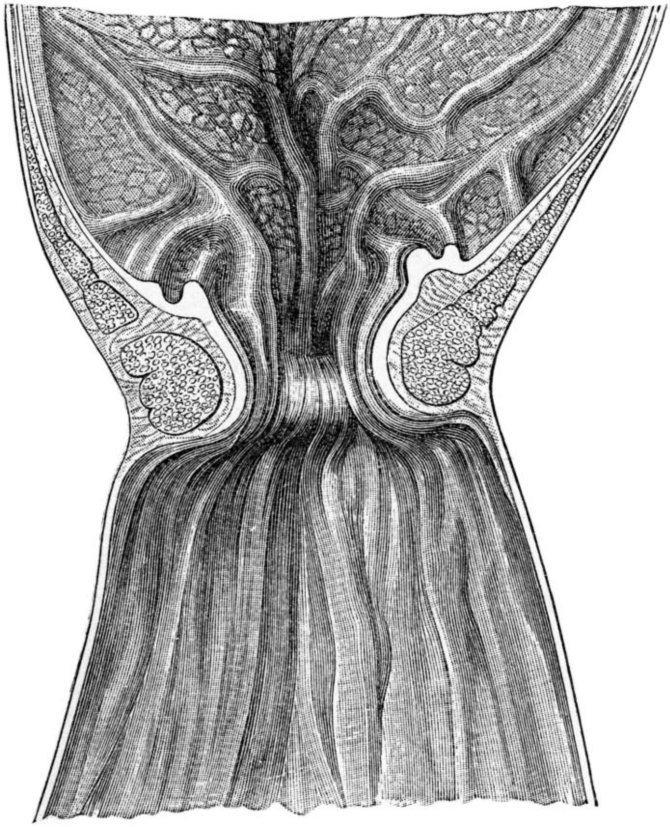

Fig. 4. *Pylorus (Heitzmann 1905, 333, fig. 397; modified by C. van Tilburg).*

medical treatises were written, imparting knowledge of anatomy and physiology; we have to assume that the medical sense of πύλαι is derived from the use in civil engineering.

Closely connected to the πύλαι is the πυλωρός (Lat. *pylorus*), civil engineering: 'gatekeeper', medical: 'pylorus'.[29] City gates must obviously be at least as old as gate keepers – there can be no gate keeper without a gate. The oldest reference as far as we know is found in Aeschylus (5th century BC).[30] In medical terminology, the pylorus is the circular muscle between the stomach and the duodenum (**fig. 4**). The function of the pylorus is to allow a fixed amount of the contents of the bowel to pass through it, on its way to the duodenum. Diocles of Carystus (4th century BC) is the first Greek medical author who mentions the pylorus,[31] followed several centuries later by Celsus, Rufus and Galen.[32] Both Celsus and Rufus make explicit why the cir-

29 Not cited by Beekes; Ruf. *Onom.* 169.3; Poll. 2.208; derived from πύλη, gate and οὖρος, keeper.

30 A. *Th.* 621.

31 Diocles (*Fr.* 109.55 Van der Eijk) mentions only the πυλωρός as 'end of the stomach', without any indication of the functioning of the πυλωρός.

32 Cels. 4.1.7; Ruf. *Onom.* 169; Haak 2013, 212; Ruf. *De partibus corporis humani* 1.42 (Daremberg cular muscle is known as πυλωρός: it works like a gate, opening and closing, letting through a certain amount of the contents of the bowel. Probably the exact function was not yet known in Diocles' time, but he observed its physiognomy: before the πυλωρός, the bowel is already narrowed, and the πυλωρός itself is narrowed again. Some gates have a similar shape, for instance the Porta di Stabia in Pompeii,[33] in order to give access to a certain amount of traffic. Rufus used a monkey as an 'object of research';[34] maybe he had knowledge of the functioning of a monkey's pylorus.

So the civil engineering meaning of the πυλωρός is older than the medical one; in order to protect settlements or cities against invaders, gates had to be equipped with gate-keepers, but the anatomical πυλωρός was only known after the first use of dissection. Galen mentions two other internal organs that are θυροειδής (door- or shield-shaped): the vein passing the pubic bone and a hollow space, where later the thyroid was found. These names could only be used after the inventions of the door and shield.[35]

The πύλαι as well as the πυλωρός are – in contrast to the πεδίον and the κιών – internal parts of the human body, only visible upon (vivi)section. In Hellenistic and Roman Alexandria, dissection of human bodies took place; according to Von Staden, the Alexandrian scientist Herophilus was the first physician who described the liver elaborately.[36] Earlier, Euripides, Plato and Aristoteles mention the πύλαι in a medical context but only after animals were being researched.[37]

Other internal organs, bearing names as parts of the digestion system, where the civil engineering meaning is older than the medical, are ἔξοδος and ὀχετός.

Both in ancient civil engineering and ancient medicine, we find the word ἔξοδος (Lat. *exitus*), 'exit',[38] referring both to the exit itself and to the process of leaving. Used in the context of civil engineering, ἔξοδος means 'exit', 'street door' of a building or city, or part of a gate. The word is used throughout Greek literature; the oldest occurrence (as far as we know) is found in Aeschylus. Its Latin counterpart *exitus*

Ruelle 179); Gal. *UP* 4.7 (3.280 K.); *Nat. Fac.* 3.4 (2.156 K.). In the Hippocratic Corpus, the πυλωρός (now feminine) is only mentioned in the apocryphal *Epistulae* (*Letters*), described as the exit of the uterus, not, therefore, the pylorus: Hipp. *Epist.* 23 (104-105 Smith 1990 = 9.396 L.) (from the 1st century BC); Jouanna 1992, 543.

33 Van Tilburg 2012, 110-113.

34 Haak 2013, 82.

35 Respectively Gal. *AA* 3.13 (2.413-414 K.) and *Nerv. Diss.* 8 (2.839 K.). θυροειδής is derived from θύρα, 'door' (Hom. *Il.* 24.317) and θυρεός, 'stone put against a door' (Hom. *Od.* 9.240) and 'shield' (Plu. *Pyrrh.* 26). The θυροειδής gland, nowadays called the thyroid (Dutch 'schildklier', German 'Schilddrüse'), was discovered by Thomas Wharton in the 17th century. He called it *glandula thyreoidea*; Hyrtl 1880, 547-549.

36 Date *De anatomia*: Jouanna 1992, 530; cf. Craik 2015, 29 (late 5th-4th century BC). Section: Von Staden 1989 *passim*. Liver: Von Staden 1992, 224; Leven, 'Leber' 560.

37 Euripides: see paragraph πύλαι. It is not clear if Plato (*Ti.* 71C) is really referring to the portal vein. According to A. Rivaud (Budé-edition, Paris 1925, 198 n. 3) Plato considers the liver as tripartite, with three entrances. Aristotle refers to πύλαι, mentioning animals' livers. Cutting open animals for sacrifice provides knowledge of anatomy: Arist. *HA* 586b19; *HA* 496b24-25; Gladigow 1995, 346.

38 <ἐξ-ὁδός, 'out-way', not cited by Beekes; not in Rufus; Poll. cites only the use with reference to drama.

(< *ex-ire*) is also used in this way.[39] In the human body there are many exits: at all points where veins, bowels etc. enter or leave an organ, the word ἔξοδος can be used. The oldest references to a medical ἔξοδος are found in the Hippocratic treatises *Epidemiae* (*Epidemics*) and *De diaeta acutorum* (*Regimen in Acute Diseases*) (end 5th century BC). Some passages in Aristotle refer to an ἔξοδος in a medical context in the case of mammals: the anus and the penis.[40] These exits are visible, just as the exits of a building or a city. However, the oldest references in medical contexts are more recent than those in a civil engineering context, especially when referring to internal exits. Mouth, penis, anus and vagina have their own, specific name, in contrast to the exits of buildings and cities and later-discovered exits of the body, all of which had the general name of ἔξοδος.

The last word in this group that I will discuss is ὀχετός, 'duct'.[41] In a civil engineering context, we come across the following references: irrigation pipe (from Herodotus onwards),[42] aqueduct[43] and sewer.[44] All these cases refer to 'duct', or 'fluid transportation pipe'. The Latin word for 'sewer' is *cloaca*, but a *cloaca* does not usually contain clean water, but rather waste water.[45] The supply of clean water (for drinking) is facilitated by means of a *ductus* (*aquae* or *aquarum*, in Late Antiquity *aquaeductus*). In a medical context, the word ὀχετός is used for the discharge of urine and contents of the bowel (after the Hippocratic treatise *De articulis* (*Joints*) end 5th century BC),[46] sweat pore,[47] bronchial tube[48] and vein/artery.[49]

In its civil engineering context, the word refers to ducts or channels where fluids (clean or polluted) stream through. Herodotus must have observed such channels, travelling through Egypt, Palestine and Mesopotamia. In these areas, irrigation was already in use many centuries before medical authors used the word in their treatises; the origin of the word ὀχετός is Indo-European. All medical references involve internal ducts filled with fluids or air, only known after the first use of dissection.

Aretaeus (2nd century AD), in discussing diabetes, compares the disease with a tube system: 'Diabetes is a strange disease, it seldom occurs amongst human beings.

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39 Passages: A. *Th.* 33; exits of a room: Hdt. 2.148; LSJ; exit of a house: Arist. *Pr.* 947a19; *Top.* 103a; (Ps.) Lucianus, *Am.* 42,2; exit of a city: Aen.Tact. 1.5.3. Latin: gate passage: Caes. *Gal.* 7.28.3; exit of a house: Liv. 39.51.5.

40 Hipp. *Epid.* 6.5.1 (240 Smith = 5.314 L.) (air); Jouanna 1992, 537; Craik 2015, 90-91. In physiological context ('outflow') Hipp. *Acut.* (*spur.*) 10.59 (254 Potter = 2.450 no 40 L.); Jouanna 1992, 559; Craik 2015, 6; 34. Animals: Arist. *PA* 675b9; *HA* 507a32; 511a27. Penis (ejaculation): Arist. *HA* 586a15. Latin: Plin. *Nat.* 11.116.

41 Derived from ὀχέω, 'to transport' and ὄχος, 'vehicle'; IE: uógho-; Beekes 2010, 1136; 1138; not cited by Rufus; Poll. 2.217. Ὀχετός has to be translated with *canalis* or *cloaca*, not with *ductus*, as some anatomists did in the early modern period; Hyrtl 1880, 188-192.

42 Hdt. 3.9.3.

43 Th. 6.100.1.

44 Artem. *Onirocriticus* 5.79.2.

45 Plautus refers to the stomach of a drunk woman: Pl. *Cur.* 123.

46 Hipp. *Art.* 48 (306 Withington = 4.216 L.); X. *Mem.* 1.4.6; LSJ.

47 Hipp. *Epid.* 6.3.1 (224 Smith = 5.292 L.).

48 Pl. *Ti.* 70D.

49 Poll. 2.217.

Flesh and bodily parts all flow into urine. As in the case of dropsy, it is caused by damp and cold. Discharge, however, takes place in the usual way via the kidneys and the bladder. The patient urinates continually; moreover, the urine flows away, as if through permanently opened pipes (ὀχετοί)';[50] just as water through an aqueduct.

2.2. Anatomical and physiological terms, used in city planning, traffic and architecture

Besides medical concepts derived from civil engineering and architecture, there are some civil engineering terms and diverse linear measurements in the Graeco-Roman world derived from medical concepts, or names of bodily parts: *dorsum*, κοιλία and δάκτυλος. The civil engineering terms refer to civil engineering phenomena, invented or discovered relatively recently.

The word κοιλία (Lat. *venter*), medical: 'belly', civil engineering: 'curve in a duct'[51] means primarily 'cavity', 'hollow space'; apart from 'belly' it refers to 'intestines' and even 'excrements' from those intestines. The word is used many times in a medical sense from Herodotus onwards, in a medical as well as in a non-medical context.[52] 'Hollow' implies that the cavity can be filled: with food, converted food and fluids.

The use in the context of civil engineering only became common after the development of aqueduct constructions, e.g. by Vitruvius in the eighth book of his work *De Architectura* (*On Architecture*). Here he uses the term *venter* ('belly'); a pipe of an aqueduct running from a slope reaches the bottom of a valley – water must always, inevitably, flow and therefore have a gradient – and the track of the pipe then becomes horizontal (inverted siphon) (**fig. 5**). Vitruvius also mentions the Greek version, *coelia* (κοιλία).[53] The fact that Vitruvius cites this Greek word shows that this concept has a Greek origin. So the use in medical context is older than the use in the context of civil engineering; it seems to be of Indo-European origin.[54] The curve is called 'belly' because it curves from diagonally upwards or downwards to a horizontal track, making a curve which can be filled. Vitruvius speaks of *geniculus*, 'small knee' (**fig. 5**) when the pipe, after crossing the valley, elevates too quickly against the corresponding slope.[55] In both cases, these constructions derive their names from their shape.

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50 Aret. *SD* 2.2.1. Cf. διαβήτης, literally: 'through-walker'.

51 IE k̑eu-lo-, > Dutch 'hol', English 'hollow'; Beekes 2010, 730; Ruf. *Onom.* 95-97; Poll. 2.168.

52 From Herodotus onwards (2.87, where he discusses the embalming process in Egypt); LSJ. Excrements: Hipp. *Aer.* 10 (98 Jones = 2.44 L.). For more references – cavities filled with blood, cerebrum etc. – see Behm 1933-1978, 786; pneuma: Haak 2013, 93 (Gal. *AA* 7.7 [2.605 K.]).

53 Vitr. 8.6.5. For detailed information concerning the construction of an inverted siphon and the use of the word *venter* in relation to Vitruvius see Kessener's article (2001), esp. 148-150; Kessener 2011, 78-79. No Greek texts on aqueduct construction are known to us, so this is the only evidence that this Greek word is used in this context: LSJ does not cite this word in this sense. For the meaning of 'belly' cf. Zola's book *Le ventre de Paris* (1873) about the former market halls in Paris.

54 See *supra*.

55 Vitr. 8.6.6. For a more detailed and technical explanation of the *venter* and *geniculus* see Kessener

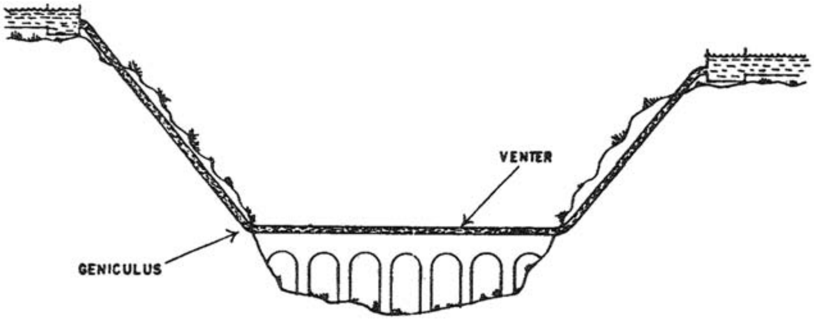

Fig. 5. Venter *and* geniculus *(Hodge 1992, 148; modified by C. van Tilburg).*

In classical Latin prose, the word *dorsum*, 'back, ridge'[56] is only used for the back of an animal; in poetry (and later also in prose), also for the back of a human being; the first occurrence is found in the *Trinummus* (*Three-Dollar Day*) of Plautus. Another meaning of *dorsum* is 'ridge'; in civil engineering 'road pavement'. Of course, this meaning came in use only when roads were equipped with pavements (from the planning and construction of the Via Appia, 312 BC). The first use of *dorsum* in this context is found in Statius, describing the construction of the Via Domitiana under emperor Domitian (81-96 AD).[57] *Dorsum* always refers to a structure in the shape of a flat half cylinder, such as a man's or an animal's back, a road surface or a mountain ridge.

Protagoras' statement 'Man is the measure of all things' is also reflected in several measures of length, derived from parts of the human body:[58]

δάκτυλος	*digitus*	'finger'	
παλαιστή	*palmus*	'palm'	= 4 *digiti*
πούς	*pes*	'foot'	= 4 *palmi*
πῆχυς	*cubitus*	'elbow'	= 1,5 *pedes*

Vitruvius used such linear measures and their proportions in building design. A great disadvantage of using these measures is, of course, their inaccuracy; not everyone's limbs are of the same length. At a later stage they were fixed and calibrated. It was only in the 19th century when many countries chose the metric system (based on the metre) that the former way of measuring, based on the human body, lost its importance.[59]

In short, we may conclude that there are more medical concepts derived from civ-

2001, 148-150 and Nikolic 2008, 15-16, 22-24, 48-50, 63-64 and 72.

56 *Dorsum* is related to the Greek δειρή or δέρη (neck, throat). The first occurrence in Homer: Hom. *Il.* 11.26.

57 Plaut. *Trin.* 719; OLD s.v. 'dorsum'. Ridge: Caes. *Gal.* 7.44. Road surface: Stat. *Silv.* 4.3.44; Van Tilburg 2012, 13-15.

58 Vitr. 3.1.5. Cf. δωδεκαδάκτυλος, *duodenum*; Hyrtl 1880, 192-194; Horstmanshoff 1989, 86; 91.

59 For detailed information concerning measuring, based on the human body see the article of

il engineering concepts than the reverse. The civil engineering terms refer to natural phenomena or human artefacts; they gave their names to the parts of the human body only at a relatively late stage. Of the six words under discussion ἔξοδος, κιών, ὀχετός, πεδίον, πύλαι and πυλωρός, three have a civil engineering name which was already cited by Homer (κιών, πεδίον and πύλαι); two other terms (ἔξοδος and πυλωρός) are in use from Aeschylus onwards (5th century BC) and ὀχετός after Herodotus (5th century BC). However, this word was perhaps already in use before Herodotus.

The corresponding medical terms all date from the end of the 5th century BC when the first Hippocratic treatises were written, except for πεδίον. This word is quite different in the sense that it is the only part of the body featuring on the above mentioned word-list which is not part of the digestive system; πεδίον and κιών are the only parts of the body visible from the exterior. The other parts of the body received their names after the use of dissection, which enabled them to be discovered. Sometimes these internal parts of the body were already known in the case of animals (πύλαι and ἔξοδος) before they were discovered in human bodies, but here again their names were originally derived from civil engineering.

With regard to the group of words where the civil engineering meaning is derived from the medical meaning, we can state that their names are relatively recent: *dorsum* and κοιλία are concepts discovered and invented in civil engineering, in which linear measures play an important role. The parts of the human body which gave their names to these are clearly visible and their medical names go back to ancient history.

2.3. Movements

Finally, I shall now discuss bodily movements and movements in the city (traffic). The concepts discussed above refer to things that move when something passes through it. In the human body as well as in the city, movement is crucial. In the case of blockage because of lack of movement, the bodily and city functions are endangered, as quoted by Goudappel at the beginning of the introduction. How did people regard movement in body and city in the Graeco-Roman world? In my opinion, there are three movements which are easily distinguished: one-way traffic, two-way traffic, and circulation.

In the Graeco-Roman world, one-way and two-way, or return, journeys were well-known. According to ancient perceptions, the digestive tract is a one-way system. As discussed above, many terms referring both to the body and to civil engineering are related to organs which are part of the digestive tract. Evidently, the digestive tract was considered as resembling a traffic highway; food or contents of the bowel travel from mouth to anus.[60] Beyond the stomach, in the intestines, the term is διαχώρημα,[61] meaning literally 'material passing through' in the various stages of

F. Zöllner, 2004, 'Anthropomorphismus in der Architektur von Vitruv bis Le Corbusier', in Neumaier, O. (ed.), *Ist der Mensch das Mass aller Dinge?* Paderborn, 307-344, esp. 313-314 and 331-333.

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

61 Διαχώρημα is derived from διαχωρέω, 'going through'; Hipp. *Vict.* 3.74 (396 Jones = 6.616 L.) (διαχωρέεται). So it is material 'on the road', like traffic. Cf. διαρρέω, 'flowing through', with the cordigestion. It is a one-way journey: material does not usually travel in the opposite direction.[62] For the excretional tract roughly the same story applies.[63]

Some ducts or channels allow return material (e.g. the oesophagus and vagina), but their contents differ. Galen correctly compares the system of blood vessels (supplying foodstuffs) to the irrigation of a garden: channels run from a main source, ending at the most distant parts of the garden where water is absorbed by the surrounding earth and plants, just like an aqueduct system in a Greek or Roman city, which is actually also a type of irrigation.[64] The vessels supply blood to the entire body, with the exception of the outer skin. Inevitably blood also has to return, but the ancient authors are not clear on this topic.[65] Before Galen it was already known that the function of the blood was to supply nutrients. This is shown in the parable of Menenius Agrippa, cited by Livy: after the separation of the plebeians in Rome, the envoy Menenius Agrippa explains that both patricians and plebeians have their own duties and are forced to cooperate with each other like body parts: the stomach feeds the body by means of the blood (*Inde apparuisse ventris quoque haud segne ministerium esse, nec magis ali quam alere eum, reddentem in omnes corporis partes hunc* […] *sanguinem*).[66]

Finally, the circulation. Κυκλοφορία (Lat. *circulatio*), 'circular motion', derived from κύκλος and φέρεσθαι, 'to move in a circle', is used in classical Greek by only two authors: Aristotle and Theophrastus.[67] They refer to circular motions concerning dizziness and heavenly movement. In classical Latin, *circulatio* is a hapax: it is only mentioned by Vitruvius referring to the orbit of Mercury before it returns to its starting point.[68] According to our evidence, then, this concept is only used in the context of perception and cosmic movement.

William Harvey, the discoverer of the circulatory system in the 17th century,[69]

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responding substantive διάρροια, 'diarrhea'. The substantive διαχώρημα is found for the first time in Hipp. *Aph.* 2.14 (110-112 Jones = 4.474 L.), possibly later than *De victu* (according to Jouanna 1992, 531 and 559; according to Craik 2015, 34 and 275 respectively ± 400 BC and late 5th-early 4th century BC) and further only in medical authors. In a similar context the word διαχώρησις is found; Hipp. *Aph.* 2.18 (112 Jones = 4.474 L.), referring to the process, 'excretion'. This word is also used by non-medical authors, e.g. Aristotle: Arist. *PA* 675a22 (animals).

62 Hipp. *Vict.* 3.80 (406-408 Jones = 6.626 L.); Stamatu 2005b, col. 893.

63 Gal. *Nat. Fac.* 1.6 (2.36-37 K.); Stamatu 2005a, col. 379. See 'Opinions concerning Faeces and Urine in the Graeco-Roman World', pp. 107-133.

64 Gal. *Nat. Fac.* 3.15 (2.210-211 K.). Cf. Hipp. *Cord.* 7 (62 Potter = 9.84 L.); Pl. *Ti.* 77C. For blood as fluid supplying foodstuffs see Gal. *Med. Nom.* 102v (Meyerhof & Schacht 1931, 30 ll. 29-30).

65 Van den Berg 1959, 34-35; Leven 2005, col. 169. Scholars have tried to prove that the circulatory system was already known in Antiquity, e.g. with reference to Hippocrates: Hipp. *Loc. Hom.* 1 (18-20 Potter = 6.276 L.), but this view has been refuted; Leven 2005, col. 169.

66 Liv. 2.32.8-12; Demandt 1993, 354; Demandt 1978, 22. The story is also referred to in Shakespeare's *Coriolanus*: Hale 1971, 11-15; 26-28; Brock 2006, 353.

67 E.g. Arist. *Ph.* 223b19 (earth rotation, according to the Loeb edition of Wicksteed and Cornford 1929, 423); Thphr. *Vert.* 8.9-10 (dizziness); *Metaph.* 5b28 (movement of the cosmos; Van Raalte 1993, 237-238).

68 Vitr. 9.1.8.

69 Plato writes in *Ti.* 70B: περιφερομένου κατὰ πάντα τὰ μέλη σφοδρῶς αἵματος, 'the blood flows firmly around through all members'. It is tempting to consider Plato as the discoverer of the circulatory system. Galen cites this four times (*Foet. Form.* 3 [4.672.1 and 4 K.] *PHP* 3.1.31 [5.292 K.] and 6.8

did not then use the term *circulatio*; in chapter IX of his work *Exercitatio anatomica de motu cordis et sanguinis in animalibus* (or, in short, *De motu cordis*)[70] he uses the word *circuitus*, 'circuit' (*Esse sanguinis circuitum*). In 1630 however, Primerose uses the words *circulatio sanguinis* in an apology to Harvey (in the title), and we find this word again in later writings concerning the circulatory system.[71] C*irculatio* (*sanguinis*) is therefore a Neo-Latin word;[72] and although already used in Antiquity, it was never used in a blood circulatory context. According to Pulkkinen, Harvey considers the heart as a pump and the circulatory system as a hydraulic system; blood vessels are compared (through a metaphor) to 'transportation' roads.[73] Civil engineering items such as pumps and hydraulics, then, were well-known amongst Early Modern physicians.

In ancient physiology therefore, the phenomenon of 'circular movement' was unknown, in contrast to one-way and return journeys. But did these terms apply to Graeco-Roman traffic? Neither the Greek nor the Latin language used the words κυκλοφορία and *circulatio* to indicate traffic circulation.[74] Nowadays we use the word 'traffic circulation' as a metaphor in city planning, like the words 'traffic congestion'[75] and 'artery', derived from the circulatory system. In a city, traffic makes a circular movement.[76]

Nevertheless, in the Graeco-Roman world the phenomena 'one-way traffic', 'return' and 'circulation' must have been known in city planning, although we do not

[5.575 K.]. According to Taylor (1928, 502-503), the functioning of veins and arteries was not yet known and Galen's notion that the liver was the source of blood instead of the heart (Van den Berg 1959, 34-35), was wishful thinking ('He [sc. Galen, CvT] assumes that Plato shared his view', cites Taylor at p. 503). In the early modern period, Spinoza, *Ethica* 4.39 (1677) and A.G. Baumgarten, *Aesthetica* I.23.338 (1750-1758) refer to this passage of Plato and the *circulatio sanguinis*. Cf. Hipp. *Loc. Hom.* 1 (18-20 Potter; 6.276 L.), where the author states that the human body is cyclic by nature. In his article (p. 45), Asper translates αἱμάτωσις in Galen's treatise *In Hippocratis de Natura Hominis* (*Commentary on Hippocrates' 'Nature of Man'*) 3.10 (15.191 K.) wrongly with 'blood circulation'. The correct translation is 'changing into blood' (LSJ s.v. αἱμάτωσις). See also for the refutation Leven 2005, col. 169.

70 Published in 1628; Scarborough 1992, 213-216; 228.

71 Primerose: *Exercitationes et animadversiones in librum de motu cordis et circulatione sanguinis adversus Guilielmum Harveum*. London 1630. Harvey, to Jean Riolan: *Exercitatio anatomica de circulatione sanquinis* (sic)*: ad Joannem Riolanum filium Parisiensem, medicum peritissimum anatomicorũ coryphæum, in Academia Parisiensi Anatomes & Herbariæ Professorem Regium & egregium atque decanum, Reginæ matris Lodovici XIII medicum primarium*, Cambridge 1649; Wear 2004, 835.

72 WNT. The Dutch word 'circulatie' is derived from the French 'circulation'. In the sense of 'blood circulation' it is found – as far as we know – for the first time in 1699 ('Anders zou de stremmende kou der hooge jaren de circulatie van haar bloed al eer gestolt hebben'). http://gtb.inl.nl/iWDB/search?actie=article&wdb=WNT&id=M012715&lemmodern=circulatie.

73 According to Horstmanshoff, Erasistratus already considered the heart as a pump; Horstmanshoff 1989, 92. Blood as hydraulic system: Pulkkinen 2008, 278-282. Transport system: Kalff 2012, 178.

74 The Latin term *commeatus* refers to separate movements, not to traffic as a whole; OLD.

75 See *infra*.

76 'Circulation' refers to a 'circular movement', a 'point to which one returns to'. The origin of the English 'traffic' and French 'trafic' (for the English forms of 'traffic' see from ± 1500 onwards *Oxford English Dictionary* 1989^2 s.v. 'traffic') is – according to many etymological dictionaries – unknown, but in my opinion it is possible that it is related to the Latin verb *transvehere*, 'to convey over', 'to transport'. It suggests here a 'one-way' direction, traffic goes in one direction only, so there is no circulation movement.

find the words in this context. In many cities, streets were narrow and in Pompeii for example, one-way traffic was common. Cities which were founded later, for example Xanten, had wider streets where two-way traffic was normal. Governments had to control traffic circulation by means of legislation, even if the streets were too narrow.

At no point should traffic flow be blocked or even hampered. If it happens, the existence of body and city comes into danger. Nowadays, if the city centre (in Dutch: 'stadshart', 'city heart') or the artery is unable to cope with traffic flow, we call it 'traffic congestion'[77] and 'traffic infarct',[78] threatening the existence of the city. In the Graeco-Roman world these phenomena were recognised, as shown by the measures taken to control traffic. [79]

Conclusion

It may be assumed that visible objects in nature or those built or installed by man, such as plains, gates and gate-keepers, already had a name before these were written down. In this introduction I have discussed six Greek words: ἔξοδος, κιών, ὀχετός, πεδίον, πύλαι and πυλωρός. Except for πεδίον, they also refer to civil engineering and architectural matters; in the case of πυλωρός, it is obvious that without the gate, there cannot be a gatekeeper at all.

From the 5th century BC onwards, new (internal) parts of the human body were continually being discovered and these needed a name. These names were derived from concepts already known, from macrocosm, on the basis of their appearance, and applied to microcosm. A portal vein evokes the image of an approaching road. This medical terminology is found from the end of the 5th century and the beginning

77 'Congestion' is derived from *congestio*, 'heaping up': *terrae congestio* (Vitr. 6.8.5). In the *Gesta Collationis Carthaginiensis* (411 AD) there is talk of *congestio populorum*. In medicine, in French it is mentioned ± 1370; in English ('congestion') ± 1634; in Dutch in 1624 in Dodonaeus' *Ars Medica* ('Abnormale opeenhooping van bloed') in a certain organ or tissue. As far as we know, in a traffic context, it is mentioned in English for the first time in 1883 ('congestion of traffic'; *Oxford English Dictionary* 1989[2]); in Dutch after 1970 (*Maritieme Encyclopedie* 2, 70 *b*); WNT. Also here it is compared with blood circulation; cf. Goudappel's observation at the beginning of this introduction.

78 'Infarct' is derived from *infarcire* or *infercire*, 'to stuff into' (Cic. *Or.* 69.231). In modern Latin we find the word *infarctus*, from which derive the French 'infarctus', English 'infarct' and 'infarction', German 'Infarkt' and Dutch 'infarct' (all 19th century), meaning 'obstructions in the lower part of the body, hardening of faeces'; nowadays the term is used for 'partial or total blockage of blood supply, causing degeneration of texture'. In traffic terminology, the word 'traffic infarct' is used only in the last decades – in the Dutch dictionary of Van Dale (1970[9]) it is not yet mentioned, but Goudappel uses the word 'congestie' (congestion). For the first time in a Dutch dictionary, it is mentioned in the Van Dale 1999[13] edition; according to an article in the Dutch newspaper *NRC* 11 January 2010, the first citation of 'verkeersinfarct' ('traffic infarct') is dated 3 August 1990, stressed by quotation marks; in the *Handelingen van de Tweede Kamer der Staten-Generaal* (*Proceedings of the Dutch Lower House of the States-General*), dated 19 December 1990, the word is used again, between quotation marks too. In German, 'Verkehrsinfarkt' was used earlier: http://weblogs.nrc.nl/woordhoek/2010/01/11/een-verkeersinfarct-tussen-guillemets. The term is strictly incorrect; a (medical) infarct is not the blockage itself, but the dying of an organ caused by the blockage. Sometimes infrastructure is too wide because traffic has decreased. Goudappel states that public transport was the victim of anaemia caused by the increased use of cars: Steÿn 2010, 42.

79 Especially the *Lex Julia Municipalis*, and other laws; Van Tilburg 2012, 128-136.

of the 4th century BC onwards, at the time that these concepts were written down; in other words, later than the civil engineering concepts. Some organs were already known by means of dissections on animals (which was reported in literature), such as the portal vein (monkeys were used as objects of research). Five of the six above-mentioned words refer to organs which are part of the digestive tract and four of these are internal, so invisible from the exterior (the fifth, the κιών, is almost visible). From macrocosm to microcosm.

From the 6th century BC onwards, new civil engineering constructions were being invented and utilised. Here the reverse took place: they obviously needed names and these names were derived from the names of parts of the human body. The linear measures, the κοιλία of the aqueduct and the *dorsum* of the road, came into existence. They are static, except for κοιλία; this concept refers again to the digestive tract and is dynamic. From microcosm to macrocosm.

It was relatively easy to acquire knowledge of anatomy by means of dissections on animals throughout history, and in Hellenistic Alexandria dissection on humans took place. During physiological research, the idea arose that movements in the body followed one-way routes (digestion and excretion tracts) or return-routes (the blood vessel system).

Unfortunately, there is little information on traffic in the Graeco-Roman period. There are no Greek or Latin words for 'one-way' or 'return', or 'traffic' in a general sense. Excavations, some statements in literature and in legislation prove that busy traffic was a problem in certain places and traffic control measures were needed. If the French and English words 'trafic' and 'traffic' are indeed derived from the Latin *transvehere* or *transvehi*, 'to convey over' or 'to transport', they refer to a 'one-way system'. The Dutch and German words 'verkeer' and 'Verkehr' refer to a 'return'. Neither in medicine, nor in civil engineering, ancient terms for 'circulation' or 'circuit' were in use, although the words κυκλοφορία and *circulatio* were used for different purposes.

Blood as the supplier of nutrients was already known in Antiquity, as is shown by the parable of Menenius Agrippa, but the *circulation* of blood was unknown at that time. It was only in the 17th century that this was discovered by William Harvey. From that time onwards, the idea arose that traffic flow in a city can be better compared with the circulatory system than with the digestive and excretion tracts, where 'one-way traffic' prevails. Terms concerning traffic which arose from the 19th century onwards and are still in use today, refer rather to the circulatory system: traffic circulation, traffic congestion, traffic infarct, artery, and bypass. Blood flow is crucial for the functioning of the human body, even more important than the flow of the contents of the bowel, or urinary flow.

Modern city planning and modern medicine are based on modern ideas and theories (from the 19th century onwards) – where medicine and city planning influenced each other; they are not based on ancient ideas and theories, but developed over a recent period. Nowadays, too, medical and civil engineering terms intermingle: the 'eye of the camera', 'he has a screw loose'. There is also the awareness that a city as well as a body always is in motion and should always remain in motion. I will end this introduction by citing Goudappel again:

‘We should be aware that what has been said above concerning traffic is only part of the entire field of what we call communication and its most evident sonsequence: mobility. This *mobilitas*, mobility and variability, is the characteristic and even the condition for the existence of everything, in nature as well as in human culture. In all movements, there is a fusion of space and time. This mobility is expressed in what has been recognised as the human condition ever since Heraclitus: *Panta Rhei*: everything is in motion and has to be in motion. It is the basis of what we call development.’[80]

80 Goudappel, cited by Steÿn 2010, 7-8; translated by the author.

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Overview of the Chapters

In this volume, six questions on the subject of infrastructure will be discussed: two concerning the infrastructures of cities, two of them will discuss the infrastructure of human bodies and their constituents, and two concern the relationship between city infrastructure and bodily health.

The most important similarity between both infrastructures is that both have to function in order to survive. No stream should ever be blocked or even hampered. If this does happen, the survival of body and city is endangered. If city waste cannot be discharged and is allowed to accumulate, people become sick – in the same way as vital organs become sick if within the human body congestion occurs. If a city (or state) is no longer accessible, the economy decreases and finally collapses, in the same way as a human being dies when air, food or fluids are no longer available.

To prevent traffic infarcts in the Graeco-Roman world, attempts were made, while leaving the infrastructure unchanged, to control traffic by means of the establishment of fixed routes. The majority of streets in Pompeii is only suitable for one-way traffic. Some thoroughfares allow return (two-way) traffic, but the blood vessel system allows only one-way traffic; Galen compared it to a garden irrigation system.[1] Later Roman towns, planned with a grid pattern, e.g. Xanten, were equipped with a larger infrastructure, able to cope with larger traffic flow, with more (and wider) city gates. Even compared to our modern roads today, the traffic-infrastructure in these settlements was very extensive.[2]

Ancient Xanten, however, did not survive as a large city – partly due to the Germanic invasions, but more importantly because the main approaching artery, the river Rhine, became silted up with sand because the city was situated on a convex bank.[3] The Dutch city of Nijmegen, close to Xanten, survived because this city was

1 Gal. *Nat. Fac.* 3.13 (2.187-189 and 197-198 K.).
2 See 'Traffic Policy and Circulation in Roman Cities', pp. 29-51.
3 When a river has an outside bend, the bank inevitably has a convex bank. People often speak of 'a

situated on an outside bend of the river Waal. More or less the same story applies to Tongeren and Maastricht: Maastricht arose as a city because the road system to Tongeren declined. The majority of cities which are nowadays in ruins were deserted by their inhabitants because the infrastructure was insufficient and trade started using other routes, e.g. in the case of Ephesus, Leptis Magna,[4] Dorestad and Bruges.

City gates play a crucial role. A city government could choose whether or not to build a defence system and if they did, they had to choose whether they wished to restrict the number of city gates and their passages, or not. A city equipped with many gates and wide passages was traffic-friendly but also vulnerable in times of war. A city with fewer gates and passages, on the other hand, was safer in wartime but there was more traffic congestion around the gates. However, even in the latter situation traffic always had to be in motion.[5]

Apart from their traffic infrastructure, Greek and Roman towns were equipped with two other types of infrastructure that played an important role: pipelines for the supply of fresh water and for sewage. Even more than in the case of traffic, strong similarities between city and body may be observed. City and body need a continuous supply of water. In a city, water flows through its own infrastructure, almost entirely invisible, in the Graeco-Roman world as well as in our modern cities. Only taps and fountains are visible, where the inhabitants tapped off their drinking-water. In the city, the quality and quantity of the fresh water supply and the maintenance of its infrastructure demand the permanent attention of the city authorities; physicians recommend the drinking of sufficient, high quality fresh water. Not only people but also cities can die from dehydration; the final collapse of Rome from the 6th century AD onwards was not only caused by the deterioration of the road system, but also by the aqueducts being demolished by the Ostrogothic king Totila.[6]

A similar situation arises with regard to the discharge of waste-products, particularly of faeces and urine. Much of this was recycled – in agriculture, industry and pharmacy – but the supply exceeded the demand. In the Graeco-Roman world the quantity of faeces must have been a problem, not only because of the stench, but also because of the amount of it. In Rome, wagons exporting excrement were exempted from the rule of driving in the city by day only. The discharge of faeces, in exiting the body as well as the city, was and is a crucial factor in keeping the quality of life under control.[7]

The theme of the last two chapters is the influence of city planning (including the infrastructure) on the quality of life. The first of these has a strong relation to the connection with the preceding chapter on faeces: it deals with the problems of city authorities confronted with the efficient discharge of human waste-products. Not

city, situated on a convex bank', but the river makes an outside bend. A comparable situation can be found in the case of Rotterdam and Schiedam, situated respectively along the outside bend of a river (bank convex bank) and a river convex bank (bank outside bend).

4 For silting up in Antiquity see Thommen 28-30.

5 See 'Gates, Suburbs and Traffic in the Roman Empire', pp. 53-81.

6 See 'Greek and Roman Ideas on Healthy Drinking-water in Theory and Practice', pp. 85-106.

7 See 'Opinions concerning Faeces and Urine in the Graeco-Roman World', pp. 107-133.

only in the Graeco-Roman world, but throughout history these problems had to be tackled. In the 19th century in many Dutch cities and villages there was a 'sewage collapse', e.g. in Gouda, where the canal water level was lower than in the neighbouring IJssel river, into which polluted canal water actually had to be drained. Faeces and other human waste were thrown into the canals, without restriction, endangering public health.[8]

Finally, the last chapter deals with the quality of life in a city in a meteorological context. In order for people to want to inhabit a city, it must be attractive: not only in socio-economic respect, but it should be situated also in a healthy and pleasant environment. Just as a human body, a city needs fresh air and sunshine, and both have to be able to withstand extreme temperatures and polluted air as far as possible. Not only nowadays but also in the Graeco-Roman world, city planning played an important role here. In Antiquity, buildings and even cities were sometimes badly planned, making them difficult to live in. In some exceptional cases, situations were improved, for instance through the measures taken by Terentius Varro to improve the health of patients in a sick-room. Cities as well as human bodies are likely to deteriorate from lack of sunshine or exposure to pollution, causing lowered resistance and even death.[9]

8 See 'A "Healthy Mistake": The Excrement Problem from Ancient Greece to Nineteenth Century Holland', pp. 137-157.

9 See 'A Good Place to Be: Meteorological and Medical Conditions in Ancient Cities', pp. 159-177.

I. CITY AND TRAFFIC

Traffic Policy and Circulation in Roman Cities

Context

In 2007, I published *Traffic and Congestion in the Roman Empire* (second edition 2012). This book was the reason for the CASA/KVSA (Classical Association of South Africa/Klassieke Vereniging van Suid-Afrika) to invite me to present a paper, entitled 'Traffic Policy in Roman Cities', at the biennial conference 'Aspects of Empire', 2-5 July 2007, held at the University of Cape Town. This paper was the basis of the following chapter.

Since then, more books and articles on this theme have been published.[1] However, the majority of these articles are restricted to the situation in Pompeii, the best preserved ancient Roman city. In 2011, however, a volume was published by R. Laurence and D.J. Newsome, in which – besides Pompeii – traffic aspects of Rome and Ostia are discussed.[2] For a positive review see R. Benefiel (2012): 'this is a beautifully produced book that moves its reader onto and through the streets of the Roman city'.[3] However, I agree with a more critical opinion by M. Anderson (2013). Anderson criticises amongst others the lack of attention to other topics than the urban contexts: 'Throughout the volume, the scale of analysis is exclusively that of the city as a whole and its infrastructure. Research dedicated to movement inside domestic structures or areas outside of the public or commercial environment is curiously absent, a lack felt all the more acutely given the particular cities under scrutiny […] The contributors generally appear not to have read one another's contributions, so that key points of argument are introduced multiple times'.[4]

1 Tilburg, C. van. 2005 (second revised edition 2014), Poehler, E. 2001, 2003, 2005, 2006, 2011a and b, Laurence, R. 2008, Newsome, D. 2009, Kaiser, A. 2011a and b (see Bibliography).

2 Laurence, R. & Newsome, D.J. (eds). 2011. *Rome, Ostia, Pompeii: Movement and space*. Oxford.

3 Benefiel, R. 2012. *Sehepunkte* 12, 7-8, http://www.sehepunkte.de/2012/07/21065.html.

4 Anderson, M. 2013. *American Journal of Archaeology* 117, 4, http://www.ajaonline.org/online-review-book/1683.

Traffic Policy and Circulation in Roman Cities

Abstract [149]
The Roman road-system (including urban street systems) is one of the most famous features of the Roman Empire. In cities, especially the older and smaller ones such as Pompeii, streets were narrower and not always suitable for (wheeled) two-way traffic or (wheeled) traffic at all; in later Hippodamic *coloniae* – as found in Western Europe like Xanten and Trier – streets were wide enough to cope with traffic. Local governments tried to keep traffic flow under control by means of legislation and creating fixed traffic circulation, including zigzag and parallel routes, and routes around the forum. The forum itself was never accessible for wheeled traffic, only for pedestrians.

Introduction

Throughout history, research into ancient Roman traffic circulation was an 'untrodden path'. The famous stepping stones and wheel ruts in Pompeii, now typical touristic features, were for a long time not considered worthy of more detailed research. In 1991, the Japanese author Tsujimura published an article 'Ruts in Pompeii', but only after 2000 more information on this theme became available, when Poehler,[1] Van Tilburg,[2] Laurence,[3] Newsome[4] and Kaiser,[5] among others, published books and articles concerning traffic in this well preserved city.

Nowadays there is a growing interest in traffic, traffic circulation and congestion and even blocked arteries in other ancient, less well preserved Roman cities. Was the [150]
traffic circulation here comparable with that of Pompeii or was it quite different? New

1 Poehler 2001, 2003, 2005, 2006, 2011a and b.
2 Van Tilburg 2005 (second revised edition 2014), 2007 and 2008.
3 Laurence 2008.
4 Newsome 2009.
5 Kaiser 2011a and b.

research shows evidence that here, too, fixed traffic routes, which road users were encouraged to follow, were quite usual.

Two cities in particular will be discussed: Pompeii and Xanten. These are both Roman cities, but their identities and features differ, as well as their infrastructures and traffic circulation. However, there are also similarities. In this chapter, I shall attempt to demonstrate the similarities and differences, and their backgrounds. The chapter will conclude with some aspects of town planning and traffic, particularly the infrastructure around fora and their corresponding traffic flow.

1. Pompeii: an old city built against the slope of a volcano

When Pompeii was destroyed in AD 79, the city was already six centuries old. Pompeii was probably founded in the 6th century BC as an Oscan settlement. This settlement (*Altstadt*) is still visible in the regions VII and VIII. In the 5th century, the city was extended to the north, region VI today. In the 4th century, the final and largest extension was built: the Samnitic extension east of the new *cardo* between Porta del Vesuvio and Porta di Stabia. The Forum, the centre of the Oscan settlement, remained in its original situation; a new Forum was not built at the intersection of the new *cardo* and *decumanus.* A reason for this is perhaps that the existing Forum was situated on a running-down slope, facilitating drainage. This street-plan remained unaltered right up until Pompeii's destruction in AD 79.

1a. The street system of Pompeii

The three above-mentioned extension phases correspond with the street system. The oldest Oscan region, regions VII and VIII today, had a relatively irregular street pattern. Some streets were even winding, such as Via degli Augustali and Vicolo del Lupanare. Region VI has straight streets, running parallel with each other (apart from Via Consolare), but the corners are not at right angles; there are sharp as well as obtuse corners, and the *insulae* are diamond-shaped. Only the section to the east of the *cardo* (the Samnitic extension) shows the typical Graeco-Roman Hippodamic grid with right-angled corners and parallel-running streets. Only this part of the city
[151] incorporated thoroughfares, wide enough for two-way traffic: Via dell'Abbondanza, Via di Nola and Via di Stabia.[6] Via Consolare could also, partially, function as a two-way street.[7]

1b. Traffic circulation in Pompeii

Tsujimura and Wallace-Hadrill have mapped the street system with the varying depths of street ruts: deep, shallow, faint or none at all **(fig. 1a and 1b)**.[8] According to

6 Tsujimura 1991, 62; Van Tilburg 2012, 137.
7 Tsujimura 1991, 62.
8 Tsujimura 1991, 64; Wallace-Hadrill 1995, 49; Van Tilburg 2012, 141; Laurence 2008, 92.

Fig. 1a. *Pompeii: streets,* regiones *and* insulae *(Laurence 1994/1996, 2).*

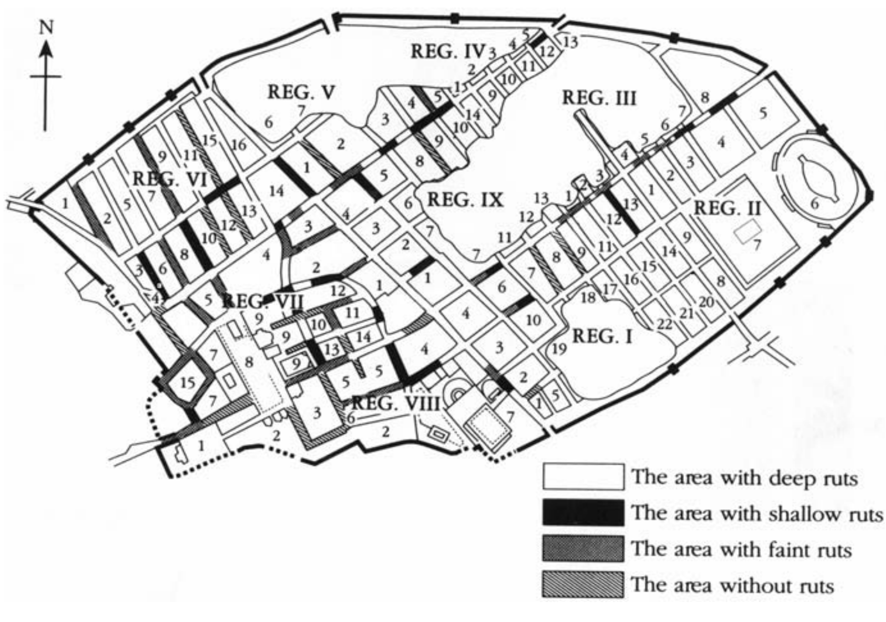

Fig. 1b. *Pompeii, plan with ruts (Wallace-Hadrill 1995, 49, referring to Tsujimura 1991, 64).*

present-day knowledge on this theme, it can be stated that east of the *cardo* the majority of streets have deep ruts; west of the *cardo* the street ruts have varying depths and sometimes no ruts at all.

The entire system of mainly one-way streets, blocked streets, closed streets, deep and/or shallow ruts show that traffic flow was not unrestricted, but that it followed fixed routes. These routes, however, could be altered by the local government or a

[152] group of civilians.[9] An example of a completely blocked street is Vicolo di Tesmo.[10]

At the time of the volcanic eruption there were many building and restoration activities going on; not only in the Forum, but also along the pavements of certain streets. A lot of research has been done over the last few years concerning traffic flow, particularly in the regions VI and VII.[11] At the corner of Via Consolare and Vicolo del Farmacista, a road section was repaved. Also along other streets in region VI, for instance Vicolo del Fauno to the west of the House of the Faun, there do not appear to be any ruts at all; here also it is evident that part of the street had been repaved.[12] In other sections of region VI, traces of wear on stepping-stones, curb stones and corners indicate that the driving direction along Vicolo di Mercurio had been changed from eastbound to westbound (according to Poehler)[13] – this street was a one-way street. More evidence that the street was planned for eastbound traffic is the street profile: every section of the street between two intersections has been widened slightly to the east; the widest part of the street section is the point just before the intersection, where the view was the best. Directly east of the intersection, the street section was narrowed again.[14]

[153] So traces of wear on stepping-stones and curb stones do not only indicate traffic intensity on the spot, but also the direction of the traffic. According to this information, traffic flow in the end-phase on the street section Porta di Ercolano – Via delle Terme (also region VI) can be determined: entering traffic, coming from Porta di Ercolano, drove along the route Via Consolare – Via delle Terme, but exiting traffic was able to use the route Via delle Terme – Vicolo di Modesto – Vicolo di Mercurio – Via Consolare. Unfortunately, it is uncertain whether this route was used frequently: one had to take a sharp bend to the left at the intersection Vicolo di Modesto-Vicolo di Mercurio, and the cornerstones at the south-west and south-east side of this intersection have disappeared. Sharp bends were unpopular, as will be discussed below.[15] In region VII, the street system west of the Forum changed from a clearly-structured one into a chaotic one.[16]

The depths of the ruts were not only created by the volume of traffic. Rainshowers and the constant flow of fountain water wore out the ruts further. Very remarkable are the ruts in Via degli Augustali; one can speak here of a 'railway' **(fig. 2)**. It would be almost impossible for carts driving along a street to cause a rut with such sharp edges by wearing down the pavement; two carts could never follow the same track exactly. When passing stepping-stones they would do so, but in this situation there is in my opinion only one explanation: the ruts here must have been created by road

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9 Van Tilburg 2012, 142; Kaiser 2011a, 95; 2011b, 179-180; 189-190.

10 Van Tilburg 2012, 139; Laurence 2008, 90; Poehler 2011a, 161.

11 Region VI: Poehler 2006, 53-74 and further his internet publications. Region VII: Newsome 2009, 121-142; Kaiser 2011a, 96; Kaiser 2011b, 180 for both regions.

12 Poehler 2005.

13 Poehler 2005.

14 Poehler 2005.

15 Poehler 2003; Kaiser 2011b, 177; 181.

16 Newsome 2009, 124-126.

Fig. 2. *Pompeii, 'railway' in Via degli Augustali (photo C. van Tilburg).*

menders. This hypothesis also dispels the problem of the extremely dense and also extremely orderly traffic flow; the depth has not been caused by carts, but by pick-axes. It must also have been more comfortable for the cart drivers while passing the stepping-stones. Such a 'railway' has also been found in Eleusis (Greece), where tracks in the road surface were cut out in order to prevent the jostling of the statues of the gods during processions. More evidence that these ruts were cut out manually is their sudden interruption some metres past the stepping stone; maybe the 'cutting-out' project along this street was not yet finished when the eruption took place. [154]

The ruts and worn cornerstones prove that wheeled traffic in Pompeii must have been intensive; in combination with the mainly one-way streets, there must have been a lot of conflict going on among road-users. At present nothing is known about rights of way.[17] According to Poehler, road users drove on the right in Pompeii. However, in Britain road users seem to have driven on the left, as proved by worn ruts in a quarry mine in the neighbourhood of Blunsdon Ridge, Swindon, between Oxford and Bristol.[18]

17 Van Tilburg 2012, 137; Kaiser 2011a, 73, 96 and 221 note 33.
18 Right-hand driving in Pompeii: Poehler 2005; left-hand driving in Britain: Van Tilburg 2012, 124 and 206 (n. 862).

Fig. 3. *Parking place at Via di Lupanare (photo C. van Tilburg).*

Another theme not yet mentioned is the parking problem. Poehler, having researched parking facilities in Pompeii, identified 36 ramps, for instance at Vicolo del Lupanare **(fig. 3),** mainly giving access to a stable for parking cart(s) and animals; most of them are constructed for commercial destinations. Among them are a lot of inns, mainly situated in the neighbourhood of the city gates. The number of ramps in front of private houses is far lower, indicating that wheeled transport was mainly used for cargo transport.[19] Another parking place, for building material transport on
[155] behalf of the reconstruction of the Forum, was at the end of Vicolo del Balcone Pensile, south of the Macellum.[20]

Due to the fact that it was almost impossible for an animal to walk backwards

19 Poehler 2011b, 197-202; 210-211.
20 Poehler 2011a, 154.

Fig. 4. *Pompeii, barricade (Wallace-Hadrill 1995, 48).*

when facing oncoming traffic, fixed routes had to be followed, or someone had to precede the animal and/or cart, giving a sign (at a side street) that the street was clear.[21] Illegally blocking a road or street could cause big problems. We do not have any information concerning the blocking of streets or the hindering of traffic in Pompeii outside legal rights, but in the southern Spanish city of Urso, there was a fine of 1000 sesterces for doing so.[22]

1c. Obtuse corners in Pompeii

The aforementioned information tells us that Pompeii had a very dynamic traffic flow. Streets were regularly maintained, barricades were common and wheeled traffic was mainly one-way. The presence of traffic signs is doubtful; as far as we know, no [156]
traffic sign has been found. However, as shown by the (worn) ruts and curb stones, we can see that traffic made significantly more use of obtuse corners than sharp ones.[23] A significant example of an 'obtuse cornered-route' is the detour which traffic was forced to take because of the barricade at the intersection of Via dell'Abbondanza and Via di Stabia (**fig. 4**).

This intersection must have been, in its original situation, the busiest point in the

21 Van Tilburg 2005, 141; Kaiser 2011b, 191.

22 *Lex Coloniae Genetivae Juliae* CIIII (*CIL* I^2 594) *ne quis limites decumanos opsaeptos* […] *sestertios mille*, 'no person shall have the said boundary roads or cross roads blocked up […] 1,000 sesterces'; Van Tilburg 2012, 131-132.

23 Van Tilburg 2012, 138-141; Kaiser 2011a, 94.

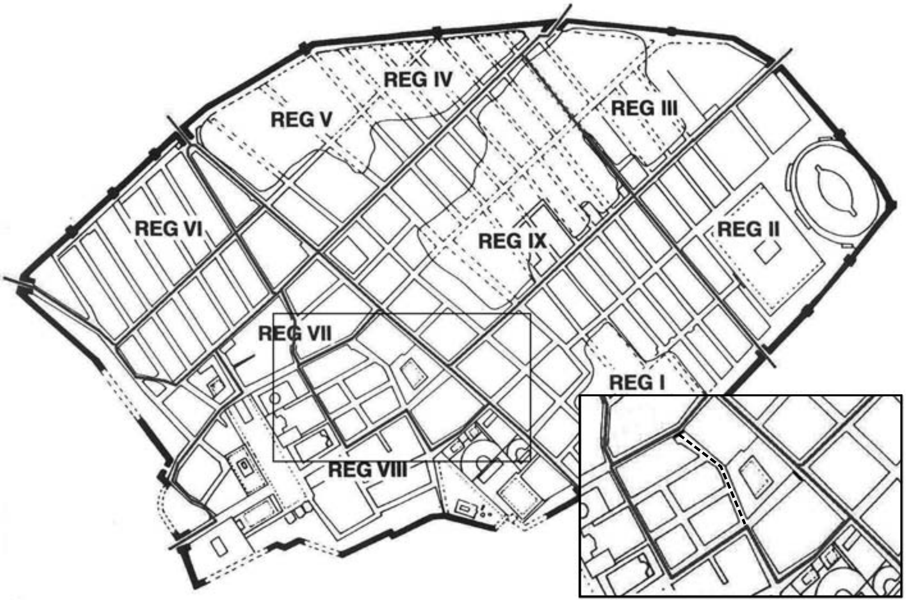

Fig. 5. *Pompeii, detour (Coarelli 2002, 28, modified by C. van Tilburg; Van Tilburg 2012, 142).*

city. Via dell'Abbondanza widens between Vicolo del Lupanare and Via di Stabia; east of the intersection the street narrows as far as Porta di Sarno. Instead of building a new forum, the government chose to erect a barricade and to close off Via dell'Abbondanza for wheeled traffic. Wheeled traffic coming from Porta di Stabia with Porta di Nola as destination was able to turn right into Via dell'Abbondanza, but the detour past obtuse corners – although it took considerably longer – was preferred.[24] Traffic was also able to use Via di Lupanare, but after the closing of this street, this route was no longer in use (**fig. 5**).

[157] In region VI, too, obtuse corners have been found showing considerable wear on the curb stones. However, some sharp corners with worn sidewalk cornerstones have also been found, but the majority of them at obtuse corners.[25] Presumably there was a fixed route system in use which the road-users kept to.

2. Xanten: a new city in a flat region

The city Colonia Ulpia Traiana (further named simply 'Xanten'), which is situated today next to the mediaeval city of Xanten, close to the Dutch frontier, is a completely different city. The region was conquered by Julius Caesar, but it was during the

24 According to the map of Tsujimura (1991, 64); Van Tilburg 2005, 141; Poehler 2011b, 194-195.

25 Via Consolare – Vicolo di Mercurio (north east), Vicolo di Modesto – Vicolo di Mercurio (north west), Via di Mercurio – Vicolo di Mercurio (north west and south east), Vicolo di Vettii – Vicolo di Mercurio (north west) etc. For an overview of all corners in Vicolo di Mercurio see Poehler 2005 and 2006, *passim*.

reign of Emperor Augustus that the first Roman settlements were founded here: the military settlements Castra Vetera and Vetera II. There was no Roman city yet; it was in AD 98 that the city was founded by Emperor Trajan and acquired the status of *colonia*. It is the most northerly *colonia* of the continent. The city was planned and designed as a complete entity and did not have the history and gradual development of Pompeii in the form of extensions and lengthening of streets. Due to the fact that the city was built in a flat region, differences in height did not play a significant role; [158]
drinking-water was supplied by an aqueduct coming from a nearby hill, and waste water drained away into the Rhine.

2a. The street system of Xanten

At first sight, Xanten has the typical features of a Roman *colonia*: a chessboard grid plan, a striking *cardo* and *decumanus* including a forum at their intersection, a city wall equipped with towers at regular distances from each other, as well as the usual facilities of a normal Roman city: temples, baths and an amphitheatre (**fig. 6**).

However, looking more meticulously at the map, some discrepancies are visible. To the south-west of the *cardo*, the *colonia* seems, indeed, perfectly symmetrical: the *insulae* are absolutely square and the corners where the streets intersect are all right-angled. To the north-east of the *cardo*, however, such *insulae* are less commonplace: except for the *insulae* 24, 25 (Forum), 26 (Capitol) and 27, all *insulae* are rectangular or irregular. These irregularities are caused by the following factors: firstly, the city wall between Vetera-Tor and the amphitheatre shows a slight deviation in rela- [159]
tion to the city wall south-west of Vetera-Tor; secondly, the street between the *insulae* 35 and 40 (amphitheatre) runs at a diagonal; thirdly, the Rhine bank also runs diagonally in relation to the *cardo*, so inevitably, sharp and obtuse corners were created; and fourthly, in the northern region between the *insulae* 22, 23, 29 and 30, there are also streets running diagonally. What is the reason for such irregularities in this *colonia*, which was otherwise designed as a complete entity?

The reason is the pre-colonial infrastructure. During the 1st century AD a civilian settlement arose to the north-west of the *castellum* Vetera I (*vicus*).[26] Excavations inside the *colonia* have shown that this *vicus* consisted of at least two streets: the *limes*-road itself, running north-west towards the *castellum* Burginatium, was situated more to the south-west, showing a slight bend inside the colonial *insulae* 19, 20 and 21; and a second road running roughly parallel to it, closer to the Rhine. For the construction of the *colonia* this street was retained; it became the street between the *insulae* 31, 36, 32, 37, 33, 38, 34, 39, 35 and 40. Other pre-colonial streets which were retained are situated between the *insulae* 29 and 30; between 24, 25, 31 and 32 and between 39 and 40. Strikingly, the main thoroughfare, the *limes* road, was *not* retained; immediately north-west of Vetera-Tor, this thoroughfare was straightened out as the new *cardo,* redirected towards the north-east and the former thoroughfare was built over by the new *insulae*. Road sections in *insulae* 37 and 38 were also occupied by *insulae*.

26 Heimberg & Rieche 1998, 27.

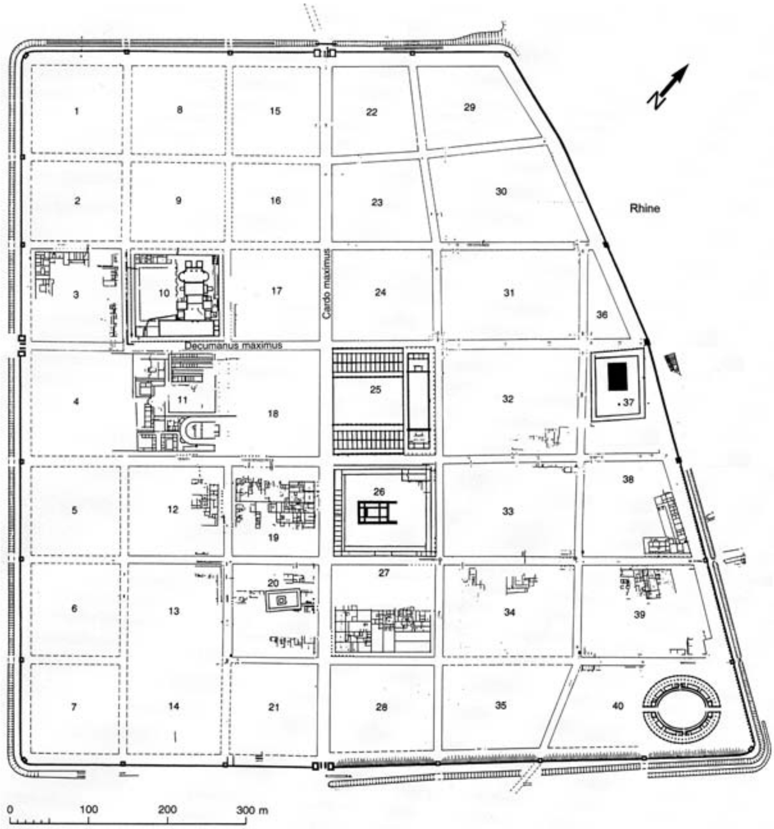

Fig. 6. *Xanten, plan (Heimberg & Rieche 1998, 7, referring to H. Stelter; modified by C. van Tilburg).*

However, it is still unclear why the pre-colonial streets in the north-east part of the colonia were retained. It should have been easy to break up or straighten them out, which was done with the original *limes* road. A possible explanation will be discussed below.

2b. Traffic circulation in Xanten

Just as in Pompeii, the streets in Xanten occupy a considerable part of the city area. In Xanten, however, the streets are extremely wide: a width of 10-12 metres, excluding the roofed sidewalks, which have a width of about 4 metres. The harbour gates, however, were single gates suitable for one-way traffic; the imposing land gates were double gates or three-passage-gates.[27] Did the planners and architects of Xanten intend [160] to avoid any type of traffic congestion and the inconvenience of one-way traffic?

27 The reconstructed Burginatiumtor was a double gate; the south western Maastor was a three passage gate. The number of passages of the south eastern Veterator is unknown; Van Tilburg 2008, 141-142.

In the case of Xanten, there was enough space to construct a city with all the usual facilities and services, without the discomfort of an *Altstadt* which was the case in Pompeii. Nevertheless, the pre-colonial infrastructure was, at least partly, retained and made to conform. It is still unclear why the *limes*-road was not retained but built over; straightening it out was perhaps done for aesthetical reasons[28] and maybe only a few buildings had to be demolished.[29]

2c. Obtuse corners in Xanten

The soil structure of Xanten was quite different to that of Pompeii: not volcanic soil but river clay. Xanten was not suddenly destroyed by a catastrophe, but abandoned in Late Antiquity. So wheel ruts and worn down stepping-stones and pavements, indicating the flow of the traffic and the direction it took, are not found here.[30] Looking at the widths of the streets – not only suitable for two-way traffic but also wide enough for parking carts and stabling animals – traffic congestion was not really a problem and driving seems to have been permitted everywhere. Inside the city, parallel to the city wall, ran a street which could also function as a ring road. This ring road, following the *pomerium*, was interrupted twice: at the amphitheatre area and at the 'Hafentempel' (Harbour Temple).

Traffic entering from the Rhine side – probably mainly cargo traffic – had to go one way, however: the gates along the quays were all narrow single gates, suitable for only one vehicle or animal to pass through. After passing through the gates one could turn right going round an obtuse corner, or left, a sharp corner. While excavating and researching the so-called Kleine Hafentor (Small Harbour Gate), archaeologists discovered that the northern cornerstone on the city side of the gate – on the obtuse
corner – shows the same wear as the worn cornerstones in Pompeii. The correspond- [161]
ing southern cornerstone of this gate does not show any wear at all. So the evidence shows that in the traffic-friendly Xanten, too – in the case of one-way traffic – drivers were following fixed routes, by using obtuse corners (**fig. 7**).

Is there more evidence of the use of obtuse corners? It has been mentioned above that certain parts of the pre-colonial settlement were retained after the founding of the *colonia*, around AD 100. After the creation of the new *cardo*, a second north-west south-east route could be constructed in this way, where traffic could make use of obtuse corners (**fig. 8**). So the *cardo* and *decumanus* both had an alternative route
with obtuse corners. [162]

What was the advantage of such an alternative route? Ring roads around the cities were unknown, so through traffic was forced to go through the gates when crossing a city. To avoid the busy centre, an alternative route could relieve this inconvenience. In his recent PhD thesis concerning Forum Hadriani (Voorburg, today a suburb of

28 The change of infrastructure for aesthetic and embellishment purposes was not unknown; e.g. the reconstruction of Rome to Neropolis after the Great Fire in AD 64.

29 Traces of buildings which had to be demolished for the straightening of the *limes* road are found between the *insulae* 15 and 22, and between 16 and 23; Heimberg & Rieche 1998, 29.

30 Stepping-stones were scarce in Antiquity; Kaiser 2011a, 50.

Fig. 7. *Xanten, Kleine Hafentor, with worn cornerstone (photo C. van Tilburg; Van Tilburg 2012, 145).*

The Hague) Buijtendorp argues that in this small town there were two *decumani*, connecting the gates. The most northerly was the widest, functioning as a thoroughfare. The most southerly, situated along the Forum, was a shopping avenue. If the wide, northerly *decumanus* was connected with the east gate (gate 5) **(fig. 13a and 13b)**,[31] the situation should have been the same as it was in Xanten, although the (obtuse) splitting of the traffic here in Voorburg would have already taken place outside the city walls, instead of within (as in Xanten). The extreme width of the northerly *decumanus*, partly paved, made it possible to drive herds through the city; thus relieving the southerly *decumanus* which was more suitable for pedestrians (and able to
[163] be narrowed easily). More examples of parallel routes are to be found in Tongeren (Belgium), Avenches and Oberwinterthur (Switzerland).[32] In Voorburg, only the centre of the northerly *decumanus* was paved. It was also possible to walk over the unpaved sections, which facilitated parking and stabling generously. Such a situation has also been discovered in Cologne.[33]

31 Buijtendorp 2010, 350, fig. 4.2.
32 Tongeren: Van Tilburg 2012, 119; Avenches and Oberwinterthur: Buijtendorp 2010, 640.
33 Buijtendorp 2010, 640.

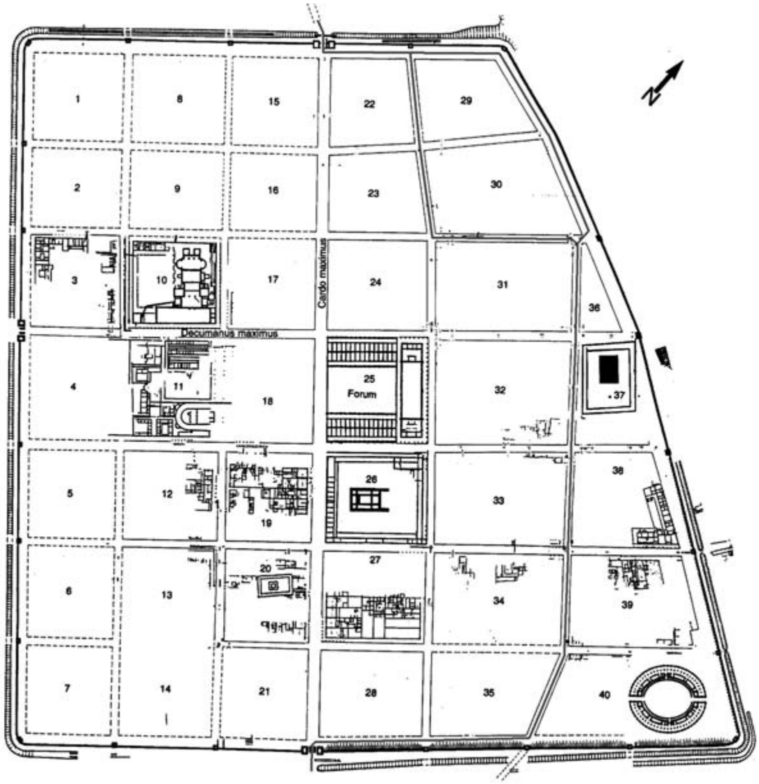

Fig. 8. *Xanten, plan with parallel route (Heimberg & Rieche 1998, 7, referring to H. Stelter; modified by C. van Tilburg; Van Tilburg 2012, 164).*

3. Traffic circulation and the forum

Usually, the forum was located at the intersection of *cardo* and *decumanus*. A forum was square or rectangular, surrounded by colonnades or walls, and always strictly prohibited for wheeled traffic **(fig. 9)**.[34] This forum was often, but not always, situated in the centre of the city: in Pompeii, Cologne and Colchester, the forum was located on the periphery.

In contrast to the planned cities in northern Europe, in Pompeii wheeled traffic could not drive around the Forum. Traffic with the Forum as destination (there was a lot of building-traffic for the rebuilding of the Forum after the earthquake of AD 62) was forced to use several culs-de-sac, finishing as dead ends against the Forum area. [164]
Recent research has provided evidence that for the reconstruction of the Forum new buildings were erected and streets to the Forum, like Vicolo del Balcone Pensile, were

34 In the first instance, however, the Forum in Ostia (a town more suitable for wheeled traffic than Pompeii) was open for cart traffic, but blocked in a later period; Kaiser 2011a, 131-132.

Fig. 9. *Forum with barricade (Giuntoli 1989, 35).*

narrowed.[35] The one and only street running along the Forum was the short road section south of the Terme del Foro. Wheeled traffic was completely closed off here. The imperial fora in Rome show the same design.[36]

In *coloniae* like Xanten, Cologne and Colchester, their fora were also closed off, but surrounded by streets suitable for wheeled traffic. There were two types of traffic design. Firstly, the intersection of *cardo* and *decumanus* was a single intersection, from where traffic could drive in four directions. The Forum was situated beside this intersection. An example is Xanten (**fig. 10**). Secondly, there was no real intersection between *cardo* and *decumanus*. One main route ran along the Forum; the other partly encircled it by means of a zigzag route. An example of this is Cologne (**fig. 11**).

Both Cologne and Xanten were designed as a complete entity, so there was no question here of an alteration in design and traffic circulation. Both designs have advantages and disadvantages. The advantage of the Xanten model was that traffic could cross the city via the shortest, straightest route. The disadvantage was that this design caused a dangerous intersection – even more dangerous in the absence of traffic signs or officials. The Cologne model had the advantage that travellers were forced to reduce their speed and the local authorities could then create an imposing view of the Forum for passing travellers to admire. This was not the case in a city such as

35 For the reconstruction of the Forum and the development of the infrastructure see Poehler 2011a, 149-163; the situation of the Vicolo del Balcone Pensile is mentioned on p. 153. See also Kaiser 2011a, 97.
36 Lanciani 1990, fig. 22.

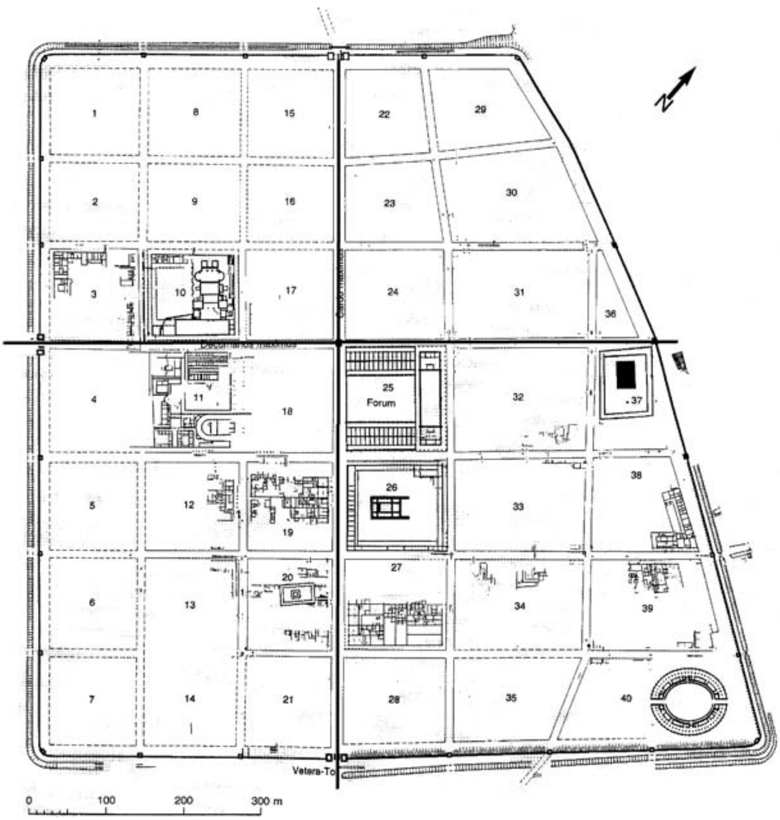

Fig. 10. *Xanten, plan with intersection (Heimberg & Rieche 1998, 7, referring to H. Stelter; modified by C. van Tilburg).* [165]

Caerwent (south-west Britain), where the zigzag route encircled the entire Forum and the approach road did not lead straight to the axis of the Forum, as in Cologne.

In the case of the Cologne model there was one zigzag route; the other route was straight. In Cologne, the *decumanus* was the zigzag route and the *cardo* the straight one; in contrast, in Caerwent the *cardo* was the zigzag route and the *decumanus* the straight one.

Another *colonia*, Trier, was not designed as an entity. Up until the end of the 2nd century AD it was an open city. Due to the instability caused by the first Germanic invasions and the struggle between Pescennius Niger and Clodius Albinus in 193, the [166]
local authority decided to construct city walls and gates. The location of the gates obviously determined the course of the north-south and east-west routes. The route of the *decumanus* was already fixed: this formed the connection between the bridge over the Mosel river and the Forum. The route of the *cardo* could, however, be modified: the city authorities could either place the southern gate (facing Porta Nigra, the northern gate) as a direct continuation of the *cardo* coming from Porta Nigra, creating an intersection as in the Xanten model, or construct the southern gate elsewhere,

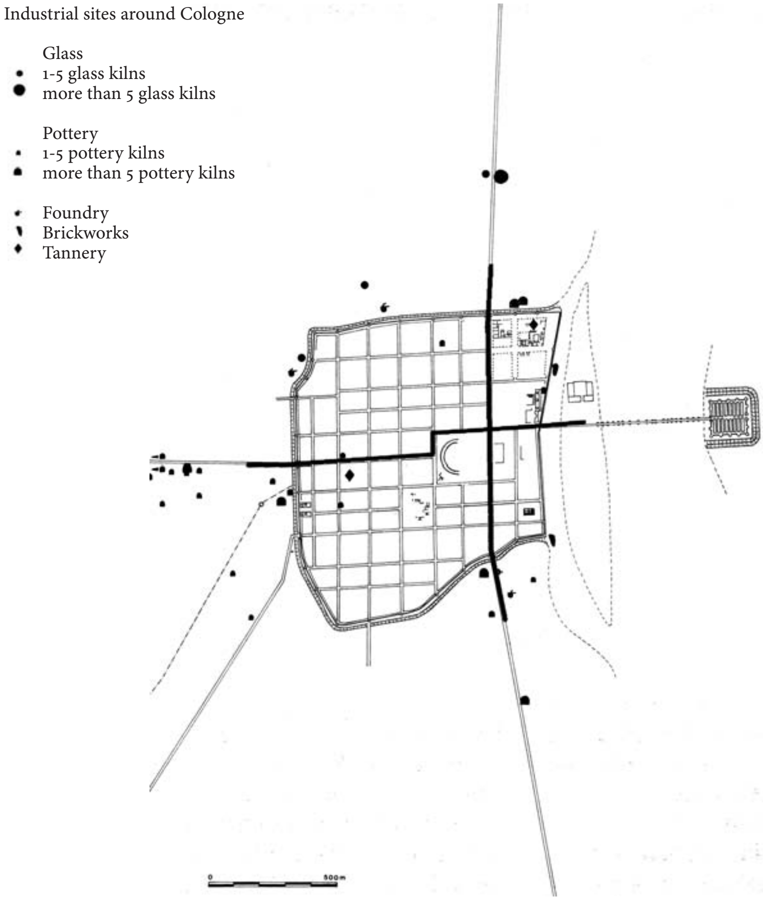

Fig. 11. *Cologne with zigzag route (Stuart & De Grooth 1987, 41; modified by C. van Tilburg).*

creating a zigzag route, as in the Cologne model. The city authorities chose the Cologne model; the Forum was partially, and not entirely, encircled (**fig. 12**). An argument for the city authorities to choose the Cologne model could have been the policy of reducing speed – traffic accidents took also place in antiquity, so laws were established[37] – but another factor could have been the existing economic importance of the street running from the Forum to the south-west.

[167] In some cities it is unclear whether the Xanten or the Cologne model was chosen. It is assumed that Voorburg followed the Xanten model, with no zigzag route (**fig. 13a**). However, it is not certain, because we do not know the number of gates in the east wall. Buijtendorp argues that the east wall probably had gates which correspond-

37 E.g. the *Lex Julia Municipalis* or *Tabula Heracleensis* (CIL 1^2 593, 56-67) and other laws; Van Tilburg 2012, 127-130; 132-136; Kaiser 2011b, 187; 189. Cf. Iuv. 3.259-260 *quid superest de corporibus? quis membra, quis ossa invenit? obtritum volgi perit omne cadaver.* Accidents with children: Laes 2004, 163; Drexhage 1986, 19; 22; Robert 1955, 280-282.

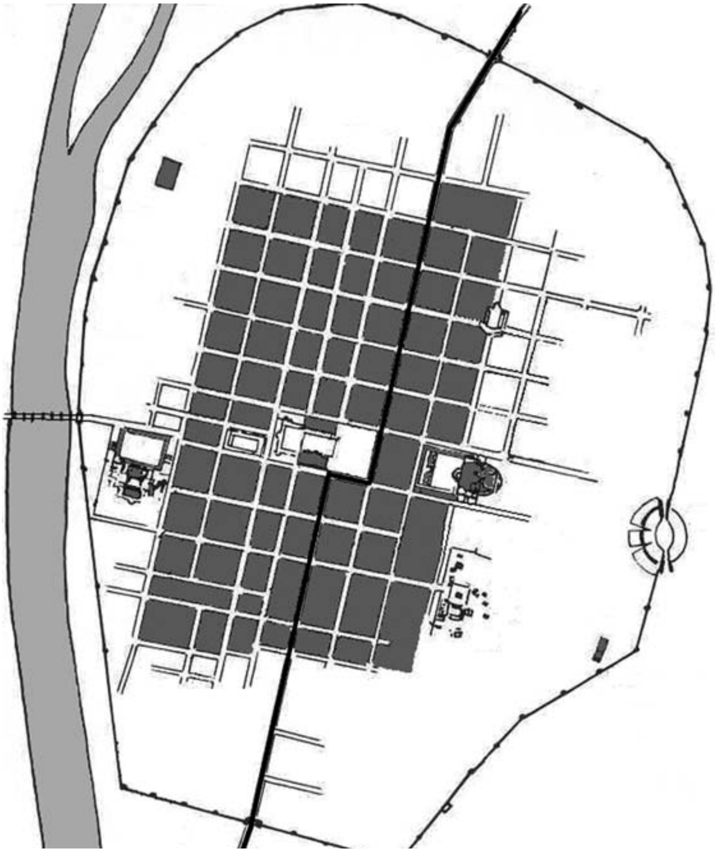

Fig. 12. *Trier with forum route (Oude Essink [1983] 104; modified by C. van Tilburg).*

ed with the gates which have been excavated in the west wall. So we can logically expect that there must have been a gate in the east wall, connecting with the wide thoroughfare *decumanus* (gate 5). However, it is not certain that there was a gate connecting the more southerly *decumanus* (gate 6); it is also possible that entering traffic passed through a gate more to the south, which in this case would have been a main gate (gate 7).[38] In that case, a zigzag route could have been possible in Voorburg (**fig. 13b**), although the Xanten model looks more likely. A parallel route in a city with a zigzag route has also been found in Cologne itself; here, too, it was the *decumanus*.[39] (**fig. 14**).

38 Buijtendorp 2010, 350, fig. 4.2.
39 Wolff 2003, fig. 1.

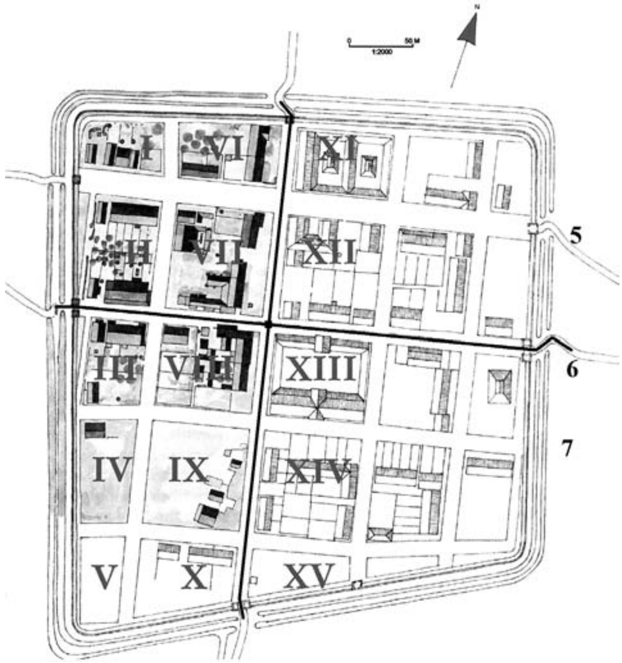

Fig. 13a. *Voorburg, plan with intersection and gate numbers (Buijtendorp 2006, 97; modified by C. van*
[168] *Tilburg).*

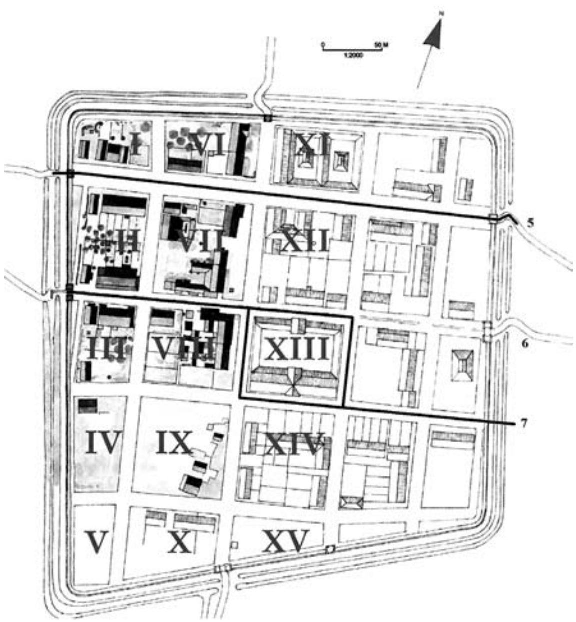

Fig. 13b. *Voorburg, plan with zigzag, parallel route and gate numbers (Buijtendorp 2006, 97; modified by C. van Tilburg).*

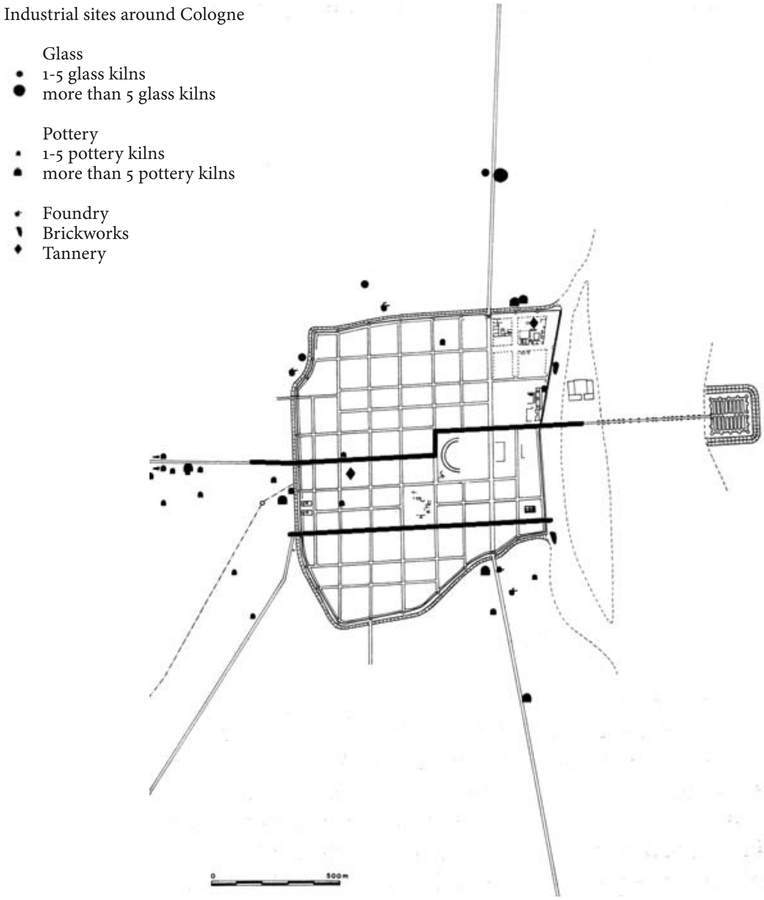

Fig. 14. *Cologne, plan with zigzag and parallel route (Stuart & De Grooth 1987, 41; modified by C. van Tilburg).*

Summary and conclusion [169]

All through history, there has hardly been any research into traffic circulation and blocked arterial roads in the ancient Roman world. Only in recent years have eroded ruts and curb stones in Pompeii been more meticulously investigated and they give us a picture of a dynamic flow of traffic. Some streets were under reconstruction at the time of the Vesuvius eruption; other streets show deep ruts. The city authorities could block or unblock streets and alter routes at will. In many cases traffic was forced to follow fixed routes, with obtuse rather than sharp corners being preferred.

It also seems that in cities with enough room for infrastructure, like Xanten, certain fixed routes were common; also here, there was a preference for obtuse corners. Unfortunately, it is unclear whether streets were closed or opened by the city authorities; the clay soil does not permit the indication of routes by showing evidence of ruts. However, the worn northern cornerstone of ‘Kleine Hafentor’ clearly proves that in the case of one-way streets, traffic passing the single harbour gates preferred obtuse corners. The local authorities probably encouraged this traffic direction.

The city government could also stimulate the use of certain traffic routes by the positioning of gates to correspond to the entry and exit roads. One could choose an intersection model or a zigzag route model, encircling the forum either completely or partially. In the latter case, one zigzag route was enough; up to now a city with two zigzag routes has not been found.

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Gates, Suburbs and Traffic in the Roman Empire

Context

Literature concerning ancient Roman city gates is scarce. The most important article on this topic (as far as I know) was published as long ago as 1909.[1] Apart from this, there is a number of publications that discuss gates. The majority of these publications, however, usually describe one particular gate from an art historical and archaeological point of view, whereas the urban and military-technical contexts are not mentioned. Due to the fact that city gates play an important role in traffic congestion, traffic circulation and city planning – discussed in Chapter 3 in my book – I had aimed to conduct more elaborate research on gates in relation to their urban contexts.[2] In 2004, I published a Dutch article discussing traffic and city gates[3] and in 2005 a Dutch book discussing traffic.[4] In 2014, N. Tuinman, student at Universiteit Leiden, wrote a (hitherto unpublished) MA thesis.[5]

The following chapter focuses on gates in relation to traffic. Presently, I am preparing an article discussing other aspects of gates: their role in the supply of drinking water, in the discharge of sewer water and in regulating social traffic.

1 Schultze, R. 1909 (see Bibliography).

2 Tilburg, C. van. 2012. *Traffic and Congestion in the Roman Empire* (see Bibliography).

3 Tilburg, C. van. 2004. 'Stadspoorten in het Romeinse Rijk' (= 'City Gates in the Roman Empire'), *Spiegel Historiael* 39, 9: 391-396.

4 Tilburg, C. van. 2005. *Romeins Verkeer: Weggebruik en verkeersdrukte in het Romeinse Rijk* (= *Roman Traffic: Road use and traffic congestion in the Roman Empire*), Amsterdam (second revised edition Leiden, see Bibliography).

5 Tuinman, N. *City gates: A gateway into Roman Society: Examining the city gates of Roman Ostia through an analysis of the city plan.*

Gates, Suburbs and Traffic in the Roman Empire

Abstract [133]
Walled cities in the Roman Empire were inevitably accommodated with city gates which had one, two, three or four passages, depending on era, place and status. From the 1st century BC onwards, particularly in the so-called *coloniae*, monumental gate complexes were erected with two or more passages, where driving traffic was separated from pedestrian traffic. Where gates are designed with special passages exclusively for pedestrians in the cases discussed in this chapter (Pompeii, Cologne, Xanten and Trier), extramural buildings are found. Where special pedestrian passages are absent, extramural buildings are not usually found.

Introduction

Looking at the following city gates – Porta di Nola and Porta di Ercolano in Pompeii, Burginatiumtor in Xanten, Porta Nigra in Trier and Porta Appia in Rome – a spectator will see that they have all been part of a (former) city wall and constructed to allow for entering and exiting traffic. Nevertheless, the differences are considerable. On the one hand, Porta di Nola is a small, simple gate, in fact no more than a door in the wall; on the other hand, there are the monumental gate complexes of Cologne and Trier, large-scaled gate buildings flanked by towers and with more than one passage.

These gates were built in different periods; in some cases – Porta di Nola (Pompeii, built in Archaic period) and Porta Appia (Rome, built in Late Antiquity) – the defence function was of more importance; Porta di Ercolano and Burginatiumtor were constructed in a period of peace and relative stability, when it was possible to give higher priority to traffic. The construction of Porta Nigra at Trier (erected in the last years of the 2nd century AD) can be considered as a transitional type.

The most significant aspect, however, in which the gates differ is in the number of passages. Porta di Nola has one single passage (a gate type that is called 'single gate' in this chapter), Porta di Ercolano three, Burginatiumtor two, Porta Nigra two and Porta

Appia, originally, two – and finally, from the beginning of the 5th century AD, one. One can conclude that gates – in the beginning – were accommodated with one passage; in later periods there came gates containing several passages and, finally, in Late Antiquity, one went back to single gates because of the growing insecurity of society.

Excavations show that the situation could occur that one city (particularly a *colonia* founded in the 1st century BC and the first two centuries AD) had gates or gate complexes which differed from each other in the number of passages. For example in
[134] Pompeii we find, – apart from the single Porta di Nola – Porta di Ercolano with three passages and the double gate Porta Marina, with a broad passage for driving traffic and a smaller one for pedestrians. Cologne, Xanten and other cities were also accommodated with single gates and gates containing two, three or four passages. Possibly, Lincoln had all of these types of gates: a single gate, a double gate, a gate with three passages and a gate with four passages.

What is the origin of such a variety of gates? Is it a matter of coincidence or did the local government have special reasons for constructing a gate with one or more passages at a fixed place, taking care of traffic flow?

In this chapter, an attempt will be made to show that there is a definite connection between the number of passages in a city gate (or gate complex) and extramural buildings, situated on the land side of a city wall; these extramural buildings or 'suburbs' were meant for living, working or – in the case of a temple – religious purposes. Cemeteries and 'Gräberstraßen', always situated outside the boundaries of the city, were fully independent of the number of gate passages; they are found in the case of all types of gates. For establishing this number in a gate or gate complex, other aspects also played an important role: in some cases an existing city was accommodated with new walls and gates, in other cases a city was completely planned and built as a whole – including its walls and gates – at one and the same time.

In comparison with other utilitarian buildings, Roman gates are scarcely mentioned – or not at all – in ancient literature. Our most important author of architecture, Vitruvius, does not pay any attention to gates at all. Our knowledge of the building and functioning of city gates is almost completely based on archaeological evidence and here also our knowledge is limited, because most gates have disappeared. Another remarkable fact is that not all cities in the Roman Empire were surrounded by a wall; in vast regions, walls were rather the exception than the rule. There are only a few cases which give an impression of the interaction between city and countryside, entering and exiting traffic and the role of city gates in this matter.

After the construction of a gate, the number of passages remained the same during the whole period of Antiquity; changes in the plan and/or the number of passages to give more space to traffic flow did not take place.[1] Only in case of damage or destruction of a gate (in wartime or natural disasters), where it was necessary to build

1 According to Gros, Porta Esquilina (Arcus Gallieni) was built in the Augustan era as a three-passage-gate (so replacing an older one, probably a single gate); Gros 2002, 29-30. If so, this should be a city gate without a closing wall; the Servian Wall was interrupted. The gate could have been designed as a triumphal arch with three passages; Platner & Ashby 1929, 39; Rodríguez Almeida 1993, 93-94.

a completely new gate, could the number of passages be adapted. In Late Antiquity, sometimes the number of gate passages would decrease when city defence was of more importance and traffic of less; passages could also be narrowed or bricked up. To keep traffic flow under control in a certain way, passing traffic had to be restricted and suburbs had to be limited as much as possible to places where the gates had space enough to sustain traffic flow.

In this chapter, four cities – Pompeii, Cologne, Xanten and Trier – will be discussed, where we have enough information on their urban infrastructure (including the situation of gates and suburbs) to set up a more detailed survey of the planning of gates and extramural buildings:

- in Cologne and Xanten, there is an integral plan of city and city wall;
- in Pompeii, the existing city was extended twice and accommodated with new walls; here the exceptional situation occurred that an old gate was replaced by a new one in an existing city wall;
- in Trier, an existing city acquired a completely new wall.

In Pompeii and Trier, the walls were in the first instance erected for city defence, but in Cologne and Xanten they were built to indicate the city boundaries. In the latter cases, the city government was able to assign certain locations for setting up extramural buildings as part of the city. So in this case, extramural buildings were part of a policy, undertaken with a specific intention.

In Pompeii, in the case of two gates, there were extramural buildings in front of the gates with side passages for pedestrians. This situation also occurs in Cologne and Xanten. In Trier and also in Rome there were neither extramural buildings of any importance, nor gates with side passages for pedestrians.

This chapter focuses on aspects of the planning, defence and traffic functions of gates; strictly architectural and art-historical aspects like columns and sculptures (a gate as a city's visiting card) are not a point of study here.

1. Pompeii

Pompeii started in the 6th century BC or earlier[2] as an Oscan settlement. Its defence wall was of great importance in the city-state society of that time and surrounded in the beginning the *regiones* VII and VIII. Later on, the city underwent two extensions: *regio* VI in the period 474-424 BC and the Samnitic extension in the 4th century. In this phase the city took its final shape (**fig. 1**). The former *cardo*, Via di Mercurio, lost its function in this extension; the city gate, situated in the wall at the north side of the [135]
cardo, was demolished and replaced by a wall tower, nowadays Torre XI.[3] The thoroughfare road, that ran its course outside the city along the wall prior to the extension, now came into the city and took over the function of the *cardo*; the former *de-*

2 Etienne 1966, 86.
3 Etienne 1966, 91-95.

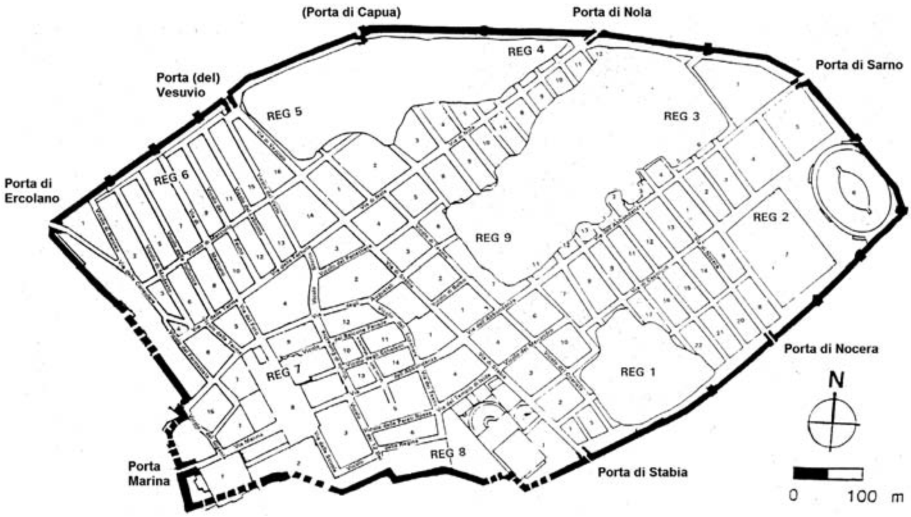

Fig. 1. *Pompeii, plan (Laurence 1994/96, 2; modified by C. van Tilburg; Van Tilburg 2012, xvii).*

cumanus was lengthened to arrive at Porta di Sarno. In the end, after this extension, Pompeii had seven gates: Porta Marina, Porta di Ercolano, Porta del Vesuvio, Porta di Nola, Porta di Sarno, Porta di Nocera and Porta di Stabia.[4] This situation continued until the volcanic eruption of Vesuvius in 79 AD.

Porta del Vesuvio, Porta di Nola, Porta di Sarno, Porta di Nocera and Porta di Stabia all have only one passage, whereas Porta Marina has two passages and Porta di Ercolano even three. Can an explanation be found here?

Originally, immediately after the third extension, all gates were designed as single gates. They made up part of the surrounding wall erected for city defence against attacks of enemies from outside. The gates, the weakest points of the wall, had to be as narrow as possible and relatively easy to defend. There were still no extended gate complexes like those discussed below in this chapter. Also from a traffic point of view, Pompeii did not need wide gates; the city population did not yet have such a volume to cause busy traffic flow and lack of space.[5] During the time that Pompeii was part of the Roman Empire, the city government decided to maintain the surrounding wall for the most part; only on the south-west and west side between Porta Marina and Porta di Stabia was the wall finally pulled down and built over by the 'Hanghäuser', but the small gates were maintained.

Porta Marina is a remarkably deep gate (with a depth of 22.63 metres);[6] it is perhaps rather more a tunnel than a gate passage. The main passage or carriageway is wide enough to give space for a wagon or a horseman, but for a pedestrian the gate

4 An eighth gate, Porta di Capua, for a long time doubtful, is now definitely rejected in Sakai's article.

5 Schoonhoven 2003, [285].

6 Overbeck & Mau 1884, 54.

Fig. 2. *Pompeii, Porta di Ercolano (Overbeck 1884, opposite p. 42).*

is difficult to pass; because of the length of the tunnel he has to wait longer until the gate is free. So Porta Marina had a special parallel side passage for pedestrians, built against the broader carriageway at the north side. According to Mau and Overbeck, the gate dates from the period between the Second Punic War and the Social War, roughly the 2nd century BC.[7] Overbeck and Mau are doubtful as to whether Porta Marina was suitable for military functions; they state that during the construction of this gate Pompeii had no walls at all on this side.[8] In fact, Porta Marina may be seen as a forerunner of a gate where traffic is more important than defence.

Porta di Ercolano (in Roman times this gate was named Porta Salis, Salt Gate)[9] is also different from the other (single) gates. At the time of the eruption of Vesuvius, it had three passages: one main carriageway for wheeled traffic and people on horseback in the centre of the gate building and on the left and right side two smaller side passages for pedestrians **(fig. 2)**. The gate replaced a former one, situated a little bit more to the southwest; a reconstruction picture by W. Gell shows older wheel ruts running to the former gate, but after the construction of the new gate they ended against the pillar between the central carriageway and the western side passage. The road surface also ends against this pillar; on the east side of the carriageway, the pillar is not placed in the road surface but in the edge of the sidewalk[10] and can be dated after 80 BC as a *terminus post quem*, when Pompeii was given its status of *colonia* by Sulla.[11]

7 Overbeck & Mau 1884, 53; Mau 1899, 238.
8 Overbeck & Mau 1884, 53.
9 Coarelli 2002, 53; Etienne 1966, 113.
10 Coarelli 2002, 32. More traces of the course of the former road can be found by the positions of the fronts of the tombs Sud 3 and Nord 3, 4 and 6 (the tombs Sud 2 and Nord 1 are erected in a later period); Fröhlich 1993, 153-156.
11 Coarelli 2002, 52. According to Fröhlich, the common view is Late Republic or Augustan period

What is the reason for the design of this gate, which is different from the other gates? The reason for this is to be found in the siege and capture of Pompeii in 89 BC by the troops of Sulla during the Social War. During the siege, the attack was concentrated on the north western part of the city between Porta di Ercolano and Porta del Vesuvio. In this attack, stone bullets were shot into the city[12] resulting in the city wall (including Porta di Ercolano) being damaged; possibly the gate was completely destroyed. It was later reconstructed but with an altered shape, with three passages.[13] Another reason why a gate was built with three passages is that, as well as increased traffic flow, extramural buildings had been developed over the course of time.[14] At the time of the eruption of Vesuvius there was a suburb outside Porta di Ercolano, the so-called Pagus
[136] Augustus: a necropolis and some large villas such as Villa dei Misteri, at first all dating to the 2nd century BC.[15] A second important necropolis was situated outside Porta di Nocera, whilst outside Porta Marina the Terme Suburbane were constructed during the time of the Emperors. This was an excellent location owing to the presence of a gate with a side passage for pedestrians and sea water, used in these baths.[16]

Incidentally, the local government followed a restrictive policy pertaining to extramural buildings. Private individuals occupied public space outside four gates – Porta Marina, Porta di Ercolano, Porta del Vesuvio and Porta di Nocera – while the city government considered these as public spaces where dwellings were undesirable.[17] Maybe traffic aspects also played a role here; in this way, the quantity of entering and exiting traffic could be restricted as much as possible to interurban traffic. Pompeii was a densely populated city and in order to cope with the housing problem, the choice was made to construct buildings in the south-west corner of the city, at the place of the former wall.[18]

One can conclude that Pompeii – in spite of an increasing population in the city itself and the surrounding region in Campania[19] and the consequently increasing traffic flow – maintained the small gates in the wall, for the most part dating from the Samnitic period. The city government chose a compact, densely crowded city inside its traditional boundaries. Extramural buildings were restricted as much as possible, probably to keep traffic congestion under control in front of the gates; the presence of a suburb in front of Porta di Ercolano caused a bottleneck, in combination with traffic going to Herculaneum and Naples. After destroying this deficient gate, the city government took the opportunity of replacing it with a new one with three passages: a central carriageway with two side passages for pedestrians.

(p. 153), like Porta di Stabia (p. 156); according to Fröhlich himself, the gate is constructed after the earthquake in 62 AD (p. 157-158); he does not mention Sulla. Cf. Chiaramonte Treré 1986, 14.

12 Coarelli 2002, 52; Etienne 1966, 114.

13 Coarelli 2002, 52.

14 Before Sulla, there was already a concentration of villas on the western side of Pompeii: Oettel 1996, 169.

15 Coarelli 2002, 346.

16 Coarelli 2002, 192.

17 Van Binnebeke 1997, 142-144.

18 Etienne 1966, 116.

19 According to Prof. Luuk de Ligt (oral communication).

2. Characteristics of a three-passage-gate

A symmetrical city gate with three passages like Porta di Ercolano in Pompeii is a typically-Roman phenomenon, occurring in many planned Roman cities in the western part of the Roman Empire. During the course of the 1st century BC, this type of gate was developed – in this chapter, I will call this a 'three-passage-gate' – and around 25 BC, when Porta Praetoria in Aosta was built, we can speak of a gate complex with the following features:

- the gate building itself, with three passages (a high carriageway in the centre, for wheeled traffic and people on horseback, and two side passages for pedestrians) and a courtyard;
- a floor for the use of the portcullis;
- two flanking towers.

This revolutionary architecture is, according to Schultze, derived from the cities in the Hellenistic areas, particularly Alexandria, where Rome made its first connections in the second half of the 1st century BC.[20] Some Hellenistic cities were open cities; other ones were accommodated with stone walls.[21]

It is clear that these large-scaled gate complexes are constructed especially, in the first instance, for traffic volume and not for city defence. In this period there were no competing city states or enemies; cities took their chances to construct imposing gate complexes not only for traffic but also to exhibit their power and wealth with much display of decoration and as a status symbol. This was especially suitable for new cities, the so-called *coloniae*, set up for housing veterans and colonists. Many *coloniae* were accommodated with a surrounding wall; in this case, however, it was initially meant to indicate the boundary of the built-up area, and not as a city defence. The aim of the gate complexes was also to impress the approaching visitors to the city and not to frighten them off. This did not mean that it was impossible to close the gate. In times of danger, the central carriageway could be closed by means of a portcullis, which made necessary the construction of a floor above the passage. Porta di Ercolano, too, already had a portcullis at its disposal.[22]

3. Cologne

One of the new *coloniae* where this type of city gate was introduced was Cologne, which received its status of *colonia* in AD 50. Before that time, there was already a local Germanic settlement, Oppidum Ubiorum. From 50 onwards, the wall was erected in a wide circle, indicating the contours of the final Roman city. Inside the wall, the

20 Schultze 1909, 296.

21 Cities without walls: e.g. Termessos (Akurgal 1973, 326) and Aspendos (Akurgal 1973, 334). Cities with walls: e.g. Priene (Hellmann 2010, 326) and Pergamum (Hellmann 2010, 337).

22 Schultze 1909, 287.

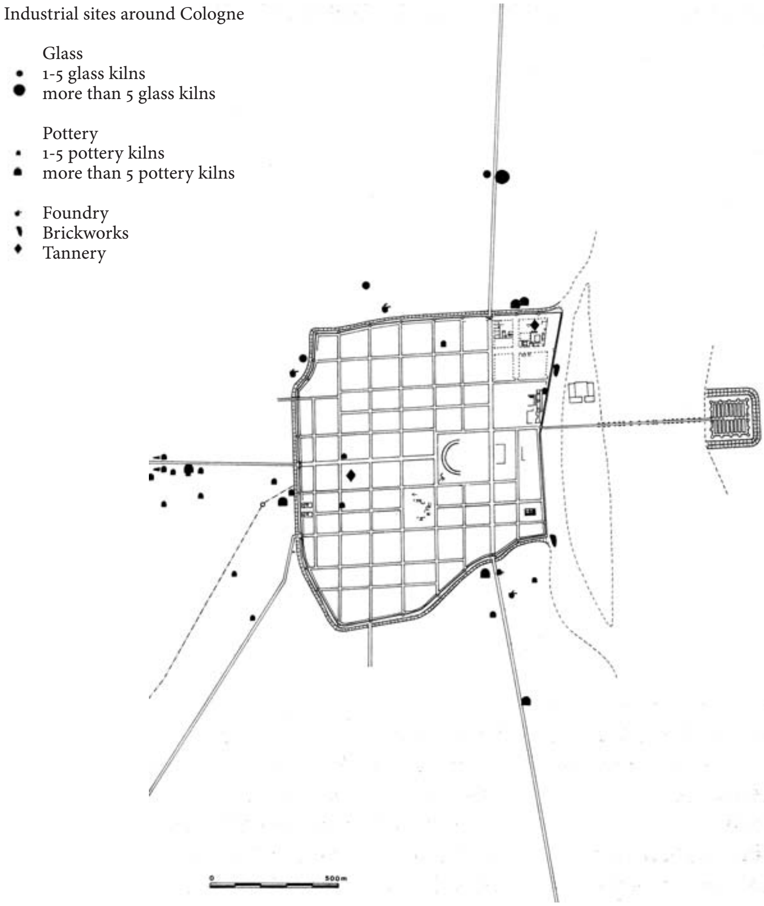

Fig. 3. *Cologne, plan (Stuart & De Grooth 1987, 41).*

city was designed according to the usual and typical Roman form of planning: streets following the form of a chessboard pattern, *cardo* and *decumanus* as main axes and the central forum situated at their intersection **(fig. 3)**. The three main land gates, completely integrated in the city wall, were constructed at the points where *cardo* and *decumanus* crossed the wall on the northern, western and southern side. The eastern side was formed by the left bank of the river Rhine where smaller harbour gates were situated.[23]

The planning of these city gates, in combination with the indication of certain
[137] areas outside the boundaries of the wall – where extramural buildings were not only desirable but even necessary – created the opportunity for designing the gates with such a number of passages that traffic flow could be sustained effectively. In the case of the three main land gates, three-passage-gates were opted for, with a high carriage-way in the centre, flanked by two smaller side passages for pedestrians.

23 Klinkenberg 1906, 179-197.

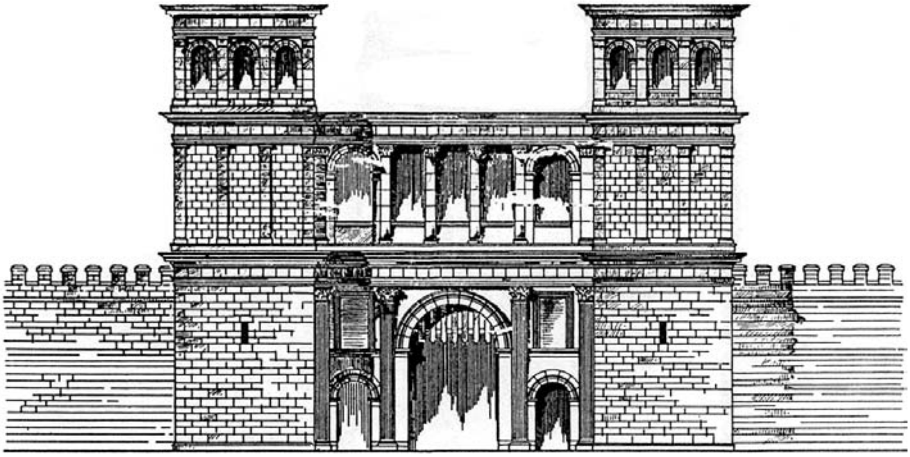

Fig. 4. *Cologne, Porta Paphia (Schultze 1909, Taf. XV).*

Cologne had nine gates in total: as well as the three main land gates there was a double gate and a single gate on the western side, a single gate on the southern side and three harbour gates on the eastern river side. One of them, the middle one, known as Porta Martis, had perhaps two passages[24] and gave access to an island in the Rhine, an industrial area.

The best-known gate is the main gate on the northern side, with its medieval name Porta Paphia **(fig. 4)**. In respect to design and dimensions, this gate was roughly the same as Porta Praetoria in Aosta, but differed from it by the fact that the side passages were separated from the main central carriageway by means of a wall.[25] Presumably the other main gates had the same plan and dimensions. The adaptation of three-passage-gates created the possibility of developing suburbs; a development that was not only desirable, but also – in some cases – necessary. Immediately outside the gates was the suburb area, consisting of dwellings, workshops, cemeteries and – in front of the southern main gate (Hohenpforte)[26] – a *statio* for the *beneficiarii*, security watchers, responsible for watching the roads.[27] The presence of side passages created an optimal interaction of pedestrian traffic between city and countryside. We can assume that in the case of suburbs, the majority of traffic consisted of pedestrians; even in a relatively big city like Cologne, the distances were, in general, no longer than a few hundred metres and the distances between the suburbs and the city itself were no shorter. Furthermore, wagons were expensive; according to the *Edictum Diocletiani de pretiis*, one had to pay thousands of denaries for them[28] – excluding the costs for track animals and food.

24 Klinkenberg 1906, 196-197.
25 Schultze 1909, Taf. XV.
26 Klinkenberg 1906, 193-194.
27 Hellenkemper 1975, 157.
28 *Edictum Diocletiani de pretiis* 15.33 [*raeda cum arcuatis rotis sine fer*]*ro tribus milibus*, 'a wagon with curved wheel parts without iron-mounting costs 3,000 denaries'. This is a relatively plain wagon. The symbol must be read as *denarii*, denaries.

For relatively short distances, no longer than a few hundred metres, carriages were not only expensive but also unnecessary when everything was close enough to walk. So we can say that in the case of three-passage-gates the side passage (for pedestrians) was mainly meant for local traffic, including the interaction between the city and the extramural buildings; the high carriageway in the centre, designed for wheeled traffic and people on horseback was initially intended for interurban traffic.

Looking at figure 3 we see that the majority of workshops (indicated as larger symbols) were situated around the wall and the northern, western and southern approach-roads. Before the nomination of the status of *colonia*, there was already industry in Oppidum Ubiorum, especially on the western side, but after the realisation of the built-up area inside the wall, these workshops – not only producing goods, but also noise, smell and fire-hazard – were removed to the areas outside the wall. So potteries were removed and banished to the west, outside the western main gate, along the western approach-road. The need to transfer workshops because of the dan-
[138] ger of fire from the walled city to the countryside is stressed again in AD 58, when the city was stricken by fire.[29] In the Flavian era, this transfer was completed successfully. The houses of the owners or managers of these workshops were removed to the suburbs, outside the city.[30] Other branches of industry, transferred to the countryside, were glass-works, metal-foundries and smithies.[31] These workshops were not only fire-hazardous, but also produced smoke, noise and nuisance.

Further, the plans of Hellenkemper (1975, 157) and Stuart show that the extramural buildings along the approach-roads outside the city are scarcer when there are fewer passages in the corresponding gates. Most extramural buildings are to be found along the suburban stretches of the *cardines* and *decumanus*, as well as the approach-roads on the northern, western and southern sides of the city, where the three-passage-gates are also situated. The road to the harbour island[32] passed a gate containing one or two passages; the southern gate of the west side of the city was a double gate like Porta Marina in Pompeii: a broad carriageway with a width of 3.70 m. and a smaller passage for pedestrians of 2.60 m.[33] The other two land gates, the northern one on the western side and the western one on the southern side, gave access to less important roads with scarcely any – or no – extramural buildings immediately outside the city. The number of tombs was also smaller.

The design and number of passages in a gate depended, at any rate in the case of Cologne, on the quantity and quality of planning and construction of extramural

29 Tac. *Ann.* 13.57 *sed civitas Ubiorum socia nobis malo improviso adflicta est. nam ignes terra editi villas arva vicos passim corripiebant ferebanturque in ipsa conditae nuper coloniae moenia*, 'But the federate Ubian community was visited by an unforeseen catastrophe. Fires, breaking from the ground, fastened onto farm-houses, crops, and villages, in all quarters, and soon were sweeping towards the very walls of the recently founded colony'.

30 Hellenkemper 1975, 157; Stuart & De Grooth 1987, 41; Höpken 1999, *passim*; Thomas 1990, 408.

31 Hellenkemper 1975, 157.

32 Hellenkemper's plan (1975, 157) shows a bridge. In the 4th century, a bridge was to be constructed over the Rhine, connecting with Porta Martis; Stuart & De Grooth 1987, 41. A reconstruction painting used by Böcking (1987, 102) even shows two bridges, and three single gates at the river front.

33 Klinkenberg 1906, 193-194.

buildings in the form of dwellings and workshops in the close environment of the city. Cemeteries depended less on the presence of main roads and gates. Stuart's plan shows two concentrations of cemeteries, situated a bit further away from the wall: one on the north western side of the city and one on the southern side. The latter field was approachable by use of the southern approach-road, but the largest concentration was situated off the road. Neither did the other main cemetery, have its location close to a main road[34] on the north western side. Settlements and farms situated further away from the city did not play a role at all in this matter; Hellenkemper's plan indicates that there were scattered dwellings in the whole hinterland and no concentration along certain roads. So we can conclude that the other two gates in the western wall could also have been designed as three-passage-gates, so that extramural buildings could be developed here.[35] *Cardines* and *decumanus*, however, had priority.

So the situation in Cologne is in fact opposite to that of Pompeii: there Porta di Ercolano (a three-passage-gate), was replaced in an existing built-up area as part of an existing wall between city buildings and extramural buildings, by a new design, because the changed situation made it not only possible, but even necessary. In Cologne, on the other hand, a start was made with the erection of a wall and gates as *tabula rasa*, in an area that was scarcely built upon – or not at all. Suburbs were not developed along every road and from every gate, but only in those places where the city government gave permission; although the industrial activities encircled practically the entire wall, the majority of the workshops developed along the three major approach-roads and the island, and not along secondary roads. So we can conclude that the city government, when planning and constructing the wall and gates, had already appointed these concentration areas. The wall of a *colonia* indicates the boundary of the city itself, the sanctified area, encircled by its *pomerium*, but the authorities of the city government (in this case the *aediles*) extended the *pomerium* up to one mile behind this boundary.[36] Therefore, the workshops outside the wall and, maybe, the cemeteries further away, were subject to the jurisdiction of the city government.

4. Double gates, three-passage-gates and four-passage-gates

A significant aspect of a gate is the fact that that it is not easy to alter during its existence. Should extramural buildings be constructed next to a gate with one or two passages – for whatever reason – the gate maintained its former physiognomy. Only in the case of destruction – by a natural disaster or during war – was the possibility created for the erection of a new gate, such as Porta di Ercolano. When a city government wished to keep the city as approachable as possible, taking into account the presence of suburbs, the possibility arose of building these suburbs on the land side of the gates with multiple passages, to sustain the interaction between city and countryside,

34 Stuart & De Grooth 1987, 41.

35 Hellenkemper 1975, 156.

36 *Lex Julia Municipalis* 68-70 *Quae loca publica* […] *procuratio est*; Van Binnebeke 1987, 124. *Contra* Liv. 27.37.9 *aedilium curulium* […] *intraque decimum lapidem ab urbe* and Pekáry 1968, 55-56, stating that there was a limit of 10 miles from the city.

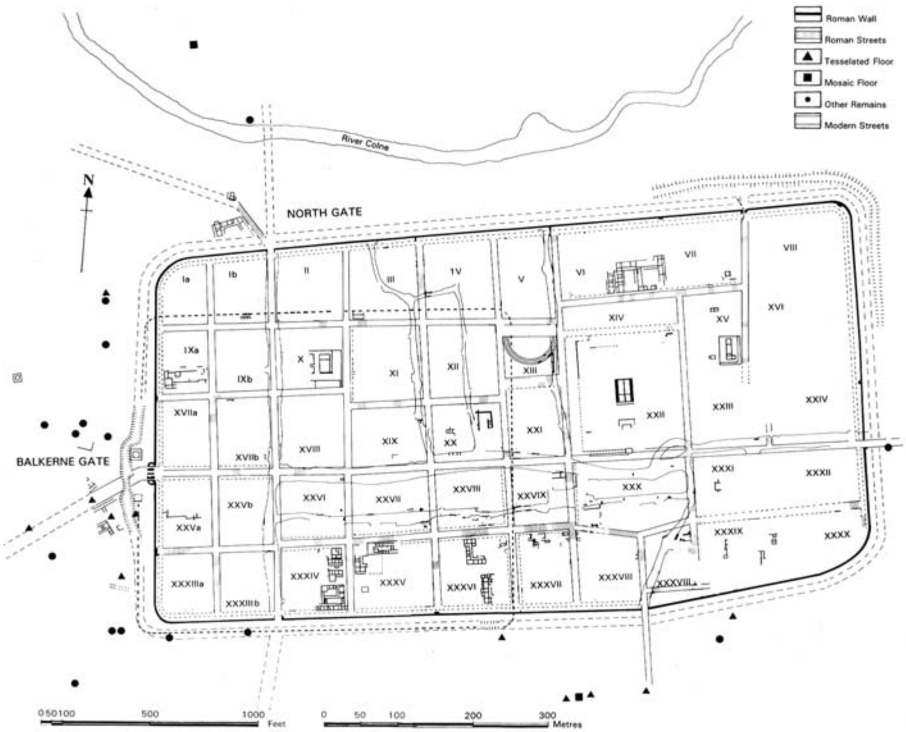

Fig. 5. *Colchester, plan (Wacher 1997, 115; modified by C. van Tilburg).*

avoiding traffic congestion in front of and inside the gate passages. The majority of the distances were relatively short and easy to walk, so the use, particularly, of special side passages for pedestrians could be helpful in keeping pedestrian traffic moving and vice versa.

Apart from the above mentioned single gates, double gates of the Porta Mari-
[139] na-type and three-passage-gates,[37] there were two other types of gate: double gates with passages of equal height and both suitable for wheeled (interurban) traffic and even four-passage-gates, with two carriageways in the centre of the gate building of equal height, flanked by smaller side passages of equal height for pedestrians. This last gate type is scarce and only found in north western Italy, the adjacent south eastern Gaul and Britain.[38]

It was possible for a city government to choose one single type of gate, used in

37 The combination of three-passage-gates (Porta Venere and Porta Consolare) and extramural buildings is also to be found in Spello. Unfortunately, I could not find information on whether the three-passage-gates were older than the extramural buildings or later. In front of Porta Urbica, a single gate, there have not yet been found any extramural buildings up to the present; see Brands 1988, 131-132 and ill. 98-111, and the maps V and VIIb in Manconi, Camerieri & Cruciani 1996.

38 Nîmes, Autun, Turin (Schultze 1909, Taf. XIII, XIV, XVI); Colchester, St. Albans, Cirencester (Wacher 1997, 72) and maybe Lincoln.

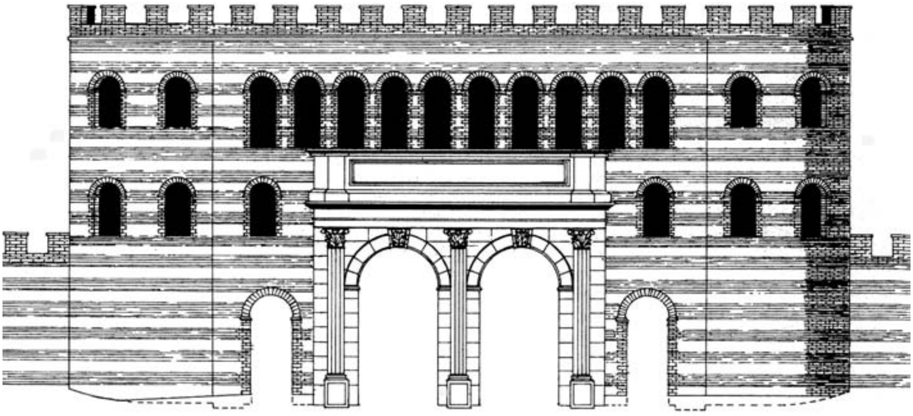

Fig. 6. *Colchester, Balkerne Gate (Van Tilburg 2005, 128).*

all cases. An example of such a policy is Autun, where four four-passage-gates were realised over all four approach-roads.[39] Nevertheless, in most cases a *colonia* had various types of gate, like Cologne. Nîmes, acquiring the right to erect a wall in 16 BC from Augustus, built a four-passage-gate. At another place in the wall a single gate was built (Porte de France); both gates had portcullises and were flanked by towers. In the upper city of Lincoln, every gate possibly had a different number of passages: a single gate on the western side, a three-passage-gate on the northern side, a double gate on the eastern side and probably a four-passage-gate on the southern side.[40] The plans of Lincoln and Colchester show the same development as in Cologne: more extramural buildings when there are more passages in the connecting gates. In Colchester, a concentration of extramural buildings is found on the land side of Balkerne Gate, a four-passage-gate on the western side, and a supposed three-passage-gate on the north western side of the city (**figs 5-6**).[41] There was no courtyard in these British gates; they were merely passages in the wall and the passages themselves were separated by walls, flanked by towers. Finally, Timgad (Africa) shows the same situation: a three-passage-gate was built on the side where many large-scaled, extramural buildings have been found, and narrower gates where extramural buildings are scarcer.[42]

39 Schultze 1909, 305.

40 Jones 2002, 59-61. Whether on the southern side a four-passage-gate was really situated, is not completely certain, but considering the fact that a suburb (the 'lower city') was developed here which was eventually larger than the former 'upper' city, a four-passage-gate is to be expected here and I agree with Jones, together with Wacher (1997, 135). Furthermore, a four-passage-gate was not an unknown phenomenon in Britain see n. 38.

41 Lincoln: Jones 2002, 55; Colchester: Wacher 1997, 115, 127 and 129 (three-passage-gate).

42 Van Tilburg 2012, 30 and 103; Goodman 2007, 70.

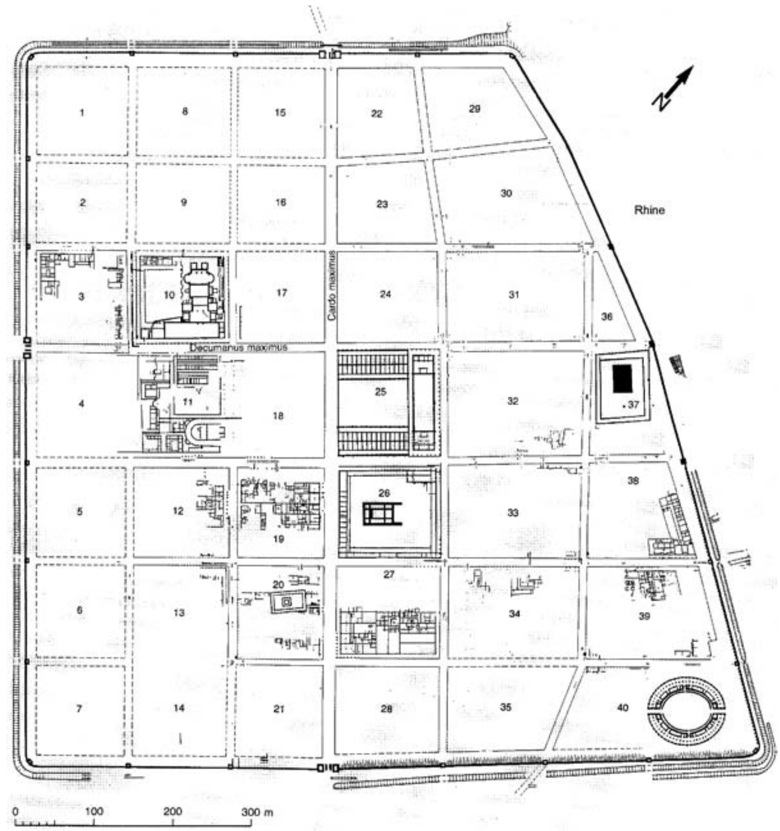

Fig. 7. *Xanten, plan (Heimberg & Rieche 7, referring to H. Stelter; modified by C. van Tilburg).*

5. Xanten

Roughly fifty years after the founding of Cologne, Xanten was the second city in the province Germania Inferior to acquire the status of *colonia* which was bestowed by Emperor Trajan under the name of Colonia Ulpia Traiana. We see here the same development in the construction of the city area: a former Germanic settlement was
[140] first surrounded by a new city wall, after which the area inside this wall was built up and accommodated with the usual chess-board street pattern – *cardines* and *decumanus* – and the typical Roman institutions such as a forum, an amphitheatre, temples and public baths (**fig. 7**).

Apart from the harbour gates, Xanten acquired three main gates on the land side, where *cardo* and *decumanus* entered the city: Burginatiumtor on the north western side (its name is modern and derived from the *castellum* Burginatium, situated northwest of Xanten along the river Rhine), Maastor (on the south western side) and Veterator (on the south eastern side, with the name of the military settlements Vetera I and II). These gate names are modern. The start of the erection of the city

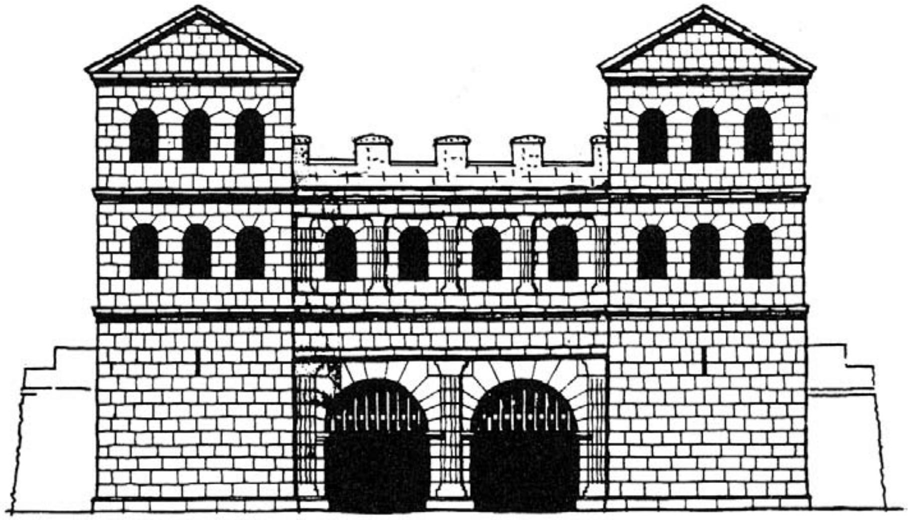

Fig. 8. *Xanten, Burginatiumtor (Böcking 1987, 274).*

wall is, by means of dendrochronological research, dated in 106[43] but the building of Burginatiumtor started later; according to coin discoveries, this is dated to around 115.[44]

Burginatiumtor has not only been excavated, but also completely reconstructed in its original situation and nowadays it is one of the most important attractions for visitors to the Archäologisches Park Xanten (APX; **figs 8-9**). The gate is designed as a double one with two carriageways for wheeled traffic and horsemen, without side passages. Like the British gate complexes, the gate does not have a courtyard; this phenomenon disappears in the second half of the 1st century AD.

Why is Burginatiumtor designed as a double gate without special side passages for pedestrians? Looking at the situation in cities like Cologne, Lincoln and Colchester, one reason may be that there were scarcely any extramural buildings or none at all. Outside the gate, some traces of a building[45] are found. If we assume that there were no further buildings,[46] this could explain why Burginatiumtor is a double gate and not a three- or four-passage-gate. The absence of a suburb of any importance did not necessitate the construction of special side-passages in the gate. So traffic crossing the gate must have been as good as completely interurban. There is also the possibility that the built-up area on the city-side of the gate was scarcer or more open than in other places in the city;[47] assigning a place for a suburb outside Burginatiumtor by the city government was not an urgent matter.

43 Schmidt 1987, *passim*; Liesen 1994, 238 n. 6; Kühlborn 1987, 486, 491.

44 Böcking 1987, 273.

45 Heimberg & Rieche 1998, 7 (plan).

46 According to H.J. Schalles (APX), not much has been found outside Burginatiumtor, but extended excavations have not yet taken place.

47 Excavations in 1968, 2000 and 2001 in *insulae* 15 and 22 (the *insulae* immediately south of Burgi-

Fig. 9. *Xanten, Burginatiumtor (photo C. van Tilburg; Van Tilburg 2012, 101).*

Another point of view is the following: extramural buildings outside the city – north of Burginatiumtor in the direction of the Rhine – would be situated in a place which was not attractive to live in. The gate did not only have the carriageways
[140] for traffic, but also the main sewer leaving the city through the eastern carriageway. The polluted waste water ran further to the Rhine whose course ran parallel to the wall. In and in front of the gate the sewer was closed, but from the point where the gate had its connection to the wall there was an open sewer.[48] Nowadays, tourists enjoy the fine view of Burginatiumtor and, climbing the towers, the magnificent panorama of the Roman city and the skyline of medieval Xanten, but in Antiquity, the smell must have been quite offensive here. Because of this, extramural buildings must have been scarce or completely absent. According to Böcking, however, there was an important cemetery.[49]

If there is scarcely any suburb outside this gate – or none at all – what about the other two main gates of Xanten? Maastor, situated on the south western side of the city, was already partially excavated, researched and described by H. Lehner around 1900, but our knowledge is still scant **(fig. 10)**. It is certain that we have to do here with a three-passage-gate, at a later stage flanked by two towers. The fact that the towers are built over the former wall indicates that there were two building-phases; the sec-

natiumtor) gave evidence of the presence of an auxiliary camp in pre-colonial time; Leih 2002, 149-154. We may conclude that there were no soil disturbances during the *colonia*. Leih (2002, 152) assumes, on the basis of that, that there was fallow land: a farm farmyard or garden. In Nijmegen, also, there was scarcely any built-up or fallow land inside the wall: Willems 1990, 69.

48 Böcking 1987, 272; Heimberg & Rieche 1998, 60-61 (plan).

49 Böcking 1987, 273.

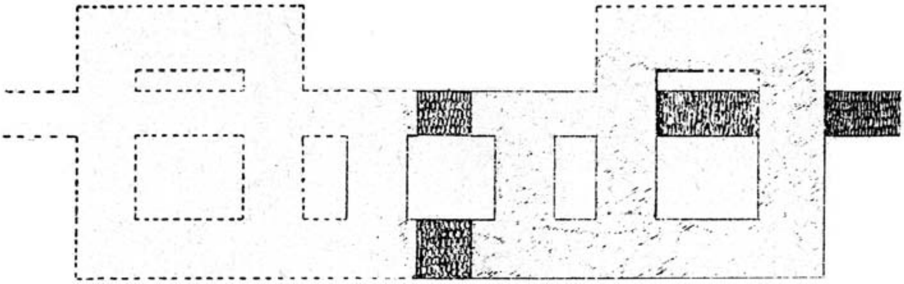

Fig. 10. *Xanten, Maastor (Lehner 1903, 182; modified by C. van Tilburg; Van Tilburg 2012, 115).*

ond phase dates from the second half of the 2nd century, after a fire.[50] This fire may be a consequence of an invasion of a Germanic tribe, the Chauci, in Belgica in the years 172-174; Didius Julianus, Emperor in 193, expelled these invaders.[51] After the fire, the former gate without towers was then accommodated with towers.

Although in the case of Maastor, there is again no detailed archaeological information which can give evidence of extramural buildings,[52] the chance of the existence of suburbs seems to be greater than in the case of Burginatiumtor. First, here was a three-passage-gate: we have to assume that there was entering and exiting pedestrian traffic as interaction between city and the countryside southwest of the city. The road over which Maastor was built entered the city as *decumanus* and ran outside the wall, in a south westerly direction, to the peaceful hinterland, making it a more attractive road for private houses than the frontier road along the Rhine. Furthermore, Maastor was not, as far as we know, part of the sewage system.

Xanten had a third land gate, situated on the south eastern side and built over the *cardo*. Apart from its location, in fact we know hardly anything of this gate which was given the name Veterator (**fig. 11**). In the years 1934-1936 excavations have shown that the gate was designed with towers, with a connection to the city wall. We also know that the supply of fresh water from the mountains southwest of Xanten ran into the city through this gate by means of an aqueduct.[53]

The most important question in the context of this chapter, i.e. how many passages Veterator must have had, cannot, therefore, be answered definitively yet. It is not plausible that Veterator was a single gate and the plausibility of a four-passage-gate

50 Lehner 1903, 182-187; Bechert 1971, 258-259 with a second reconstruction proposal of the three-passage-gate, after the fire. The fact that Maastor was not initially flanked by towers is remarkable; the gate must have had, in the first building phase, roughly the design of Porta di Ercolano.

51 *Historia Augusta, Didius Julianus* 1.7 *Belgicam sancte ac diu rexit. Ibi Chaucis, Germaniae populis qui Albim fluvium adcolebant, erumpentibus restitit tumultuariis auxiliis provincialium*, 'he ruled Belgium long and well. Here, with auxiliaries hastily levied from the provinces, he held out against the Chauci (a people of Germany who dwelt on the river Elbe) as they attempted to burst through the border'.

52 According to Mrs. J. Obladen (LVR, Landschaftverband Rheinland) foundations of buildings are found on the western side of the city in the neighbourhood of Maastor. They have, however, not yet been researched or published.

53 Heimberg & Rieche 1998, 57-58; Berkel 2002, 133 (plan).

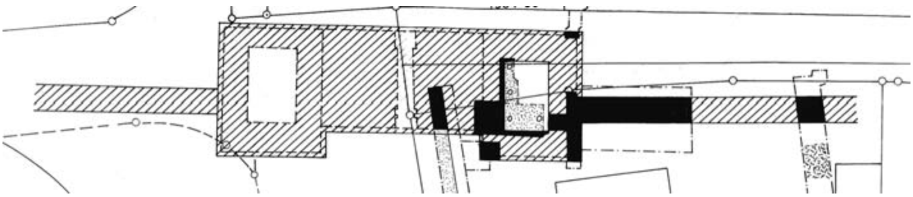

Fig. 11. *Xanten, Veterator (Böcking, APX; modified by C. van Tilburg).*

is also minimal; this gate type did not occur in this part of the Roman Empire. So the possibilities of a double gate like Burginatiumtor and a three-passage-gate like Maastor remain.

In spite of this lack of knowledge about the outlook of Veterator, the APX (Archäologischer Park Xanten) has launched the idea of reconstructing Veterator, as a pendant of the (also reconstructed) Burginatiumtor.[54] When a complete reconstruction has taken place, the question must be answered what the design and physiognomy of the gate were. At the moment APX is confirming the design – in respect of costs, building material and physiognomy – of a double gate like Burginatiumtor. In fact this is not an unreasonable idea. As far as I know there is one reconstruction plan of Veterator, following the excavation results,[55] which is indeed a plan of a double gate with equal carriageways. The reconstruction plan shows, however, that the majority of the plan is imaginary, based on hypotheses and no real evidence has been found concerning the number of passages and their sustaining walls (pillars).

What we do not know is how many passages there were in Veterator, and this is also a problem in the case of publications of city maps of the Roman city. Burginatiumtor and Maastor have one and two central pillars respectively; Veterator has sometimes one and sometimes two pillars.[56] The reason for this is simple: the designer is forced to make a choice.

[142] That Burginatiumtor was designed as a double gate with equal carriageways is confirmed by the fact that the sewer was found relatively close to the tower;[57] a pillar straight above the sewer was improbable. A subterranean pipe also ran into the city through Veterator: the aqueduct supplying fresh water coming from the surrounding mountains. Whether we can state that for this reason Veterator was also designed as a double gate is doubtful, because a pipe can also be constructed under the surface of the central carriageway of a three-passage-gate. So it is still not clear – using the

54 Schalles 2002, 262.

55 This plan was given to me by APX.

56 Veterator as double gate: in *Xantener Berichte* 12, 2002, 85, 231 and 239; Böcking 1987, 265. Veterator as three-passages-gate: in *Xantener Berichte* 13, 2003, 118 and 308, Kühlborn 1987, 489, Böcking 1987, 246 and Precht 1983, 67, in which the reconstruction plan is integrated; Heimberg & Rieche 1998, *passim*. Böcking (1987, 283) refers to an older and no longer valid plan of Ch.B. Rüger, where not only Maastor and Veterator but also Burginatiumtor and even the harbour gate connecting the *decumanus* are designed as three-passage-gates.

57 Gerlach 1983, 105; Precht 1983, 66.

scarce information about the design of Veterator – whether there is a double gate or a three-passage-gate. Nevertheless, I will try to set up a hypothesis.

It has already been shown that in Cologne, Lincoln and Colchester three- and four-passage-gates are found in relation to suburbs; in the case of Lincoln, even a completely new city was developed outside the southern gate (and extramural buildings south of the new city).[58] When we compare this situation to the south eastern gate of Xanten, we can conclude – if we refer to extramural buildings – whether a double gate or a three-passage-gate was present.

South-east of Xanten, relatively close to the *colonia*, there were two legionary settlements: the important *castra* Vetera I (with space for two complete legions) and the smaller settlement Vetera II. Here thousands of soldiers and their staff were housed. They were still in use around the year 110,[59] when the realisation of the city was in full swing or even almost completed. Furthermore, between the military settlements and the city, approx. 300 metres south of Veterator, there was a smaller settlement (*vicus*) west of the medieval cathedral church. Traces of this *vicus* were found in 1971 by the excavations of H. Borger. The *vicus* was situated along the *limes* road and included – besides private houses – potteries and iron workshops: fire-hazardous industry. When we consider the short distance between this *vicus* and the city, we can state that this *vicus* still belongs to the territory of the *colonia* where the authority of the *aediles* was still valid and we can also assume that the workshops were placed here on behalf of the city government. These workshops were still in use in the 3rd century.[60] New excavations are difficult to carry out because the area has been built over by the medieval city of Xanten.

On the sections of road between the *colonia*, the *vicus* and the military settlements, there must have been – apart from interurban traffic – a large amount of local traffic. Part of this traffic will have been people on horseback and wheeled traffic: cavalry and officers on horseback and transport of pottery and (raw) building materials, but there must also have been a huge crowd of pedestrians. To sustain such traffic, the city needed a gate with side passages for pedestrians. However, the traffic situation around Veterator was quite different from that of Burginatiumtor, where there were considerably less extramural (and probably, also intramural) buildings and suburbs. It is not completely impossible that Veterator would have been a double gate, but as long as definitive archaeological evidence is not yet available, I assume that – following the information above – Veterator was a three-passage-gate.

The history of the development of the *colonia* Xanten is comparable to that of Cologne: a Roman city wall around a former Germanic settlement; after that time the area inside the wall was built up. If the city government of Xanten followed the same policy concerning city planning and traffic policy as that of Cologne, we can assume that both Maastor and Veterator were examples of three-passage-gates with suburbs,

58 Cleary 1987, 106-113; ill. 42-43.

59 Böcking 1987, 157.

60 Hinz 1975, 154-155; Böcking 1987, 206-208. For a detailed report on the excavations see Heimberg & Rüger 1972, 84-118.

comparable with the three main gates of Cologne. Burginatiumtor, however, had a more interurban-oriented function: less built-up area inside and outside the wall did not create the need for the design of a gate with special side passages for pedestrians and therefore the city government chose the design of a double gate, which functioned well for interurban traffic.

6. Trier

The promotion of a settlement or city to the status of *colonia* did not inevitably lead to the erection of walls and gates, although this was usual in certain parts of the Empire. Trier became a *colonia* during the reign of Emperor Augustus; but for a long time the city remained an open city like many other cities in Gaul.[61]

For a long time, the date of Porta Nigra, the famous city gate of Trier (**figs 12-13**), was uncertain. Lehner dated the building of the gate to the second half of the 3rd century (the reign of the usurper-emperor Postumus, 259-268). However, other dating suggestions refer to the 4th century, but nowadays it is assumed that the gate was constructed during the last quarter of the 2nd century AD, as was the connecting city wall. Confirmations of this date, in fact, are that the gate is built partially over a cem-
[143] etery which was in use from the 1st century until the third quarter of the 2nd century AD. Besides that (according to Cüppers) there is a historical indication: the gate was not yet finished when Trier was besieged by the Germans – during the struggle between Septimius Severus and Clodius Albinus – in the years 196-197.[62]

Contrary to Cologne and Xanten, the wall was added to an existing city without following the contours of that city. In the new city wall there were five gates: apart from the already-existing and imposing Porta Nigra (in Antiquity known as Porta Martis)[63] there were Porta Media, Porta Alba and Porta Inclyta. A fifth gate was formed by one of the main entrances of the amphitheatre and had, indeed, three passages – one in the centre, giving entrance to the arena, suitable for wheeled traffic and horsemen, and two for pedestrians, giving entrance to the spectators' part (*cavea*) – but in this respect the name of three-passage-gate is, in fact, not correct here.[64]

The wall was not constructed to indicate the boundaries of the city, but to protect the city against enemies. In the last decades of the 2nd century the first Germanic invasions began in the northern frontier regions of the Rhine and Danube; in this context, the invasion of the Chauci and their attack on Xanten should also be remembered. The city government of Trier decided to surround the city yet again – after two centuries – with a wall and gates. The military aspect of Porta Nigra is remarkable in its design: a high massive gate complex with two floors, flanked by heavy towers, semi-circular to the countryside and – reverting to gate building history – a court-

61 Cf. Van Es 1981, 143; Grénier 1931, 282-284; Drinkwater 1983, 151.
62 Schultze 1909, 337; Cüppers 1980, 25-26; Dahm 1991, 30.
63 Heinen 1985, 110-111.
64 Dahm 1991, 12, 13, 30 and 31.

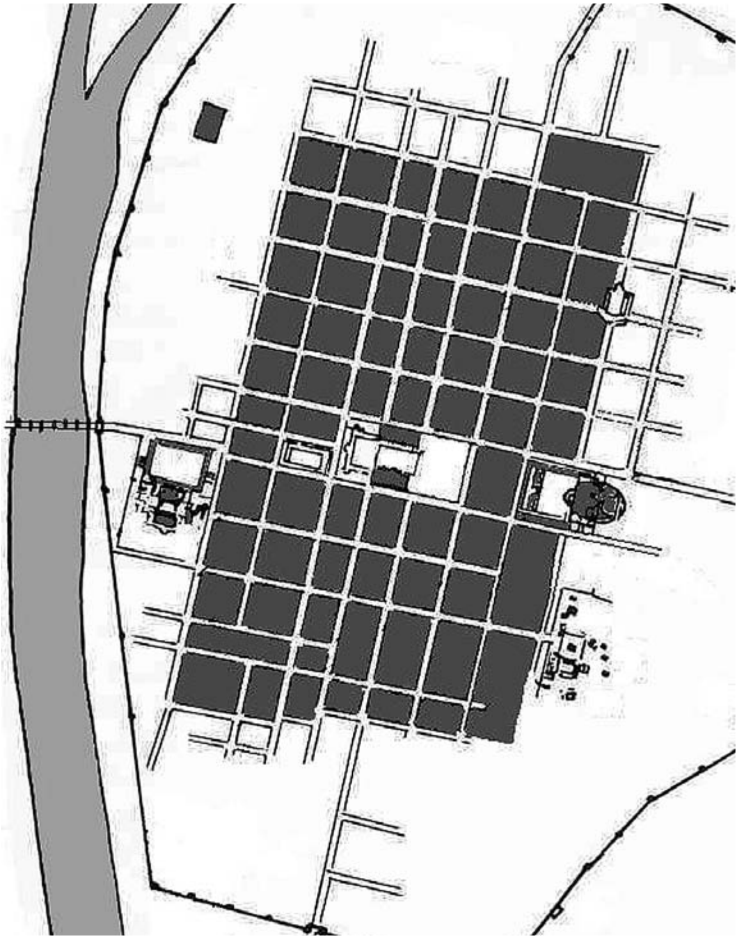

Fig. 12. *Trier, plan (Oude Essink [1983] 104; modified by C. van Tilburg; Van Tilburg 2012, 116).*

yard. The gate is an example of a new generation of gates realised in the course of the 3rd century. The gates of the Aurelian Wall in Rome also belong to this type, viz. as part of a structure meant for the city's defence. The military-defence interest of these gates is far more important than the traffic aspect; this limits the number of passages to one or, in some cases, two.

In Trier, the city government's choice was for at least two double gates: Porta Nigra and Porta Media. Information on the two other newly-built gates – Porta Alba and Porta Inclyta – is lacking, but we can assume that they were also double gates.[65]

Taking a look at Trier's plan in Late Antiquity, we see that the wall surrounds the city in a wide arc. A wall following the boundaries of the existing built-up area would be shorter, cheaper and easier to defend. Eventually, the circus (probably situated north of the amphitheatre) would be incorporated into the city wall.

65 See *infra*.

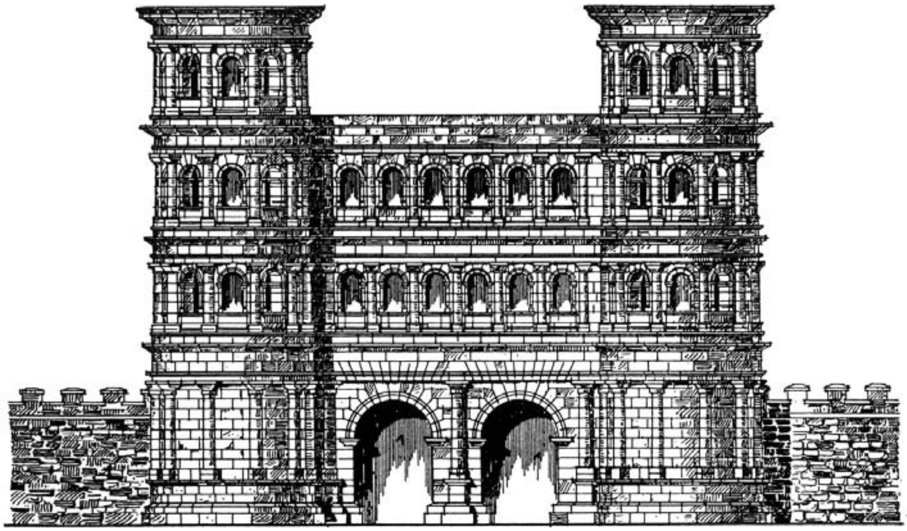

Fig. 13. *Trier, Porta Nigra (Schultze 1909, Taf. XVI).*

Why, then, did the city government prefer a long wall with a wide arc? One possibility could be to create gardens and parks inside the wall. In times of siege one could grow food; so the danger of starvation would be considerably decreased. A second reason could have been to create space for city enlargements inside the wall without the necessity of the construction of new walls – the same situation as in Pompeii. If
[144] this was the reason, the city government was very optimistic; this would involve filling up the whole area inside the wall, roughly doubling the built-up area of the existing city. Besides that, walls making wide arcs around cities were not unusual; we see the same development in Augst and Avenches.[66]

A third possibility could be that the gates were intentionally placed at those places where the last ribbon-development of the city ended and the countryside began. So all buildings were within the surrounding wall and there were no longer any extramural buildings.[67] Because the choice was made for double gates, passing traffic (especially pedestrians) had to be limited as much as possible. Furthermore, the gates were deeper, with longer passages, making the passing time for traffic longer.

At the same time (3rd century AD), London was also surrounded by a wall.[68] Unfortunately our information on the gates is scarce, but in any case two of the six main land gates – Newgate and Aldersgate – seem to have been double gates like Porta Nigra.[69] Outside Newgate – in other words outside the new wall – there was a temple.[70] Hence, we can state that there was, in this case, an extramural building outside a double gate. However, it should be noted that according to Marsden, Newgate was already

66 Heimberg & Rieche 1998, 36.
67 In the 4th century, there is some building of churches outside the wall; Dahm 1991, 12-13.
68 Wacher 1997, 97.
69 Wacher 1997, 76.
70 Wacher 1997, 89.

been built as an independent gate before the construction of the wall. In planning the wall, the city government decided to incorporate the gate into the wall as a new city gate. [71] A logical choice, which created the situation that the temple remained outside the walled city area, in front of Newgate, in the countryside.

Another example of a wall with double gates is the long and imposing Aurelian Wall in Rome. This wall – including fourteen[72] gates – surrounds the city, including some green areas like Horti Sallustiani. Four gates were designed as double gates: Porta Ostiensis, Porta Appia (**fig. 14**),[73] Porta Flaminia and Porta Portuensis;[74] besides them Porta Praenestina in combination with Porta Labicana can be considered as a double gate, although here there are two separate gates, built over two different approach-roads.[75] Furthermore, the wall contained some small gates (the so-called *posterulae)* of lesser importance and probably only meant for pedestrian traffic.[76] Immediately outside the Aurelian Wall there was the countryside; buildings were very scarce or even absent.[77] Firstly, suburbs – if they existed – were situated outside the protecting wall of the city and at this time, it was not attractive to plan them or to live there. Secondly, they offered an unobstructed view of the surroundings of the wall to approaching, attacking and besieging enemies and, thirdly, the absence of suburbs meant following the policy of reducing as much as possible passing (pedestrian) traffic through single and double gates. But there were numerous funereal monuments along the principal roads.

Former open cities like Trier, London and Rome, still surrounded by a wall in the last years of the 2nd century and in the 3rd century, were accommodated with double gates just as Porta Nigra: gates with two equally high carriageways, suitable for wheeled traffic and people on horseback, mainly meant for interurban traffic. There were no side passages for pedestrians. Local traffic was restricted and had to function as much as possible within the contours of the new wall. In the cases discussed above – Trier, London and Rome – there were in fact no extramural buildings. A period of unrest began, in which it was not attractive to live or to work outside the safe wall of a city. Furthermore, an unobstructed view from the wall to the surrounding countryside was necessary.

71 Wacher 1997, 89 and 100; Marsden 1980, 124.

72 According to Lugli & Gismondi, Lanciani and Van Tilburg. Steinby 1993-2006 (*LTUR* IV, 113) mentions twenty gates.

73 This gate was later connected with the Arco di Druso. So an imposing gate complex was created; Schultze 1909, 343 and Taf. XVII. A combination of a city gate and a triumphal arch also occurs in Pula (Istria); Von Hesberg 1992, 283-284.

74 Lugli & Gismondi 1949; Giovagnoli 1973, 42 and 101; Platner & Ashby 1929, 412. *Contra* Schultze 1909, 343 (single gate). Emperor Honorius bricked up these double gates to single gates: Giovagnoli 1973, 42-44; Richardson 1992, 300 (Porta Appia), 303 (Porta Flaminia), 305 (Porta Ostiensis) and 306 (Porta Portuensis).

75 Platner & Ashby 1929, 413.

76 Giovagnoli 1973, 44-45.

77 As in Trier, later some churches arose outside the Aurelian wall, e.g. San Paolo fuori le Mura (4th century).

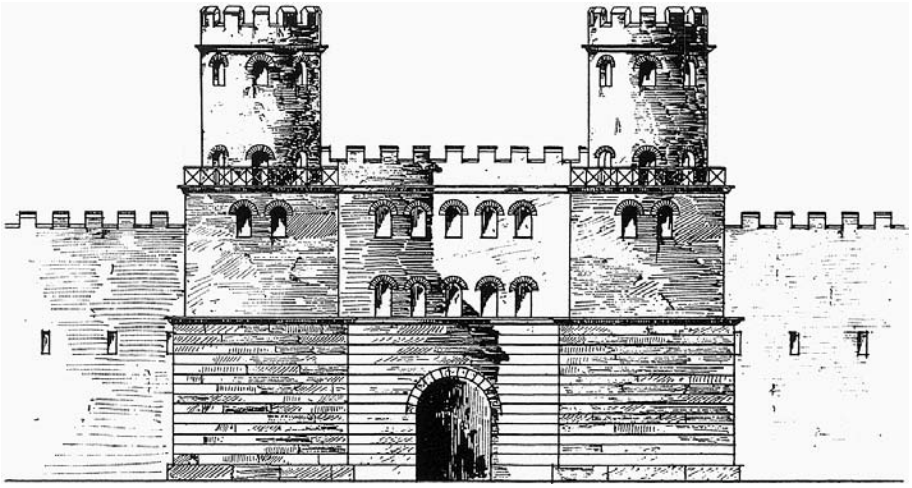

Fig. 14. *Rome, Porta Appia (Schultze 1909, Taf. XVII), a single gate from Honorius' reign onwards.*

Conclusion

City gates are part of the wall of a city and have two important functions: being part of the city defence structure (or indication structure) and allowing traffic to enter and leave the city. Because gates were not easy to alter, the city government had to take measures to keep traffic flow under control when it passed the gates, or in any case to try to do so.

Usually, gates maintained their original physiognomy. In Pompeii, the majority of the gates retained their initial design until the eruption of Vesuvius in 79, many centuries later, despite increasing traffic flow, like Porta di Stabia. Only when a gate was destroyed or badly damaged, was the city government forced to construct a new one; this
[145] new gate could be adapted to new traffic demands or to other incentives; this was the case with Porta di Ercolano. Nevertheless, a new gate must have been a rare occurrence.

The gate as an unchangeable artefact forced the city government to follow a certain policy concerning city planning. Firstly, in the case of a newly-founded city, one had immediately to decide how to design the gates, how many passages, and whether – and if so, where – extramural buildings were to be developed to keep traffic flow under control. In the case of Cologne and Xanten (two *coloniae* in Germania Inferior) the walls were part of the city plan. The wall was built around a former Germanic settlement, the area within the walls was divided according to the usual chessboard pattern and then built up. We see a development of suburbs, usually in the form of polluting and nuisance-creating workshops, along the approach- (main) roads. Gates crossing these roads needed three or four passages: one or two high carriageways in the centre of the gate complex, flanked by two smaller passages for pedestrians. We see examples of this type of gate in Cologne, Colchester and Lincoln. There are indications that Xanten also followed this pattern, although there is on the one hand a three-passage-gate (Maastor) with little information on extramural buildings and, on the other hand, extramural buildings with little information on the number of passages of the connecting gate (Veterator).

In the case of double gates with two equally high carriageways, suitable for wheeled traffic and people on horseback, up until now no suburbs of any importance have been found in the *coloniae* discussed in this chapter (Xanten and Trier). In Xanten, however, traces of a building have been found outside Burginatiumtor, but considering the presence of an open sewer it must have been an unattractive place to be in. Maybe it was a stable, a *statio* for *beneficiarii* (road watchers) or a barn.

We can assume that there is a connection between side passages for pedestrians and suburbs. This is also the case in Trier, London and Rome, where the walls were built after they had long functioned as open cities. The city governments chose double and single gates. They also decided to concentrate the entire built-up area inside the wall without any suburbs. The only exceptions were formed by churches, erected in cemeteries. The situation of cemeteries was fully independent of the number of passages of each type of gate; they were planned in front of both single gates and gates with several passages.

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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.). 1987². *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 12*th *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 developments whenever necessary. [4]

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 ἐστι 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), [8] 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

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]

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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 [13]
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]

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 [15]
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.

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*).

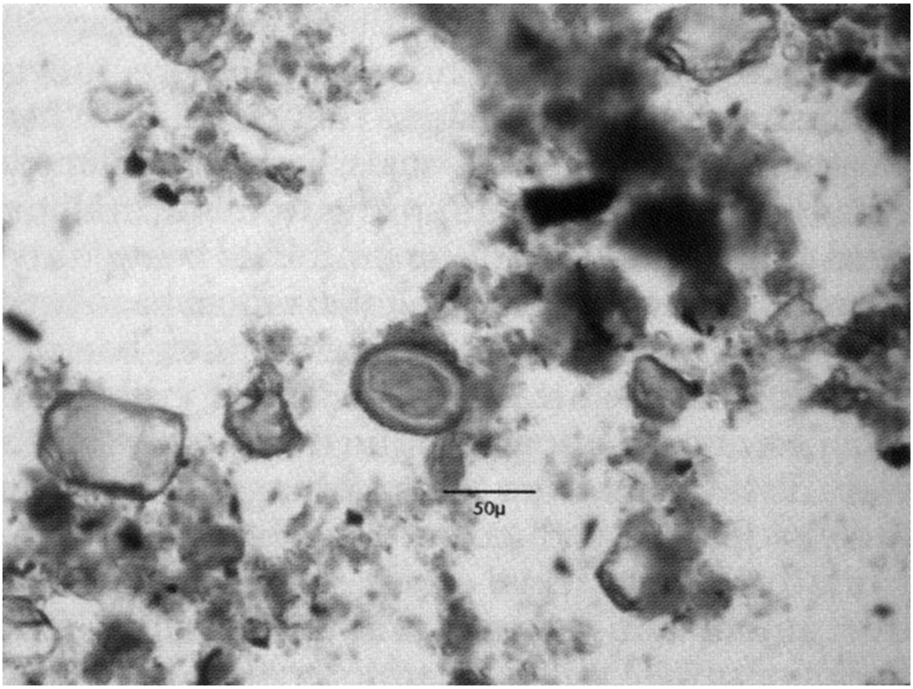

Fig. 2. *Eggs of* Ascaris lumbricoides *in Carnuntum (photo I. Feuereis; Jansen, Koloski-Ostrow & Moormann 2011, 162).*

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

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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 ΙΓ 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.

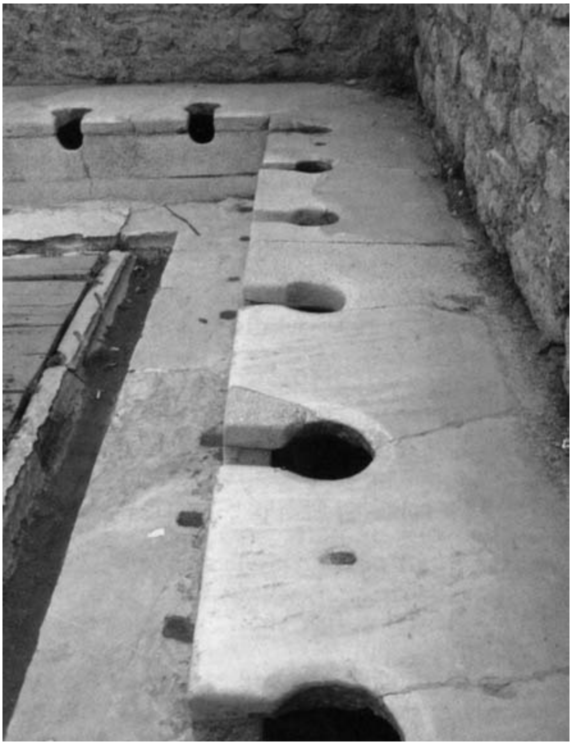

Fig. 4. *Roman public toilet in Ephesus (photo G. Wiplinger; Jansen, Koloski-Ostrow & Moormann 2011, 102).*

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 IV*viri viis in urbe purgandis* and II*viri 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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III. CITY AND ENVIRONMENT

A 'Healthy Mistake': The Excrement Problem from Ancient Greece to Nineteenth Century Holland

Context

This chapter is actually a sequel to the previous one, from a diachronic perspective.

In the course of history, Roman sewers were considered as masterpieces of hydraulic and hygienic engineering. They showed that the Romans were centuries ahead of their time. The *communis opinio* was that Roman streets were clean, with a strict separation of drinking and sewer water. In the Middle Ages, however, hygienic circumstances are supposed to have deteriorated. However this may be, even until the 19th century, people still drank water from canals and rivers. Only after the discovery of germs in polluted water, sewers were constructed again.

The *communis opinio* was, therefore, a misunderstanding. In fact, in Antiquity sewers were built for other purposes: reclaiming marshy lands and discharging rain and bath water after use, at street level or underground. So the decision to construct sewers in the 19th century – by filling up or covering canals, or by constructing underground pipes – was actually based on a mistake.

Many books and articles discuss the hygienic situation in the Netherlands in the 19th century, including their solutions from medical, civil engineering and historic points of view.[1] These publications are, however, restricted to the 19th century, little or no attention having been paid to the preceding centuries since Antiquity; see Van Hee and Weynants, who published articles in 2007 about the Italian utopians in the Renaissance.[2] Shortly before the publication of my article, G. Bartelink wrote in 2014 an article about the Italian city planner, architect and utopian Leon Battista Alberti;[3] he is currently preparing a Dutch translation of Alberti's *De re aedificatoria*.

In the article published in Germany, the editors preferred to leave out the illustrations; in this version, they are included again as in the original Dutch article, published in *Studium*.

1 Medical perspective: Meijer, H.A.M.M. 2005 (see Bibliography); civil engineering perspective: Berens, H.E.M. 2001. *W.N. Rose 1801-1877: Stedenbouw, civiele techniek en architectuur*, Rotterdam; historic perspective: Woud, A. van der. 2010 and Swaan, A. de. 1989 (see Bibliography).

2 Van Hee, R. 2007 and Weynants, S. & Van Hee, R. 2007 (see Bibliography).

3 Bartelink, G. 2014. 'Leon Battista Alberti en zijn voorbeeld Vitruvius', *Hermeneus* 86, 3, 139-144.

A 'Healthy Mistake': The Excrement Problem from Ancient Greece to Nineteenth Century Holland

Abstract [103]

Nowadays, faeces and urine are considered as noxious and unhealthy. In ancient times, however, urine and excrements were seen as harmless and even useful; urine for textile production and excrements for agriculture. The Romans constructed sewers like the Cloaca Maxima, in the first place to remove (rain-)water and drainage. Only later, toilets were connected to these sewers to remove the smell of urine and excrements. The idea that sewers were constructed with the specific aim of removing urine and excrements is therefore no longer valid, but the memory of this function of the (Roman) sewers lasted throughout the Middle Ages.

From the Renaissance onwards, city planners developed their 'ideal cities'. In these cities, there was no place for the dirty smell of urine and excrements, so subterranean sewers had to be constructed. Yet such ideals proved difficult to implement in the Dutch context. The Dutch engineer Simon Stevin realised that the situation described by the ancient and Renaissance sources did not offer a solution for the problems in Dutch cities, with standing water in canals and without natural drainage. Moreover, in this period there was not yet an awareness of the relation between the presence and smell of urine and excrements on the one hand, and hygiene and public health on the other.

Awareness of this relation came not earlier than the 18th century. The German physician Johann Peter Frank argued in favour of diminishing the bad smell by means of filling up canals; the city physician Willem Frederik Büchner was confronted with the extremely unhealthy situation in the typical Dutch city of Gouda. But their political influence was small. Only at the end of the 19th century, the construction of sewers began in Dutch cities, thus improving health conditions.

Introduction

At first sight, there is little coincidence between the cities in the Graeco-Roman world and the Dutch city of Gouda,[1] in the south-western part of the Netherlands in the 19th century, far away in time and distance. On the other hand, comparing the city hygiene of these different cities, we see an astonishing similarity until far in the 19th century. Which policy concerning urine and faeces was in use in these different con-
[104] texts and were these substances considered as dangerous for public health? When, and for what reasons, did a change of policy occur?

The Graeco-Roman civilisation was mainly situated in the Mediterranean area. The Romans had occupied a part of the area nowadays called The Netherlands, but their influence was relatively small. In the province of Zuid-Holland (in the western part of the Netherlands) there was, indeed, some habitation along riverbanks in a vast marsh, nowadays no longer visible – except for some reconstructions of road parts and milestones. After the Roman period, the Middle Ages came up.

Thousand years later, the situation had changed dramatically. The Netherlands were no longer a vast marsh without habitation, but an emerging superpower. In the Middle Ages new cities arose. Renaissance and Classicism came up, but their features had to be incorporated into the Dutch Christian culture. No Roman temples, but Christian churches with classicistic elements.

Medicine was still mainly based on ancient medicine.[2] The works of Hippocrates and Galen influenced medical sciences until the middle of the 19th century; the physicians' knowledge was examined by explaining passages from the Hippocratic Corpus,[3] especially the *Aphorismi* (*Aphorisms*), although many ideas were no longer deemed valid.[4]

During Renaissance and Classicism, people were aware of the fact that the Romans constructed sewers, and it was generally assumed that they were constructed for evacuation of urine and faeces. In fact, they were constructed for other purposes. At the same time, physicians stated that stench was unhygienic. Solutions for the export of urine and faeces, however, were not developed by physicians, but by planners and engineers. They knew the existence of Roman sewers and the works of the Roman engineer Vitruvius. City governments started to enact rules concerning sanitation,[5] but only from the 19th century onwards, city governments were convinced of the necessity to tackle the stench problem by constructing sewers, like ancient Roman cities. Nowadays, this seems to be a 'mistake', but a 'wholesome' one. The Roman sewer, although realised not in the first instance for the discharge of excrements, was the model for the solution of the stench problem in the 19th century.

The Roman model to plan cities was used also by the Dutch. They stated, however,

1 I have chosen Gouda, because this city was a representative, medium-sized one, and the city physician Büchner (1780-1855) discussed the city hygiene in Gouda, providing a lot of information.

2 Van Hee 2007, 260-261.

3 Houwaart 1991, 35.

4 Huisman & Warner 2004, 40.

5 Van Hee 2007, 269.

already in the 17th century, that the Roman model was not always suitable because the marshy soil and large quantity of canals, used for dropping excrements, caused different situations.[6] Dutch (and Flemish) canals were used for dropping urine and excrements, inevitably causing stench. Physicians considered them as dangerous for public health, but they did not tackle the problem. The situation in the city of Gouda offers an interesting example, since the municipal physician W.F. Büchner described the unhealthy situation of the city in the 19th century, although without giving any solution.

1. Ancient medicine and sewerage [105]

In ancient Greece, urine and faeces were collected in cesspits,[7] fixed and mobile toilets[8] and urinals.[9] Chamberpots containing faeces were emptied in gardens or exported to the countryside for fertilising; urine was used in fulleries.[10]

The Greeks were also the first people in Europe who constructed underground sewers for waste water. At the beginning of the 5th century BC, in Athens the Great Drain was built for draining the Agora; at the beginning of the 4th century, a southern branch was added.[11] This drainage sewer must have had the same goal as the underground Cloaca Maxima in Rome: to drain a valley amongst hills **(fig. 1)**.

In a later period, we see a decrease of the use of cesspits and an increase of the use of fixed toilets. If possible, fixed toilets were connected to sewers. Of course, there was not always the possibility to do this; in Rome, for example, chamber pots might be emptied by throwing their content out of the window.[12] Public baths and toilets were usually connected to sewers. In Late Antiquity, there were 144 public toilets in Rome itself.[13]

In ancient medicine, no attention was paid to discharge of human waste. In the Hippocratic treatise *De aëre aquis et locis* (*Airs Waters Places*), the position of a city is mentioned, but not its planning.[14] According to the Hippocratic-Galenic tradition, stench was causing diseases, so stench had to be tackled and not the cause of stench.[15] In short: in the Graeco-Roman world, urine and faeces were exported to fulleries and the countryside, and sewers were built for drainage. In later times, these sewers were also in use for the evacuation of human waste.

6 Weynants & Van Hee 2007, 11-20.

7 Thompson 1959, 91-108; Owens 1983, 47 n. 32.

8 Fixed toilet: Artem. *Onirocriticus* 2.26; mobile toilet: Poll. 10.44; Pherecr. *Fr.* 88 Kock. For more references see Thédenat 1910, 987.

9 Henderson 1975, 191.

10 Wilson & Flohr 2011, 147-153; Morley 2015, 114-115.

11 Owens 1983, 49; Young 1951, 135-288, esp. 151.

12 Jansen 1998, 119; Wilson 2011, 96.

13 Thüry 2001, 12 and 63; Jordan & Hülsen 1871, 573.

14 The only ancient physician paying attention to city planning is Sabinus (1st-2nd century), advising parallel streets for sunlight and fresh air; Sabinus apud Orib. *Med. Coll.* 9.20. He does not mention the evacuation of waste water.

15 Gal. *In Hipp. Nat. Hom. comment.* 2.3 (15.118-119 K.); Nutton 2000, 71. Here the stench of sick people is meant.

Fig. 1. *Cloaca Maxima, Rome (internet, http://www.romanaqueducts.info/aquasite/foto/cloacamax_gt_I.jpg).*

2. Vitruvius and his reception

The Roman architect Marcus Vitruvius Pollio (85-20 BC) is the author of *De Architectura* (*On Architecture*). In this work, he pays attention to buildings and constructions, amongst others aqueducts. Vitruvius had a basic knowledge of medicine (which he prescribes for architects in book 1.1.10) and he refers to the conditions for building an ideal city; however, he does not mention the evacuation of human waste.

[106] After the fall of the Roman Empire, these ways of discharging human waste were not yet completely forgotten. In some monasteries (e.g. St. Gallen), sewers were in use.[16]

In the Renaissance, there was a growing interest in ancient problems and their solutions. During the Middle Ages, European cities were unhygienic according to our modern point of view. Unpaved and muddy streets with pigs, cows and other animals and full of dung and urine, causing epidemics like the Black Death in the 14th century. At the end of the Middle Ages, new interest in ancient problems and solutions arose. People started to study Vitruvius' works; moreover, ancient Roman sewers, like Cloaca Maxima, were still visible and sometimes even in use.

16 Horn & Born 1979, II, 300-311.

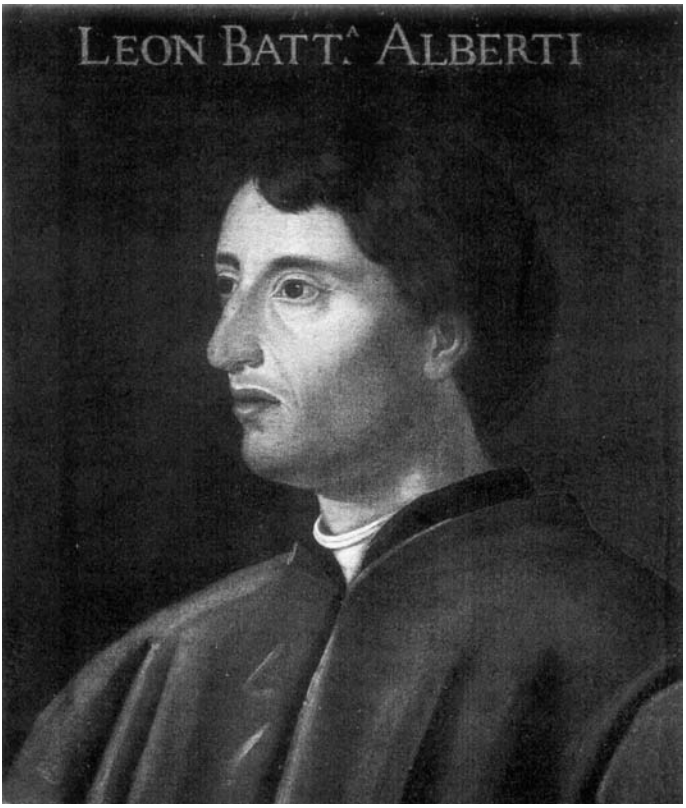

Fig. 2. *Leon Battista Alberti (internet, http://files.umwblogs.org/blogs.dir/6253/files/2011/12/Alberti.jpg).*

3. Leon Battista Alberti (fig. 2)

In 1450, the Italian artist, philosopher and architect Leon Battista Alberti (1404-1472) wrote a monograph, subdivided into ten books on architecture, entitled *De re aedificatoria* (*On the Art of Building*), following Vitruvius (printed in 1486).[17] But there are differences; Vitruvius describes buildings, but Alberti describes cities and buildings to be built.[18] So, Alberti can be considered as a utopian. Beside Vitruvius and other architects, Alberti's ideas are also based on the Hippocratic Corpus.[19] Following *Airs Waters Places*, Alberti starts his work with a description of climatological circumstances.[20] Another difference from Vitruvius is that Alberti does mention sewers:

17 Alberti 1988, XVI-XVIII.
18 Alberti 1988, X: 'The essential difference between Alberti and Vitruvius is therefore that the ancient writer tells you how the buildings that you may admire as you read him *were* built, while Alberti is prescribing how the buildings of the future *are to be* built' (emphasis in original).
19 For information of Vitruvius' influence on Alberti see Taverne 1978, 30; Alberti 1988, IXf.; Daru 1985, 10 and further the voluminous work of Wulfram 2001, *passim*.
20 Alberti 1988, chapters 1.3-4; 9-15.

> 'I have observed that the best architects ensured that rainwater was [...] forced to flow somewhere to wash away human filth, making it less offensive to the noses and eyes of mankind.'[21]

By his mentioning the nose (the smell), I suppose that faeces and urine are referred to. Further on in his work, Alberti discusses cesspits and sewers and their constructions. They are part of the urban infrastructure (roads) and they have to be compared with bridges: this implies that they have to be covered.[22] He admires the sewerage of Rome, after having stated that a good sewerage is crucial for fresh air in the city; he refers to Smyrna and its absence of a good urban sewer.[23] It is hard to live in a city without a sewer, like Siena in his time.[24] Especially the stench is noxious. Sewers have
[107] to be slanting to realise a fluent evacuation of waste water to the river.[25] The material must be solid enough; and, finally, there must be a sufficient height between sewer and river to prevent barriers arising as a result of floods or sludge.[26] Neither Alberti, nor Vitruvius mention any trade in faeces and urine, although this took place in Antiquity.

4. Simon Stevin (fig. 3)

After Alberti, other utopian city planners developed ideas concerning city hygiene and the export of human waste, like Helmut Siefert, Johann Valentin Andreae, Thomas More and Ulysses Aldrovandi, all based on a continuing disposal of water.[27] Amongst them, there was also Aldrovandi's contemporary, the Dutch-Flemish engineer Simon Stevin (1548-1620), who knew the theories of Vitruvius and Alberti.[28] In his treatise *Onderscheyt vande oirdeningh der steden* (*City Planning*, published posthumously by his son Hendrick), he recommends 'overwelfde waterloopen' (covered sewers):

> 'A vaulted sewer in the middle of the street, 3-4 feet deep and just as wide, with branches, connected to the houses. The branches are equipped with bars or perforated sheets of iron, keeping off stones or other raw material, causing congestion.'[29]

Unfortunately, it is unclear if human waste can be dropped in these sewers; maybe, these sewers are constructed only for rainwater drainage:

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21 Alberti 1988, 32.

22 Alberti 1988, 113; Taverne 1978, 41, 412 and 417; Daru 1985, 10. An example of a vaulted sewer called 'bridge' is the Langebrug ('Long Bridge') in Leiden.

23 Alberti (1988) 113; cf. Str. 14.1.37.

24 Alberti (1988) 113.

25 So, the city must be built on a higher level than the final destination of waste water; Str. 5.1.7.

26 Alberti 1988, 114.

27 Daru 1985, 10-11. For a description of Aldrovandi's ideas see Van Hee 2007, 268.

28 Stevin 1649, 110; Stevin mentions here, amongst others, Vitruvius and 'Leo Baptista Albertus'. Taverne often refers to the relation between Stevin's and Alberti's opinions. Cf. Taverne 1978, 40-48.

29 Stevin 1649, 21-22, translated by the author; Daru 1985, 11; Taverne 1978, 35-36; 41-43.

Fig. 3. *Simon Stevin (internet, http://www.physics.ua.ac.be/~devreese/stevin/stevin19aug2001.html).*

> 'The evacuation of rain water and street drainage must be planned from the outset and developed. At some places, a sewer must be realised (...); at other places two sewers along the houses; here, the central part of the street must be a little bit curved. A third solution is the best: an underground vaulted sewer [see the previous citation]. This solution does not cause congestion, collection of mud in the street and stench as a consequence.'[30]

Open sewers on street level have the disadvantage that they are open to waste like fish and slaughter waste, and for animal dung. Stevin does not mention human faeces here, but he does so in another chapter entitled 'Heymelicken' ('secrets', toilets), where he discusses the advantages and disadvantages of cesspits and drain pipes. Stevin is a fan of cesspits; faeces do not produce stench in ground water and they are removed easily. Pipes are worse, causing stench, and they are blocked quickly. For

30 Stevin 1649, 21-22, translated by the author; Daru 1985, 11; Taverne 1978, 40-43.

sick people, a stench-producing indoor toilet is dangerous. In order to prevent stench, toilet covers were used. A more radical way to prevent stench was an outdoor toilet, but a disadvantage was that one always had to leave his house, also when it was rain-
[108] ing.[31] In this context, he does not mention the evacuation of faeces, which may be seen as a confirmation that sewerage is developed for drainage and evacuation of rain water. Like Vitruvius and Alberti, he does not mention the export of faeces to the countryside. He knew the sewers of Rome; probably, he considered them as drainage sewers. He also remarked that the situation described by Vitruvius was not the same as the Dutch situation in his time:

> 'Vitruvius states in book VIII, chapter 4, that he has read Theophrastus, Timaeus, Posidonius, Hegesias, Herodotus, Aristides, Metrodorus about water. After Vitruvius, Pliny the Elder, Palladius and some others have described this topic. But I will explain that the Dutch situation is totally different, so the solutions of the Ancients are not valid here and now.'[32]

The similarity of Stevin's ideas, the separation of discharge of rain water by sewers and faeces by cesspits, and the present views on the situation in the Graeco-Roman world as researched in the last decades, is striking.

5. Johann Peter Frank (fig. 4)

Two centuries later, the German physician Johann Peter Frank (1745-1821) was the first who compiled a coherent work, describing everything concerning public health: *System einer vollständigen medizinischen Polizey* (*A System of Complete Medical Police*), in the years 1786-1790, in which he advises local and national governments.[33] It is translated into Dutch, entitled *Geneeskundige Staatsregeling*. The compilation covers entire Europe. In the introduction of the third book (where city hygiene is discussed), he mentions that there are more excrements in the street scenery in Vienna than in Constantinople and that the amount of waste (including faeces) in Paris is larger than that in Amsterdam or London.[34]

Like his predecessors, Frank states that, at first instance, the stench problem must be tackled and marshy areas have to be drained, for example by paving streets, as in the Roman Empire, preventing that

> 'Animal dung and water, standing in ruts and holes, transform a city into an unhealthy and not fordable marsh (...). The Romans paved all their public roads and streets with bricks.'[35]

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31 Stevin 1649, 91-95.

32 Stevin 1649, 83, translated by the author. Here wells are discussed.

33 Lindeboom 1993, 251; Porter 1995, 466.

34 Frank 1787-1795. For this chapter, I used the Dutch translation by H.A. Bake. See 'voorbericht' (introduction) VII-VIII.

35 Frank 1787-1795, 725, translated by the author; Daru 1985, 14. Cf. concerning marsh the Hippocratic

Fig. 4. *Johann Peter Frank (internet, http://upload.wikimedia.org/wikipedia/commons/4/41/Johann_Peter_Frank.jpg).*

According to Frank, animal dung had to be collected at fixed places, exported from the city boundaries and brought to the countryside.[36] He refers to Galen, who states that excrements have to be brought to gardens via *cloacae*.[37] I suppose that human excrements are referred to, because animal excrements are usually not removed via sewers. Human excrements had to be evacuated through underground sewers in Roman style:[38] [109]

> 'Planning and maintaining a good system of street sewers is one of the most important measures to improve public health. It is a benefit of the Roman king Tarquinius

Corpus: *Aer* 7.

36 Frank 1787-1795, 724-725; 731-732; Daru 1985, 14.

37 Frank 1787-1795, 723; In Frank's text, the reference is mentioned as follows: Gal. *Epid.* 1 conc. 14. This is Gal. *Hipp. Epid. III* 3.1.14 (17a.563 K.).

38 In the 19th century, sewers were usually ruts in streets: De Swaan 1989, 129. I suppose that Frank is describing the situation in Europe in general, because in the Netherlands faeces were usually dumped into the canals.

> Superbus to construct underground sewers (...), so that all waste from the streets were removed and flushed through seven small streams, pouring out into the Tiber.
>
> So it is an advantage when a city is situated on a slope along a river; the evacuation of waste can take place easily. If not, it is an intensive and expensive matter.
>
> One has to clean sewers with a small fall regularly, preventing stench. Besides that, cleaning these sewers must not take place in the hot summertime. The Romans knew that.'[39]

In a later passage, Frank recommends to erect public toilets, following Emperor Vespasianus:

> 'In order to prevent pollution in cities, caused by inhabitants and visitors, who have the need to defecate during their occupations in the street, the government must install public toilets, like Vespasianus did in Rome.'[40]

So, Frank stated that improvements of public hygiene in respect to the removal of faeces had to be derived from Antiquity. Still completely embedded in the Hippocratic-Galenic tradition, he suggested that for a healthy city stench had to be removed. His work is describing entire Europe, but the fact that it was translated into Dutch is an indication that his ideas were appreciated in the Netherlands. Stevin, however, had already acknowledged that the ancient ideas were not always suitable, due to the marshy soil.[41] Moreover, the city canals, containing mostly standing and stench producing waters, were exactly in contrast to the theories of the Hippocratic Corpus and its successors, condemning that situation. Frank recommends to fill up canals:

> 'Our canals are usually the final destination of all urban waste. The sewers discharge all their contents, all waste; dead bodies are dropped into them, but nobody has the intention to clean them. On the other hand, cleaning them should be even dangerous for the inhabitants in hot summertime. The government has to fill up all redundant canals of each smaller city, if they can not be cleaned by flowing water.'[42]

[110] 6. Willem Frederik Büchner (fig. 5) and the city of Gouda

This was the situation found by the Gouda physician Willem Frederik Büchner (1780-1855). He had studied at Leiden University and the influence of the Hippocratic Corpus and Frank is visible when he discusses the unhygienic stench of the canals.

Büchner started his medical education in 1798 at Leiden University; he finished his PhD thesis in 1801 in Würzburg and in 1802 he became municipal physician in Gouda. He wrote several books, amongst them *Wenken en raadgevingen, betreffende*

39 Frank 1787-1795, 736-737 and 754, translated by the author.
40 Frank 1787-1795, 755, translated by the author.
41 Stevin 1649, 83.
42 Frank 1787-1795, 720, translated by the author.

den Aziatischen braakloop aan zijne stadgenooten (*Recommendations to the People of Gouda concerning Cholera*) in 1832 and *Verslag van de epidemie der kinderpokken, gedurende de jaren 1831 en 1832 te Gouda waargenomen* (*Report of the Epidemic of the Child Variola, observed during the Years 1831 and 1832 at Gouda*). His most important work in this context is *Bijdragen tot de geneeskundige topographie en statistiek van Gouda* (*Contributions to the Medical Topography and Statistics of Gouda*), which was published in 1842 describing meticulously the local hygiene.[43] This was, inevitably, a consequence of the development of the city.

After the year 1000, Gouda arose as a settlement on the banks of the Gouwe river, where it flows into the IJssel river. The environment was a bog forest, intersected by some small rivers. The bog forest yielded fuel and building material for the city. To drain the soil, canals were dug out and the entire city was surrounded by a concentric canal for defence. After deforestation of the surrounding area, peat was dug out for fuel, and wooden houses were replaced by brick ones. So the typical Dutch city, with stone houses and canals, arose.

In the 19th century, Büchner's time, Gouda was converted into a stone city and due to the need of peat, underwater peat was dug out, causing vast lakes; they were reclaimed again in the course of the 19th century. By compact soil, however, the soil became lower and the river Gouwe could no longer export its water to the IJssel. On the contrary, the level of the IJssel was high enough to incite watermills, moving water *into* the Gouwe (**fig. 6**).[44] The polluted water of the Gouwe could hardly be refreshed by IJssel water.[45] Nevertheless, this way of refreshing water was usual until 1866, but the result was meager.[46]

What about the removal of excrements in Gouda? In the Middle Ages, the local government enacted laws and edicts concerning the deposit of waste, cleaning streets and reducing stench. In Gouda, in the 15th century, there were restrictions in respect to times and places for the deposit of waste and dung, including places where it was forbidden. In the 16th century, however, dung heaps are no longer mentioned and it became allowed to connect toilets immediately to the open canals.[47] There were fixed points where waste and ash could be offered; this was forbidden at other places.[48] [111]
Streets and lanes were too small to give access to the horses and rubbish carts of the refuse collector's service.

> 'There are only a few locations providing refuse-bins where rubbish can be collected, being now and then emptied. Nearly all waste, including slaughter and tinner waste

43 The first one was *Proeve eener geneeskundige plaatsbeschrijving (topographie) der stad Amsterdam* by C.J. Nieuwenhuys, 1816-1820; Houwaart 1991, 44-45.

44 The water-wheels of the fulling-mills in Gouda were moved by giving access water from the IJssel river. So, inevitably, the water level of the IJssel was higher than the water level of the city canals. Cf. Büchner 2007, 51-53.

45 Büchner 2007, 52-53.

46 Vogelzang 1956, 59. Even until the 1950s, this way of refreshing canals was scarcily used.

47 Van Zon 1986, 21. Cf. the enactments from the 16th century onwards: Van Hee 2007, 269.

48 Büchner 2007, 52.

Fig. 5. *Willem Frederik Büchner (photo SAMH; Habermehl 2007, 13).*

> is thrown into the canals and water pipes, because there are nearly no refuse-bins, the times of picking up refuse of the house of the residents are unregular and the carts and horses cannot pass a lot of streets and lanes.'[49]

In Gouda, the situation was not worse than in other parts of the Netherlands.[50] Everywhere were dung heaps (sometimes even indoor heaps; poor people kept animals for selling their dung); everywhere waste was dumped into the canals and everywhere enactments concerning this were neglected.[51] Büchner states that a citizen of Gouda (and I suppose that this rating is valid for an average man) produces 1 pound of urine, and a quarter of a kilogram faeces each day.[52] The amount of animal urine and dung is not even mentioned, but certainly must be added. Büchner does not mention cesspits; they were probably scarce or lacking.

49 Büchner 2007, 52, translated by the author; Bik 1989, 18-19.

50 Van Zon 1986, *passim*.

51 Houwaart 1991, 258; Van Zon 1986, 32-32; 130-131.

52 Büchner 2007, 52. In 1842, Gouda had 14.451 inhabitants. For other calculations see Van Zon 1986, 73 and 289 n. 2; Van der Woud 2010, 269-270.

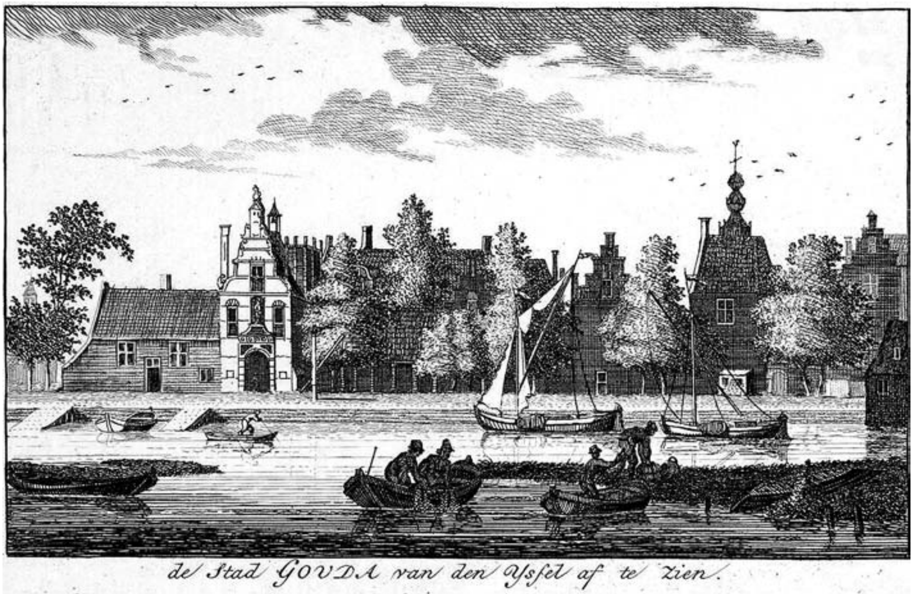

Fig. 6. *View of Gouda from the IJssel river. Left of the gate the watermill building (photo H. Zuidervaart).*

Is it possible to see Büchner as a physician still belonging to the Hippocratic-Galenic tradition? Did he consider the polluted urban situation as a danger for public health, or did he consider diseases as a result of a wrong balance of the four humours and constitutions as described by Galen? There is clear evidence that Büchner knew the Hippocratic treatise *Airs Waters Places* very well; he cites it at the beginning of chapter seven, which discusses drinking-water.[53] Stench is an important cause of several diseases, especially marsh stench. The amount of waste and faeces is enormous:

> 'The quantity of faeces and waste, carried away by flowing water, is so large that the water, leaving the city and discharged through the Gouwe river, looks more like mud than water.'[54]

He continues, speaking about faeces:

> 'In the winter of 1840, the frozen canals were covered with a layer of the most disgusting waste and excrements, one foot thick. The bridges were surrounded by waste and dung heaps, their levels were higher than the quays. I have observed a lot of times – who did not? – two people, next to each other, in conversation, not aware of their actions, the one ladling out the water from a hole in the ice in a bucket for

53 According to Büchner, the people of Gouda belong to the choleric and phlegmatic type; Büchner 2007, 57. See also 63.
54 Büchner 2007, 51-53, translated by the author.

> drinking, the other emptying his bucket full of faeces and cleaning it. The water in the small canals, lacking the most basic qualities, spread a horrible stench.'[55]

[112] According to this story, Büchner disapproves the drinking of canal water with excrements, but he does neither give a solution for this problem nor for other hygienic problems. These were common situations. In Moordrecht, a village close to Gouda, people drank water from the IJssel river and polder canals, usually polluted. Rain water was not a good alternative, because rain water tanks were also polluted and roofs were small.[56] Moreover, in Büchners time, Gouda was still enclosed within the medieval defence walls. In the course of time, the physiognomy of the city did not change and human and animal dung and urine were a usual part of the street scenery. On the other hand, the population density of Gouda was higher than in the preceding centuries.[57] Solid waste like bones and building material was also part of everyday life and the situation seems to be strikingly similar to the street scenery in the Graeco-Roman world. In Rome, non-organic waste like sherds was dumped at Monte Testaccio, in Gouda in the surrounding lakes. Büchner's opinions do not differ from the Hippocratic authors and Galen, ascribing the causes of diseases and epidemics not to urine and faeces, but to their stenches. One has to tackle the stench, not the excrements themselves. According to Büchner, stench of canals causes diseases, especially due to dredging the canals and rivers in summertime:

> 'Moist and noxious exhalations fill the houses and deteriorate the health of the inhabitants, aggravated by the exhalations caused by sledging the canals in the hottest period in summertime.'[58]

Dredging in summer is exactly against the advice of Frank. The common opinion in the Netherlands was that not excrements themselves, but their stench caused unhygienic situations, the so-called miasmatic theory.[59] After the cholera-epidemic of 1832, Büchner discusses in 1833 the miasmatic and contagion aspects in his work *Aanteekeningen en opmerkingen betrekkelijk den Aziatischen braakloop te Gouda*; he started to be an adherent of the contagion theory, but the stench of water is the main cause:

> 'Although I do not agree with the physicians' opinion that the cause of cholera is miasmatic, I argue that the bad quality of drinking water must be noxious (...); but improving its quality will be wholesome to fight against the extension of the epidemic, and it does not matter whether the cause is contagious or miasmatic.'[60]

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55 Büchner 2007, 65, translated by the author; Vogelzang 1956, 58.

56 De Graaf 1970, 151-152.

57 De Swaan 1989, 138, n. 47 concerning deteriorated hygiene, caused by population growth.

58 Büchner 2007, 62, translated by the author; Van Zon 1986, 15. See also Frank's references *supra*.

59 Van Zon 1986, 5-7; he mentions the German physician Max von Pettenkofer (1818-1901), a supporter of the miasmatic theory. Cf. Van der Woud 2010, 281-285.

60 Büchner 1833, 7-8 and 74, translated by the author.

Although Büchner was, more than Frank, a practical man, discussing the situation in Gouda meticulously, one has to observe that he – still in the Hippocratic-Galenic tradition – does not give solutions and advice, such in contrast to Frank. He does not advocate a verdict on dredging in summer; he does not advise to vault or fill up canals; he does not call on people to stop drinking faeces water from the canals and, for example, drink rain water; he does not mention the removal of dung heaps. It should have been possible to construct a windmill to remove filthy water, as in Leiden. This might be due to the bad financial situation of Gouda. The construction of a well-functioning sewer system costs a lot of money, also in Antiquity: [113]

> 'These [sewers] were the accommodations, marvelled at and praised by Dionysius of Halicarnassus (...). One gets an impression of the large amounts of money involved, taking into account that C. Aquilius spent 1000 talents – according to his own words – were spent on maintaining and improving the sewer system only.[61] Nowadays, we spend our money and work for useless and extremely expensive foundations, neglecting the most important needs for a densely populated city, without any responsibility.'[62]

According to the books of the Roman agronomists Varro and Columella, the possibility to export human faeces to the countryside for fertilising soil, instead of dumping it into the canals is not explicitly discussed by Büchner. Probably, in the environment there were many lakes, but only a small amount of land suitable for agriculture was available. Moreover, farmers preferred bovine dung.[63]

Büchner was still mainly embedded in the Hippocratic-Galenic tradition, restricting his task as a physician to cure sick people in a polluted environment; this pollution was stench and filthy water.[64] It is not sure if a realistic solution was available. In the thirties and forties of the 19th century, Gouda was a poor city and in the Hippocratic-Galenic medicine there was no hint of a solution; one had to accept the situation. Only after the middle of the 19th century, after the cholera epidemics of 1832 and 1849, the city government was convinced that a sewer system was needed to remove the stench and to improve public health.[65]

In other Dutch cities, the situation was the same. In Leiden, for example, the canals were also in use for dumping garbage and providing drinking-water. In this city, smaller canals had already been covered, some of them in the Middle Ages, so that they actually functioned as sewers. But the large-scale process of filling-up canals for improving health (and traffic flow) took place in a later time.[66]

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61 D.H. *Antiquitates Romanae* 3.67.5.

62 Frank 1787-1795, 754-755, translated by the author.

63 Vogelzang 1956, 67.

64 Next to his profession of city physician, Büchner was also engaged in education and fighting poverty; Habermehl 2007, 21-23.

65 Finally, everywhere sewers were constructed at private or public expenses, like the railway system; De Swaan 1989, 140-149.

66 Wieles & Van Noort 2002, 15-16 and 55-61.

Only after the cholera epidemics of 1832 and 1849, local authorities were convinced that they had to tackle the problem radically by constructing sewer systems; not only for removing the stench, but also to improve public health of both the poor and the rich. Hitherto, the upper class had the opinion that the poor people's lifestyle caused unhygienic situations.[67] In 1849, the English scientist John Snow had discovered that polluted drinking-water, rather than stench, caused epidemics like cholera. His German opponent Max von Pettenkofer, on the other hand, argued that these were
[114] caused by faeces pollution of the soil. The majority of the Dutch physicians and scientists were adherents of von Pettenkofer's theory. Only after 1866, Snow's influence became more important.[68]

After the 1870s, the so-called 'tonnenstelsel' (barrel system) was introduced: faeces were collected in barrels, for fertilising soil in the countryside, as in Roman times. In Gouda, however, the unlimited dumping of faeces and garbage continued for a long time, due to the system of refreshing water by water from the IJssel river.[69] In Leiden, where the possibility to refresh canal water was absent, the so-called 'Liernur system' was introduced in 1871. In this system, faeces were collected in iron tanks, emptied by compressed air and finally exported to the countryside. This system remained in use until 1915. For this reason, Leiden realised a modern sewer system relatively late. Still in the 1980s, polluted water was still drained immediately into the canals.[70] Of course, the time that they supplied drinking-water was already long ago. Also in Germany, from about 1900 onwards, sanitation in the cities got better, after the hygiene situation was improved.[71]

Summary and conclusion

In former times, urine and faeces were not considered as noxious and dangerous, to be removed as quickly as possible. Stench had to be removed, not the cause of stench. Authors of the Hippocratic Corpus, Galen and Celsus do not mention human waste in the street scenery and their removal. Some cities, like Athens and Rome, constructed sewers to drain lower areas and created the possibility to connect toilets to them, reducing stench. The idea that the Romans realised sewers especially for the evacuation of faeces and urine remained popular for a long time, but it was a wrong one. The Italian humanist Alberti referred to Cloaca Maxima in his argument of reducing stench and for improving the discharge of excrements and waste water. A city without a sewer was an unliveable city. On the other hand, he was not a physician and he does not mention the connection between excrements and public health. Stevin, referring to the Roman architect Vitruvius and Alberti, pays attention to the typical Dutch situation, including its canals and marshy soil. He recognises that a sewer like Cloaca Maxima cannot be realised in the Netherlands, because the soil level of the

67 Wieles & Van Noort 2002, 138-140; Meijer 2005, 20.

68 Eelkman Rooda 1989, *passim*.

69 Van Zon 1986, 85; Vogelzang 1956, 59 and 64.

70 Van der Woud 2010, 323-327; Wieles & Van Noort 2002, 59-78.

71 Huisman & Warner 2004, 213-214; Witzler 1995, *passim*, esp. 205-209.

Dutch cities is not high enough for a fluent evacuation. He still makes a distinction between sewers for water drainage and the removal of faeces. Medical authors are not mentioned.

The first to consider faeces stench in standing canal waters – like marshes – as dangerous for public health is Johann Peter Frank. He argues for filling up redundant canals and dredging them in cold weather. The Gouda physician Büchner shares his opinion; according to him, the stench of the polluted canals is responsible for the unhygienic conditions in Gouda. From the point of view of the Ancients, the situation of Gouda, with its large quantities of standing water and its marshy environment, represents the worst medical and geographical situation.

So there is the paradox that in the latter part of the 19th century sewers were con- [115]
structed, inspired by their Roman forerunners, considered as a symbol of excellent hygiene, no stench and no annoyance being caused by excrements. On the basis of this misunderstanding, the faeces problem was tackled from the 19th century onwards; according to recent research, however, cities in the Graeco-Roman world were not as healthy as thought for a long time, and sewers were constructed for another purpose, drainage.

So we can rightly speak of a wholesome mistake: wholesome because the construction of sewers caused less stench and an improved public health, but a mistake because it was based on the opinion that underground sewers were built for these purposes, and this opinion was incorrect.

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A Good Place to Be: Meteorological and Medical Conditions in Ancient Cities

Context

From the 5th century BC onwards, people are aware that a healthy environment is an important factor for a town. The first treatise discussing this theme is the Hippocratic *De aëre aquis et locis* (*Airs Waters Places*), indicating (albeit in a speculative way), in which direction a city has to face in order to have a healthy location, fresh air and sunshine, and some winds are supposed to be healthier than others. These points of view are discussed by other ancient authors.

In practice, however, many settlements were built fulfilling other conditions, e.g. connections to roads, means of support and the availability of drinking water. Sometimes (new) settlements and towns, however, could also fulfil conditions described by ancient medical authors, possibly after adjustments.

In this next chapter we meet the scientist and commander M. Terentius Varro. He put knowledge of theories concerning the ideal medical and meteorological circumstances into practice and radically changed the orientation of a patient's room full of sick people after the Battle of Pharsalus in 48 BC. Although his measures were mostly based on speculation (he posed a hypothesis of the existence of bacteria!), he was ahead of his time. Fresh air was first considered healthy in early modern times; polluted air, like stench of marshes, had to be avoided.

A Good Place to Be: Meteorological and Medical Conditions in Ancient Cities

Abstract [1]
The founding of a city requires certain hygienic and meteorological conditions. The climate must be moderate, neither too hot, nor too cold; neither too dry, nor too moist; fresh air and water are crucial.

Ancient medical writers such as the authors of the Hippocratic Corpus, Celsus and Galen prescribe ideal conditions for the city. Wind-directions, local climate (heat, cold, humidity), quantity and quality of air and water and a clean environment were crucial factors to establish a healthy city. Did their opinions correspond with the opinions of non-medical ancient sources like Vitruvius, Varro, and Columella? And, finally, were these conditions really realised in practice, as proved by excavations?

According to his book *On Agriculture*, the Roman author M. Terentius Varro improved the hygienic situation by cleaning polluted air, when he changed the position of doors and windows. If this story is true, there is evidence that there was some knowledge of improving health, bringing theory into practice.

Introduction

The Roman statesman and scientist M. Terentius Varro (116-27 BC) tells us in his *Res rusticae* (*On Agriculture*) that, after the Battle of Pharsalus in 48 BC, he improved the hygiene in the sick-rooms of his comrades and his servants by changing the position of the windows and a door in order to extract polluted air. If this story [2] is true, then it provides evidence that Varro accepted a correlation between public health and the direction of the wind, showing that he actually took active measures to correct the flow of air to the convalescents under his care. Whilst one might wonder about the veracity of this story, it does, at the least, spur one to consider whether there was any connection between a) the planning and construction of buildings (and cities) in Antiquity and b) concerns about public health that were connected to meteorology. If there were any such connections, a further important question arises as to whether medical theory played any role in informing thought on this issue.

In discussing how and where cities should be built, authors in Graeco-Roman Antiquity display clear preferences for certain types of location and layout and they pay particular attention to questions concerning wind direction. In this chapter I will investigate the similarities and differences between the actual practice of city planning and building and the theories of medical and non-medical authors. My focus will be restricted to issues concerning location and climate.[1]

1. Health and wind directions: Varro

In Varro's *On Agriculture* a story is told about how Varro, confronted with houses full of the dead and ill in the city of Corcyra after the battle of Pharsalus, played an important role in the recovery of his comrades and his servants by changing the positions of windows and a door so as to admit the fresh north wind and drive out polluted air:

> 'Did not our friend Varro here, when the army and fleet were at Corcyra and all
> houses were crowded with the sick and the dead, by cutting new windows to admit
> the north wind and shutting out the pestilential winds, by changing the position of
> [3] the door [this will be discussed in paragraph 10], and other precautions of the same
> kind, bring back his comrades and his servants in good health?'
>
> *Non hic Varro noster, cum Corcyrae esset exercitus ac classis et omnes domus repletae essent aegrotis ac funeribus, immisso fenestris novis aquilone et obstructis pestilentibus ianuaque permutata ceteraque eius generis diligentia suos comites ac familiam incolumes reduxit?* (Var. *R.* 1.4.5).[2]

This conversation takes place during a meeting with, amongst others, Varro himself and his father-in-law Fundanius. Another guest, Gn. Tremelius Scrofa, 'a man distinguished with all virtues, who is esteemed as the Roman most skilled in agriculture' (*virum omnibus virtutibus politum, qui de agri cultura Romanus peritissimus existimatur*),[3] narrates the story here.

Varro, the author of *De lingua Latina* (*On the Latin Language*) and *On Agriculture*, was already considered to be a very important scholar in the ancient world[4] but most of his works have been lost, making it difficult to be sure about the breadth of his learning. Despite this, some surviving evidence suggests that he may have had a medical education. One of his lost works was entitled *Disciplinae*, a 'handbook' for

1 I will not consider here issues concerning military settlements, civic water supplies, soil types, or economic factors, although I hope to return to these topics in future articles.

2 All citations in this chapter come from the Loeb series (slightly revised), except citations from Hippocrates' *Letters*, which come from W.D. Smith's edition (see the Bibliography).

3 Var. *R.* 1.2.10.

4 August. *C.D.* 6.2; Van Rooijen-Dijkman 1999, 301.

liberal arts, including medicine,[5] whilst a passage of Pliny shows that Varro knew of Hippocrates' works.[6] This evidence is, of course, not conclusive by itself but it provides a valuable framework within which we can set the passage recounting Varro's actions at Corcyra.

Let us consider the context of the passage quoted above. The guests in this story are discussing agriculture and, in particular, the orientation and position of a villa. The gentleman-farmer must have a knowledge of meteorology and medicine in order to judge whether or not a region is healthy and, thus, must know which types of climate and winds are beneficial and which are not.[7] So, a connection is assumed here between meteorological phenomena and the salubriousness of a given region. What might be the basis for this connection? Why did Varro think that the northerly wind was beneficial and which winds did he aim to shut out? And what could possibly have been the intended effect of changing the position of the door?

2. Health and wind direction: the Hippocratic Corpus

The Hippocratic Corpus contains a number of views about wind directions and their influence on public health. An early treatise in which wind direction is considered is [4] *De morbo sacro* (*The Sacred Disease*, second half 5th century), in which the author considers the polarisation of a northerly wind and a southerly wind and takes northerly winds to be the most beneficial.[8] However, the most important Hippocratic treatise that describes the relationship between wind directions and public health is *De aëre aquis et locis* (*Airs Waters Places*), which was probably written by the same author as *The Sacred Disease*.[9] *Airs Waters Places* has a specific place within the Hippocratic Corpus: it describes the influence of wind directions, seasons, and their changes on the human body and was meant for travelling physicians.[10] The author distinguishes four types of cities based on their situation: those cities that are exposed to hot south winds (*Airs* 3); those exposed to cold north winds (4); cities lying towards the rising of the sun (i.e. towards the east) (5); and cities lying towards the setting of the sun (i.e. towards the west) (6). It is noteworthy that there is talk here of the north and south winds, but not of east and west winds.

If we examine the relation of wind directions to the health of the inhabitants of cities in *Airs Waters Places*, we find that the cities facing east are the healthiest be-

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5 Van Rooijen-Dijkman 1999, 308. For Varro's knowledge of medicine, see Boscherini 1993.

6 Plin. *Nat.* 29.2.4; Pinault 1992, 12; Boscherini 1993, 741. In ancient medicine, there was a strong sense of continuity.

7 Var. *R.* 1.4.4.

8 Hipp. *Morb. Sacr.* 13 (16, 170-172 Jones = 6.384 L.); cf. *Vict.* 2.37-38 (298-304 Jones = 6.528-534 L.); Kosak 2000, 37. In this chapter, I follow Jouanna's sequence (1992).

9 Jouanna 1992, 549; Jouanna 1996, 82; Lo Presti 2012, 169; Craik 2015, 11 and 195. These works are not, however, the first to mention the connection between meteorology and medicine. See already Alcmaeon, DK VS 24 B 4, 215-216; López Férez 1989, 52; Miller 1962, 129; Stamatu 2005b, col. 502.

10 *Airs Waters Places* is one of the first treatises that describes the connection between nature and human diseases from a sophisticated perspective; see Horstmanshoff & Stol 2004, 5; Cilliers & Retief 47. On travelling physicians: Hipp. *Aer.* 1-2 (70-72 Jones = 2.12-14 L.); Jouanna 1996, 10-11; Kosak 2000, 36.

cause the temperatures are moderate and the water is the best. Cities exposed to hot and cold winds are less healthy and cities facing west are the unhealthiest. However, these passages in *Airs Waters Places* cause a problem: what exactly is meant by 'lying towards the rising of the sun'?

One possibility is that we are not to understand 'lying towards the rising sun' in terms of a cardinal direction but, rather, as referring to exposure to the east wind. But such an interpretation runs into difficulties when we consider the situation of cities mentioned in chapter 5: 'those that lie towards the setting of the sun, […] while the hot south winds and the cold north winds blow past them'. A second possibility is that 'lying towards the rising of the sun' is a reference to the direction of the façades and front doors of a city. Consistency in the directions of the buildings is only possible in cities in which there are parallel streets. Some cities in the ancient world, for example Olynthus and Priene, were, indeed, constructed on a chess-board-like grid but many other cities were constructed without adhering to such a
[5] plan and it seems unlikely that the author would have restricted his reflections to this limited group of cities. A third possibility is that wind direction is determined by the coastline. On this analysis, a city 'lying towards the rising of the sun' would be a city situated on a coastline that runs on a north-south axis, like Corcyra.[11] There were, however, cities with no connection to a coastline, so, again, unless the author of *Airs Waters Places* left implicit restrictions there may have been as regards the application of his views, this possibility is not particularly attractive. A fourth option is that 'lying towards the rising of the sun' is a reference to the slopes of a hill or mountain against which the city was built. In a mountainous region like Greece it was common practice to build a city on a slope with the top of the mountain functioning as a fortress (Corinth provides a good example). The presence of a mountain can also answer the question as to what is meant by 'sheltered from cold winds' and 'exposed to hot winds'. But this hypothesis is also problematic. For instance, a person moving from one side of a city to the other should, if the city is built across a number of slopes, thereby suffer changes to his physical constitution, which hardly seems plausible.

The final possibility I will consider is that the expression 'lying towards the rising of the sun' should be understood as meaning 'situated in the east'. If one takes the central area of Greece as a starting-point, 'situated in the north' would indicate northern Greece, 'situated in the east' would be Asia,[12] 'situated in the south' would mean in Crete or Africa, and 'situated in the west' would mean Italy. *Airs Waters Places* is after all written in Greek for a Greek audience. In my opinion, this explanation is the most plausible in this context. The arguments are the following:

- The references in the text are vague but climate is *not* confined to man-made boundaries.

11 Crouch 1993, 50-51.
12 Hipp. *Aer.* 12 (104-108 Jones = 52-56 L.).

- Wind directions are described as 'between the rising and setting of the sun'. A city 'lying towards the rising of the sun' is situated between summer sunrise and winter sunrise, so in the direction of the horizon between summer sunrise and winter sunrise.[13] In *Airs Waters Places*, the cardinal directions are not indicated by straight directions but in quadrants (**fig. 1**).
- *Airs Waters Places* is written for travelling physicians. [6]

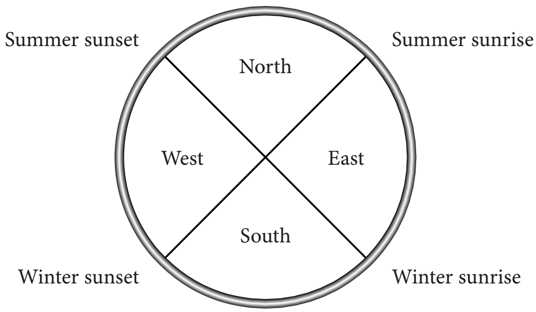

Fig. 1. *Wind directions, sunrises and sunsets.*

3. Health and wind directions: other authors

Celsus claims that northerly winds are more beneficial than easterly and southerly winds, although he also states that this depends on the region.[14] In another passage, he makes a rough division of winds into those that are northerly and those that are southerly but without indicating a clear preference; both, he thinks, are unhealthy.[15] In *On Agriculture*, Varro advises that insalubrious winds and exhalations should be avoided in general but without identifying a specific wind direction.[16] P. Agrasius has a preference for the north (see *infra*).

Vitruvius' theory gives preference to the east and the north winds, despite mentioning only the beneficial characteristics of the directions and not the specific winds themselves. The disadvantages of heat are discussed extensively here and it follows that the warm southerly winds are detrimental to the health.[17] But there is another problem, for, as Vitruvius writes, the wind's 'aspects should neither be extremely hot nor intensely cold', and this implies that the north – which is coldest – is not a good direction either. Yet he continues to describe the north and its coolness in positive terms: in summer, healthy regions change into unhealthy regions and unhealthy re- [7]
gions become healthy in winter.[18] The situation of Altinum, Ravenna and Aquileia to the north and north east (of Italy) is one of the reasons that these cities have an *in-*

13 Jouanna 1996, 34-35.
14 Cels. 2.1.3-4.
15 Cels. 2.1.10-11.
16 Var. *R.* 1.4.4.
17 Vitr. 1.4.1; Fleury 1990, 126. Cf. Gal. *Temp.* 4 (1.533 K.).
18 Vitr. 1.4.2-4; Fleury 1990, 127. People in the north are also, according to Vitruvius, stronger and

credibilem salubritatem, an 'unbelievable health'.[19] Concerning the ventilation of a city, Vitruvius states that streets should be planned in such a way that the prevailing wind, if bringing disease, is prevented from blowing in the streets. Wind must be moderate and draught must be avoided. North and south winds are unhealthy but northerly winds slightly less harmful than southerly winds. Gentle winds, however, are harmless and can even be therapeutic.[20] Like Vitruvius, Columella also keeps a more open mind concerning his preference for a wind direction. The direction of the villa – the façade? – should be exposed to the east or the south; if this is impossible, then to the north, but always away from pestilential winds.[21]

In general, our texts consider northerly winds to be more beneficial than southerly winds. The physician Sabinus is an exception. He prefers the heat and advises a southern situation with hot southerly winds.[22] He is, together with Rufus of Ephesus,[23] the only medical author who gives information on wide streets and hygiene.

4. Health and the seasons

In Graeco-Roman medicine, the practitioner needed to be aware of not only the importance of wind directions but also the influence of the seasons on public health. In the Hippocratic Corpus and Celsus, 'constitutions' (καταστάσεις, *constitutiones*)[24]
[8] are exploited as a category that brings together a range of variables, such as descriptions of oncoming diseases in combination with season changes, wind directions and sometimes regions.

Five constitutions are mentioned in *Airs Waters Places* (10) and *Aphorismi* (*Aphorisms*). Chapter 11 of *Airs Waters Places* claims that marked seasonal changes are harmful.[25] Changes in the season cause changes in the qualities of human bodies (the dry, wet, hot and cold) and these changes are generally mistrusted in Hippocratic medicine. In spring these qualities are balanced in the best way, with temperatures being neither too hot nor too cold; so in cities 'facing spring' (= east), the temperatures are also well-balanced while the other wind directions are less healthy.[26] According to *De natura hominis* (*Nature of Man*), seasons alter the four humours.[27] In

braver than people in the south: Vitr. 6.1.4; Callebat 2004, 73. Cf. the remarks concerning people and climate, paragraph 5.

19 Vitr. 1.4.11; Str. 5.1.7; Fleury 1990, 132; Potter 2005, col. 616.

20 Vitr. 1.6.1; 1.6.3; Fleury 1990, 156-157; Gros 1997, I.94 n.232.

21 Col. 1.5.

22 Sabinus apud Orib. *Med. Coll.* 9.19.

23 Rufus is cited in the Arabic treatise *K. Daf' maḍārr al-abdān bi-arḍ Miṣr* (*On the Prevention of Bodily Ills in Egypt*, ch. 6) of the Egyptian scholar Alī ibn Riḍwān († 1068); Ullmann 1974, 39-40; Haak 2013, 170.

24 Stamatu 2005a, col. 487; Stamatu 2005c, col. 613; Langholf (1990, 169) gives, in discussing the constitutions of the *Epidemics*, the translations 'condition', 'situation', and 'state'. See also Nutton 1995, 28; Hulskamp 2012, *passim*.

25 Hipp. *Aer.* 11 (104 Jones = 2.50-52 L.); Wenskus 2005, 465-466; Hulskamp 2012, 158 and 162.

26 Miller 1962, 130-132; Lo Presti 2012, 180. Other winds: south: Hipp. *Aer.* 3 (74 Jones = 2.14-16 L.); north: Hipp. *Aer.* 4 (76 Jones = 2.18 L.).

27 Hipp. *Nat. Hom.* 7 (18-22 Jones = 6.46-50 L.); Hulskamp 2012, 159.

Airs Waters Places (12) the moderate changes in season in Asia are praised and in (13) the more marked changes in season are described as unhealthy for the inhabitants of Lake Maeotis. Other Hippocratic treatises also provide evidence for the relation between seasons, wind directions and diseases.[28] In *Epidemiae* (*Epidemics*) 1 and 3, four constitutions are described[29] and here we see again the strong connection between seasons and wind direction.[30] Celsus does not attribute the various diseases to the winds, as does the author of *Airs Waters Places*, but, rather, to the seasons, in agreement with the author of *Aphorisms*. His four constitutions correspond to four Hippocratic *Aphorisms*; he declares that he is a follower of Hippocrates, sometimes also adopting the theories of later authors.[31] So, in short, all authors mentioning seasonal changes agree that there could be some relationship between wind direction, season and disease.[32] It is impossible to avoid disease entirely at any time but periods of sea- [9]
sonal change are described as particularly detrimental to one's health.[33]

5. Philosophical aspects

Is there any theoretical underpinning given for these descriptions of climate and diseases? In ancient medicine, theories were not exclusively based on perceptions, but perceptions had to correspond with theories. For example, in *Airs Waters Places*, in his polarisation between Europe and Asia,[34] the author states that in Europe, where there are noticeable seasonal changes, the landscape is mountainous and the people are 'wilder'. Therefore in Asia, with its moderate changes, the people are 'gentler' and the landscape must inevitably be flatter, because Asia is the opposite of Europe. Here, characters are determined by seasonal changes and by landscapes. Galen

28 E.g. in the *Aphorisms;* spring: Hipp. *Aph.* 3.20 (128 Jones = 4.494 L.); summer: Hipp. *Aph.* 3.21 (128 Jones = 4.494-496 L.); autumn: Hipp. *Aph.* 3.22 (130 Jones = 4.496 L.); winter: Hipp. *Aph.* 3.23 (130 Jones = 4.496 L.); Hulskamp 2012, 160.

29 On which see Langholf (1990, 171-179), Brunn (1947, 14-18 and 74-76) and Hulskamp (2012, *passim*) for an extended description.

30 Unhealthy summer: Hipp. *Epid.* 1.2 (148-150 Jones = 2.604-610 L.); unhealthy autumn and winter: Hipp. *Epid.* 1.5 (154 Jones = 2.616-618 L.); Wenskus 2005, 465. See for the seasons' influences on the human body described in the *Epidemics* also López Férez 1989, 54-56. Connotations of spring and autumn: Spring: Hipp. *Epid*. 2.1.5 (20 Smith = 5.74 L.); autumn: Hipp. *Epid*. 2.1.4 (20 Smith = 5.72-74 L.); López Férez 1989, 56.

31 Spring: Cels. 2.1.6 (= Hipp. *Aph.* 3.20); summer: Cels. 2.1.7 (= Hipp. *Aph.* 3.21); autumn: Cels. 2.1.8 (= Hipp. *Aph.* 3.22); winter: Cels. 2.1.9 (= Hipp. *Aph.* 3.23). Later authors: Cels. 2.pr.1; Gros 1997, I.88 n. 188.

32 For other references to noxious season and wind changes see Hipp. *Morb. Sacr.* 10 (13, 166-168 Jones = 6.380 L.); *Epid.* 1.1-4 (152-154 Jones = 2.598-614 L.).

33 In reality, in some cases there *is* a connection between diseases and seasons. Mosquitos are seasonal and so are coughs (winter) and digestive upsets (summer). Galen states that the Mediterranean area has the best temperature: Gal. *San. Tu.* 2.7 (6.127 K.).

34 According to Jones (Loeb edition of *Airs waters places*), 'Asia' means, respectively, Anatolia and Asia Minor: nowadays Turkey. According to Lo Presti (2012, 169), 'Europe' includes Europe from South Spain to the Maeotis Marsh; 'Asia' includes the Persian Empire, Egypt and Libya. For the polarisation between Europe and Asia, see Lo Presti 2012, 180-181 and 190-192.

agrees: not only the body but also the soul depends on these features.[35] In reality, however, Asia Minor is *not* flatter than Europe and seasonal changes are even more extreme.

Is there a reason why the east was deemed healthy and the west unhealthy? Perhaps the answer simply lies in the benevolent connotations of all things 'right' and the malevolent connotations of all things 'left'. This association is mentioned in an-
[10] cient texts from Homer onwards.[36] The Greek word σκαιός means 'infamous', 'stupid' and 'west', as well as 'left', and the west, the direction of the sunset, was ill-famed, being associated with Hades.[37]

If the west is to the left hand side, and the east is to the right, then inevitably the view straight ahead is to the north. This direction was associated with the home of the gods (Mount Olympus is in the north of Greece) or considered as the primary direction, because, from this point of view, the 'positive' right is to the east and left is to the west.[38] In addition, if we consider the wind rose, we see that the east is positioned to the right and the west to the left, and looking in the direction of the words, the north is uppermost.[39]

6. Healthy and unhealthy soil

In addition to the climate and the prevailing winds, the configuration of the ground is also important if a city is to be situated agreeably. I will now examine whether the authors who wrote on this topic had a preference for certain favourable positions. Aristotle states that the best situation for a city is on a slope, facing east or receiving the east wind. If that optimal arrangement is impossible, the city should face south instead.[40] Vitruvius agrees: the best situation is in a high place, facing neither towards the hot or cold directions, nor to the west – so facing east.[41] The situation of a city on a slope is also mentioned by Athenaeus Medicus and Antyllus, who consider the slope of a hill to be a healthy place to situate a city.[42] Columella, too, thinks that slopes provide a good situation and they are his preferred locations for farms.[43] Ac-

35 Hipp. *Aer.* 12-13 (104-110 Jones = 2.52-58 L.), 16 (114-116 Jones = 62-66 L.), 23-24 (130-136 Jones = 2.82-92 L.). Cf. Stamatu 2005b, col. 502; Boudon-Millot 2014, 8. Galen: Gal. *QAM* 8 (4.798-803 K.). Cf. Van der Eijk 2005, 225 and Lo Presti 2012 *passim*.

36 Lloyd (1966, 37) states: the adjective 'right' may mean (1) morally good ('do the right thing'), (2) true or correct (the 'right' use of words, the 'right' way of doing something) and (3) sound or sane (in your 'right' mind), while 'right' the substantive stands for a legal entitlement ('right' of way, 'right' to the throne). Cf. *ibid.* 42; on p. 47 he discusses the association right = east = good, left = west = bad since Homer: *Il.* 12.238-240. Cf. Lloyd 1996, 114. At p. 135, he mentions that Aristotle describes 'right' as naturally superior; it is an ἀρχή, 'starting-point' (*Met.* 986a23-26).

37 LSJ s.v. σκαιός. Infamous west side: Wirth 2010, 15-16 (with commentary); 243. See for the negative connotation of 'left' Wirth 2010 *passim*; Masselink 1956, 25-26.

38 Wirth 2010, 79-80.

39 For the north as starting-point see also Obrist 1997, 40.

40 Arist. *Pol.* 1330a38-41; Wycherley 1962, 31.

41 Vitr. 1.4.1; Fleury 1990, 126; Gros 1997, I.88 n. 187.

42 Ath.Med. apud Orib. *Med. Coll.* 9.12.1; Antyll. apud Orib. *Med. Coll.* 9.11.1.

43 Col. 1.4.10.

cording to Sabinus, in cities not situated on a slope but in a flat area, the wind can remove polluted air and the sun can shine on all the streets, since none will be shaded by the landscape. Other cities, built in a flat area but with an irregular street pattern and winding streets, receive either less or no sunshine at all or are subjected to harmful winds, causing draughts.[44] Polluted air remains in the lower part of the city, so city quarters that are built higher up have fresher air (a striking example of this is [11]
Rome).[45] In short, all authors prefer a slope, both from a strategic and a hygienic point of view.

In many cases, flat areas contain marshes, usually considered to be unhealthy.[46] Varro thinks that marshes near villas are extremely unhealthy. He speaks of small marsh creatures (*animalia minuta*), so minute that they are invisible to the eye, which float in the air and enter the body through the mouth and nose, causing serious diseases.[47] Like Varro, Vitruvius speaks of marsh creatures but calls them *bestiae palustriae*.[48] Columella and Pliny the Elder also advise against agriculture in the vicinity of marshes, as do Antyllus and Galen. Athenaeus Medicus describes marshes as pathogenic areas, especially in summer, a sentiment which Antyllus shares.[49]

7. Practice: general aspects of meteorology and city planning

So according to the sources considered thus far, a city should be on high ground, receiving fresh air. Its aspects should be neither extremely hot nor extremely cold, but temperate. Marshes must be avoided and the east is the best direction. Did cities exist which fulfilled all these conditions?

A settlement or city can be established either spontaneously or in a planned way. As far as its situation is concerned, this will, in the first instance, depend on the local terrain. For instance, a city situated on the east coast, along a north-south running coastline, will inevitably be orientated to the sea in the east and a city will be erected on a slope when there is one available.

What about the orientation of cities and buildings? In the preceding discussion it was mentioned that 'situated to the north' could refer to the direction of the façades and front doors of a town house and that the situation of the doors is mainly determined by the street pattern.[50] An important question is whether there is actually any [12]

44 Sabinus apud Orib. *Med. Coll.* 9.20.1-7; Nutton 2000, 69-70.

45 Sabinus apud Orib. *Med. Coll.* 9.20.8. Air pollution was one of the causes that rich people escaped from Rome to villas in the countryside: Mudry 2006, 234. Cf. Ath.Med. apud Orib. *Med. Coll.* 9.5.5-6 and 9.12.1-4.

46 Hipp. *Aer.* 7 (84-86 Jones = 2.26-28 L.); the author continues to enumerate many diseases, caused by drinking stagnant water.

47 Var. *R.* 1.12.2; Sallmann 1986, 216-217; Boscherini 1993, 749.

48 Vitr. 1.4.1; 1.4.11; Fleury 1990, 125-126; Sallmann 1986, 219-220. Cf. Lucr. 6.1096-1102.

49 Col. 1.5.6; Plin. *Nat.* 18.33; Sallmann 1986, 220-221; Nutton 2000, 69. Antyll. apud Orib. *Med. Coll.* 9.11.4; Gal. *Diff. Feb.* 1.6 (7.289-290 K.); Ath.Med. apud Orib. *Med. Coll.* 9.12.6; 9.12.8; 9.12.10; Nutton 2000, 67. Sallares' reference (2002, 61 n. 43) to this citation (Ath.Med. apud Orib. *Med. Coll.* 9.2.10) must be 9.12.10.

50 E.g. Hoepfner & Schwandner 1994, 83 and 87 (Olynthus) and 214 (Priene).

coincidence between street orientations and wind directions? On the one hand, city planners were subjected to local circumstances, as Fleury states. Street patterns of planned Roman cities, for example, usually follow the directions of rivers and reliefs. On the other hand, Strabo and Diodorus praise the orientation of the streets of Alexandria; following its grid plan, the northwesterly Etesian winds can blow through the northwest-southeasterly running streets. Vitruvius mentions Mytilene as a city that has been poorly planned with respect to the winds. In Goritsa, a forced north-south street pattern is found, although considering the shape of the city outline one would expect diagonally running streets. It seems likely that meteorological circumstances were crucial for street design.

Although Miletus and Priene are close to each other (so they enjoy the same meteorological conditions), their orientations differ. In Miletus, the streets follow the landscape and, thus, run slightly diagonally. However, in Priene, founded later, the orientation is exactly north-south and it is possible that, as in Goritsa, this is due to meteorological considerations.[51]

Perring states that in Britain 'Even in the later period many Romano-British houses were built without any particular concern for the distinction between east and west. Other issues, of location and aspect, were of greater importance'.[52] In short, there is no clear evidence that the orientation of real buildings took place according to the advice of the authors. Other factors, depending on the actual situation, such as the presence and direction of rivers and water sources, as well as infrastructure and local customs, were at least as important. Therefore, Varro's changing of the orientation of door and windows was exceptional.

8. Practice: marshes

In the ancient world marshes were considered to be dangerous areas where malaria was common but they could be reclaimed and made habitable, as they sometimes were by the Romans. According to literary tradition, King Tarquinius built the Cloa-
[13] ca Maxima in order to drain the marsh between the hills, the later Forum Romanum.[53] Settlements near marshes could also be moved – Vitruvius mentions Salpia in Apulia, first situated in a marshy region but later removed to a healthier environment[54] – but they were more usually maintained in their original locations (Strabo mentions a vast marsh in the neighbourhood of Tarracina, for instance).[55] Cosa, a

51 Local circumstances: Fleury 1990, 150 with references. Roman cities: Le Gall 1975, 311-318. Alexandria: Str. 17.1.7; Jones 1932, 267. D.S. 17.52; Hoepfner & Schwandner 1994, 237. Mytilene: Vitr. 1.6.1. Miletus and Priene: Hoepfner & Schwandner 1994, ill. 11 and 179. Goritsa: Cahill 2002, 17, 'Although Goritsa could have been laid out on a very regular grid oriented northeast-southwest, it was in fact oriented almost due north-south'.

52 Perring 2002, 143-145. For more villas see Becker & Terrenato *passim.*

53 Liv. 1.38.6; see for more references Bauer 1993, 288.

54 Vitr. 1.4.12; Fleury 1990, 132-133.

55 Pliny the Elder mentions 24 former cities, arguing that it's a wonder: *Nat.* 3.5.59; Borca 2000, 79-80; Walsh, Attema & De Haas 2014, 37. Cf. Str. 5.3.6 (Tarracina); Nutton 2000, 84 n. 2; Sallares 2002, 168-191.

former *colonia* (273 BC) was situated strategically on a hilltop and was comparable with Olynthus and Priene. However, the city was not a success, due to it being plagued by malaria.[56]

Malaria was common, not only in the areas around Rome but also in Rome itself, due to floods and the presence of stagnant water. The pathogenic south winds transported malarial mosquitoes from the Pontine Marshes and other marshy regions to Rome. Whether they were dry or wet, these winds caused fever.[57] Empirical observations may have prompted Varro and Vitruvius to discuss marsh animals (respectively *animalia* and *bestiae*) as the cause of these diseases.[58]

9. Varro's measurements: true or false?

We can now return to our point of departure: Varro's text. Did Varro actually take measures to change the positions of the door and windows in Corcyra? To answer this question, we have to take account of the views of ancient authors, including those concerned with medicine, as well as the actual situation in Antiquity and Varro's (Scrofa's) text. The central question is whether the story concerning Varro's precautions is apocryphal or not. One way of approaching this question is to consider whether the text says that Varro changed just one door or several. Both Heurgon and [14]
Hooper & Ash translate *ianuaque* in the plural (respectively 'changé la place des portes" and 'changing the position of the doors") but, since it defies belief that many houses could have been rebuilt in a short period of time, if we accept this reading then there are good grounds for supposing the story to be apocryphal. If, however, we translate *ianuaque* in the singular (and it *is* a singular form, according to all MSS), then Varro will have changed only one room or a building with one door (plus some windows), a story that is much more credible. The fact that Varro is explicitly said to have saved his own people,[59] rather than all the sick, provides further important support for the claim that his modifications were limited to a single structure.

Scrofa refers to a legend about Hippocrates: Varro would have aided the recovery of the sick in one building, but Hippocrates would have saved entire regions. Maybe this is a reference to (hyperbolical and apocryphal) letters of Hippocrates:

> 'Did not the famous physician, Hippocrates, during a great pestilence save not one farm but many cities by his skill?' (Varro, *On Agriculture* 1.4.5).

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56 Sidonius Apollinaris 1.5.8; Sallares 2002, 64-72. Cosa: Ward-Perkins 1974, 27 and fig. 45; Owens 1991, 107-108. Malaria in Cosa: Sallares 2002, 250-251.

57 Sallares 2002, 201-226. In his opinion, malaria could be the disease with which besiegers of Rome were confronted. Pathogenic south winds: Arist. *Pr.* 862a; Plu. *Moralia* (*De Curiositate*) 515c; Plin. *Nat.* 2.48.127, but see especially Celsus: Cels. 1.10.4; 2.1.15; cf. Palladius 1.7.4. Nevertheless, other winds could also cause fevers: Cels. 2.1.16; Sallares 2002, 73-74; Walsh, Attema & De Haas 2014, 29-30.

58 The fact that the malaria mosquito is responsible for malaria was first discovered in the 19th century. See Sallmann 1986, 222-228 for the right statements of Varro, Vitruvius and Palladius on the development of early modern microbiology.

59 Heurgon 1978, 121 'Les mesures d'hygiène qu'il a prises ne portaient que sur le bâtiment qu'il occupait avec son État-Major et ses esclaves'.

> *An non ille Hippocrates medicus in magna pestilentia non unum agrum, sed multa oppida scientia servavit?*

> 'Whereas Hippocrates of Cos, being a physician and descended from Asclepius, has shown great concern for the safety of the Greek people. And whereas on the occasion of a plague coming from the land of the barbarians towards Hellas, he sent out his pupils to different places to proclaim what therapies they had to use to keep themselves safe from the imminent plague, and, in order that medical science bequeathed to the Greeks would preserve safe those that were ill from it, he generously published his writings on medical science because he wanted there to be many physicians who saved people.' (Hippocratic Corpus, *Epistulae* (*Letters*) 25 (106-107 Smith 1990 = 9.400 L.).
>
> Ἐπειδὴ Ἱπποκράτης Κῷος [...] σώζοντας ὑπάρχειν ἰατρούς.

> [Thessalos is speaking] 'The benefaction of my father Hippocrates [...]. In the time in which the plague was running through the barbarian land north of the Illyrians [...]. And he (Hippocrates) made inquiry what kinds of disturbances there were, area by area, in heat and winds and mist and other things that produce unusual conditions [...] he arranged to announce to the Thessalians by what means they
> [15] could contrive protection against the evil that was coming, and, writing down the therapy, he posted it around the cities.' (Hippocratic Corpus, *Letters* 27.7 (116-119 Smith 1990 = 9.418 L.).
>
> Εὐεργεσίην Ἱπποκράτους [...] περὶ τὰς πόλιας.

Pliny the Elder mentions a similar story about Hippocrates:

> 'In medicine, Hippocrates, who foretold a plague that was coming from Illyria and despatched his pupils round the cities to render assistance.' (Pliny the Elder, *Historia naturalis* [*Natural History*] 7.123).[60]
>
> *Hippocrates medicina, qui venientem ab Illyriis pestilentiam praedixit discipulosque ad auxiliandum circa urbes dimisit.*

The legend is roughly as follows: Hippocrates saved northern Greece from a plague coming from Illyria by sending his collaborators, including his own sons, to the region; his precautions were successful and he published these results.[61]

But which precautions are meant? There is no reference at all to changing the positions of doors or windows. On the other hand, there are (exaggerated) stories concerning Hippocrates' recommendation that precautions be taken against plagues

60 But does Pliny refer to the same story of Hippocrates as Varro? Indeed, according to Flach (2006, 246), the Loeb edition of Varro (Hooper & Ash 1935, 186) and Heurgon (1978, 121), but according to Boscherini (1993, 742) this point of view is not proven: Varro does not speak of a specific epidemic from Illyria.

61 Varro: Pinault 1992, 43-45. Hippocrates: Hipp. *Epist.* 25 (106-107 Smith 1990 = 9.400 L.); Hipp. *Epist.* 27.7 (116-119 Smith 1990 = 9.418 L.). Pliny: Flach 2006, 246; Pinault 1992, 44; Smith 1990, 3-4.

by lighting fires. Both the apocryphal letters of Hippocrates and Pliny's citation mention precautions taken *around* the cities (περὶ τὰς πόλιας and *circa urbes*). According to Scrofa, Varro improved the situation in Corcyra not by lighting fires but by changing the positions of windows and doors. In Varro's book, the orientation of doors and windows is of crucial importance for constructing a villa, as is stated in the previous lines: 'The situation of the buildings, their size, the exposure of the galleries, the doors and the windows, are matters of the highest importance' (*quod permagni interest, ubi sint positae villae, quantae sint, quo spectent porticibus, ostiis ac fenestris*).[62] The comparison between Varro and Hippocrates seems intended to identify differences in scale (Varro's works are small-scale, *unum agrum*, affecting only one building; Hippocrates' are large-scale, *multa oppida*, affecting complete cities) rather than differences in the precautions taken. If Hippocrates had changed the [16] positions of doors and windows, his collaborators would have been, inevitably, *inside* the cities.

Which sources did Varro draw upon for his knowledge of wind directions? Being the author or compiler of the *Disciplinae*, including works describing astronomy, architecture and medicine,[63] he must have had knowledge of the different wind directions and their influences on public health. This topic is mentioned for the first time in Graeco-Roman literature in the Hippocratic Corpus and Varro did have knowledge of Hippocrates, as mentioned at the beginning of this chapter. In *On Agriculture* (1.2.4), P. Agrasius, a publican and guest at the meeting, states that the north is healthier than the south and this could explain why Varro allows the north wind in Corcyra; in his opinion, a north wind is more beneficial.[64]

Not only did Varro arrange for the north wind to have free access but he also ensured that 'pestilential winds' (*pestilentibus*) were excluded. From which direction did these polluted winds come? It is possible that they came from a marsh, situated south or west of Corcyra, or from the exhalations of seriously injured people and from corpses, emanating from adjacent rooms or buildings. We cannot know the origins of these pestilential winds with any certainty but what *is* clear is that Varro does consider the winds to be bringers of health or disease.[65]

According to ancient criteria, Corcyra must have come close to being the ideal city. It was situated to the east, on the eastern coastline of the island. It was built against a slope, underwent only minimal changes of temperature across the different seasons, and had a fresh north wind during the summer.[66] Perhaps these conditions led Varro or other leaders to choose Corcyra as a place for recovery and convalescence. However, the particular building in which Varro's patients were housed was not suitable for the convalescents. Corcyra was a healthy city but the health-bringing north wind was not admitted in to the sick-room and the door was constructed in the wrong place.

62 Var. *R.* 1.4.4.

63 Van Rooijen-Dijkman 1999, 308; Janssen 1979, 217.

64 For Varro's preference for fresh northern wind see Boscherini 1993, 749.

65 Boscherini 1993, 749.

66 Bürchner 1921, 1404; Strauch 2008, 753.

Which pestilential winds is Varro referring to when he discusses the situation in the sick-room in Corcyra? Perhaps marshes in the neighbourhood of Corcyra, areas with stagnant water caused by abundant rainfall, created a breeding-ground for insects or *animalia minuta*.[67] It is possible that due to a temporary wind direction, a
[17] pestilential wind gained access to the sick-room through the original windows and door, blocking the fresher and healthier north wind. Added to this, it is also possible that other sick-rooms close to Varro's room, possibly containing dead bodies, spread stinking, polluted air.

To summarise, in answering the question of whether Varro actually took measures to improve the situation in Corcyra we must consider the following points: 1) Varro was well-versed in medicine and meteorology; 2) Corcyra must have had a reputation as a healthy place; 3) according to the MSS there was only one *ianua*, so Varro's reported actions probably concerned only one room or building; 4) Varro was a commander, so he would be in a position to order the changing of the position of the door and windows; 5) pestilential winds were caused either by the presence of the sick and/or dead bodies in adjacent rooms or by the presence of pathogenic marshes in the south of the island. Putting these points together, it seems that there is little reason to doubt the truth of Scrofa's story of Varro's reconstruction of the building.

Conclusion

Some authors in the Graeco-Roman world concerned themselves with describing the various conditions that needed to be met in order to ensure that a city was situated in a healthy position. *Airs Waters Places* (from the Hippocratic Corpus) concentrates on the influence of climate and the configuration of the land on the people who lived in cities and some diseases here are related to corresponding wind directions. The Hippocratic *Aphorisms* describe the connection between seasons and diseases. Later authors give more empirically grounded advice concerning the salubriousness of the various positions of cities, including arguments concerning the influences of the seasons, the heights, and the proximity of marshes. Varro, Vitruvius, Columella and Sabinus also discuss aspects of city and estate planning, but their discussions were influenced and informed by older treatises. Sometimes, a city came close to conforming to the ideal, as was the case with Corcyra: the situation of this city, its climate and its environment were coincidentally very similar to those approved by the majority of our authors. But cities were more normally planned and built for other reasons: economic, social and military factors played a crucial role.

According to Vitruvius, an architect had to know about medicine, including meteorology, but city planning and architecture were apparently not embedded in medicine. While some ancient physicians do discuss city planning (see Sabinus and

67 In 1537, during the Turkish attack, a lot of inhabitants of Corfu fled into local marshes: Nicander Nucius 84.3. According to http://www.islandsinfo.com/corfu_greece.htm (seen 11 June 2012), nowadays there are still marshes in the neighbourhood of Lake Korission, south of the city.

Rufus) this is not common. Varro, Vitruvius and Columella, on the other hand, are [18] not just medical authors but well-rounded scientists with a broader array of interests. It appears, then, that ancient medicine was restricted to the human body itself and not to its urban and environmental context.

In his book *On Agriculture*, Varro describes how he cured many of his sick comrades and servants by changing the positions of the door and windows that determined the flow of air through the sick-room, admitting the fresh, beneficial north wind and keeping away other pestilential winds. If this story is true (and I believe that it is), Varro was exceptional in putting into practice his theoretical knowledge of both meteorology and medicine.

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Samenvatting in het Nederlands

In onze moderne tijd wordt aan het goed functioneren van infrastructuur grote aandacht besteed. Sinds de 19e eeuw zijn op grote schaal wegen, spoorlijnen, kanalen, viaducten, bruggen, tunnels, riolen en waterleidingen aangelegd en dit proces gaat door tot op de dag van vandaag. Reeds lang geleden zijn hindernissen als muren en poorten gesloopt en grachten gedempt. Doorstroming – voor alle soorten verkeer – is cruciaal voor de leefbaarheid en de economie.

In het hier gepresenteerde onderzoek heb ik getracht aan te tonen dat ook in de Grieks-Romeinse wereld de doorstroming als een cruciaal punt werd beschouwd. Er waren echter wel enkele verschillen met de steden en infrastructuur in onze tijd. De steden waren kleiner en naast het wegverkeer en de aan- en afvoer van drinkwater respectievelijk afvalwater was er ook de stadsdefensie: muren of wallen die om de steden heen lagen. Stadspoorten vormden dus knooppunten waar de diverse vormen van infrastructuur werden gebundeld.

Niet alleen de infrastructuur zelf, ook datgene wat via de infrastructuur wordt getransporteerd moet aan hoge kwaliteitseisen voldoen om de (Grieks-Romeinse) stad leefbaar te houden. Voedsel (via de weg of waterweg) en water (via een aquaduct of, in bepaalde gevallen, opgevangen in cisternen) moeten de bevolking in stand houden en gezond houden. Om aan die voorwaarden te voldoen dient naast de weginfrastructuur tevens het waterleidingnet in staat te zijn de aanvoer gestaag en zonder oponthoud door te laten gaan. Hetzelfde geldt voor afval: ook dit moest zonder problemen de stad kunnen verlaten, over de weg of per pijp.

Evenals tegenwoordig werd ook in de Grieks-Romeinse wereld het functioneren van een stad of gebied soms vergeleken met een menselijk lichaam. In beide gevallen is sprake van voedsel- en drinkwatervoorziening, uitscheiding van afvalproducten en een interne infrastructuur die de producten naar en van hun plaats moet brengen en als zodanig de stad c.q. het lichaam in stand moet houden. Evenals in de stad heeft in het menselijk lichaam elk onderdeel een eigen functie. Wanneer de infrastructuur echter niet meer kan functioneren – te weinig capaciteit, een onderbreking of een verkeerde inhoud – komt de doorstroming in gevaar en lopen lichaam en stad de kans ziek te worden met uiteindelijk de dood als gevolg. De infrastructuur móét in bedrijf zijn en blijven. Stadsbesturen zagen in dat iedereen baat had bij een goed functionerende stad – en dus een gezonde stad – en troffen voorzieningen om de leefbaarheid van een stad te optimaliseren.

De antieke medische auteurs hadden kennis van het menselijk lichaam, maar niet van stadsbeheer en -infrastructuur (omgekeerd schrijft Vitruvius, onze voornaamste bron op het gebied van stadsinrichting, dat architecten en stadsplanners wel enige kennis van geneeskunde moeten hebben). Genezing was gericht op individuen, niet op groepen en ook werd geen verband gelegd tussen ziekte en stadsvuil dat overal aanwezig was. De ideeën van de medische auteurs waren grotendeels gebaseerd op theorieën en speculatie en dit was ook onvermijdelijk: men had immers geen kennis van bacteriologie en hygiëne in de moderne zin des woords en ziekten werden ook wel toegeschreven aan 'kwade machten'. Zo stonden de meningen betreffende het ideale drinkwater en de overlast van fecaliën en urine van de medische auteurs ver af van die van de meer praktijkgerichte stadsbestuurders, planologen en architecten – soms zelfs diametraal.

In onze tijd wordt velerlei terminologie gebruikt in de architectuur, civiele techniek en stadsplanning die verwijst naar lichaamsdelen, en omgekeerd: maagportier, leverpoortader, Groene Hart, groene longen, maag-darmkanaal en flessenhals, om er een paar te noemen. In de *Introduction* komen enkele van deze termen uit de Grieks-Romeinse wereld aan bod. Ook in de Grieks-Romeinse wereld zag men dus overeenkomsten tussen het functioneren van het menselijk lichaam en de stad.

Errata and Corrigenda

Traffic Policy and Circulation in Roman Cities

On p. [150], I had mentioned that the Forum of Pompeii was situated on the top of a hill. This is not right; the Forum is situated on a running-down slope.

p. [150]:

On the top of a hill	changed into	on a running-down slope (p. 32).

E. Moormann also remarked the expression (at the same page) 'chess-board grid'. In case of a genuine chess-board, the fields are exactly square; the map of Pompeii shows, however, that the eastern part of the built-up area is divided into rectangular parts instead op square parts. However, the street grid is Hippodamic; the corners are right.

p. [150]:		
chess-board grid	changed into	Hippodamic grid (p. 32).
p. [153]:		
Vico di Mercurio	changed into	Vicolo di Mercurio (2×) (p. 34).
Vico di Modesto	changed into	Vicolo di Modesto (p. 34).
p. [157 n. 25]:		
Vico di Mercurio	changed into	Vicolo di Mercurio (5×) (p. 38 n. 25).
Vico di Modesto	changed into	Vicolo di Modesto (p. 38 n. 25).
Vico di Vettii	changed into	Vicolo di Vettii (p. 38 n. 25).

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

p. [4]

Hipp. *Vict.* 32	changed into	Hipp. *Vict.* 1.32. (p. 89 n. 7).

p. [5]:		
Hipp. *Aer.* 7	changed into	Hipp. *Aer.* 8 (p. 89 n. 8).
p. [8 n. 13]:		
Gal. *San. Tu.* (6.56 K.)	changed into	Gal. *San. Tu.* 1.11 (6.56 K.) (p. 92 n. 20).
p. [13 n. 21]:		
Gal. *San. Tu.* (6.57 K.)	changed into	Gal. *San. Tu.* 1.11 (6.57 K.) (p. 96 n. 42).
p. [15]:		
Gal. *San. Tu.* (6.56-58 K.)	changed into	Gal. *San. Tu.* 1.11 (6.56-58 K.) (p. 98 n. 53).

A 'Healthy Mistake': The Excrement Problem from Ancient Greece to Nineteenth Century Holland

p. [109]:		
advices	changed into	recommends (p. 148 and 149).
p. [110]:		
Advices	changed into	Recommendations (p. 149).
p. [112]:		
advices	changed into	advice (p. 153, 2×).

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