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The interpretation of pollen assemblages from medieval and post-medieval cesspits: New results from northern Belgium

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ABSTRACT

Pollen has been studied from cesspits and other archaeological structures containing human faecal remains from different sites in northern Belgium, dating from the 12th to the 17th century. The results show that a large amount of information can be obtained by analysing pollen from such archaeological features. In addition, it is demonstrated that this information is largely complementary to the results obtained by the analysis of botanical macro-remains. The consumption of different food plants like herbs, spices and leafy vegetables, but also the use of honey, pharmaceutical plant use, and the use of peat fuel is reflected in the pollen assemblages from the studied archaeological structures. Most of this information cannot be obtained through the analysis of botanical macro-remains.

1. Introduction

Cesspits, latrines, sewers, garderobe chutes and other kinds of structures containing human faecal material are frequent finds during archaeological excavations in historic urban areas in NW Europe (Sabine, 1934; Greig, 1982a; Addyman, 1989; Van Oosten, 2015). These structures are a very important source of information on former diet, medical practices and other types of plant use. Next to a general good preservation of botanical remains, the direct relation between the botanical content of the faecal material and ingested plant material facilitates interpretation of the results, at least for the botanical macro-remains, like seeds and fruits. Therefore there are numerous studies of botanical macro-remains recovered from this type of archaeological feature (e.g. Moffet, 1992; Dickson, 1996; de Hingh and Bakels, 1996; Hellwig, 1997; Badura, 2003; Märkle, 2005; Fairbairn, 2007; Smith, 2013; Badura et al., 2015). Pollen analysis on the other hand is only very occasionally applied to this kind of archaeological features (Greig, 1994; Smith, 2013). The main reason for this is the general lower taxonomic identification level of pollen compared to seeds and fruits. As a consequence, many crop plants cannot be detected by pollen analyses as they belong to pollen types that contain several taxa or even whole families. Another important obstacle in the interpretation of pollen assemblages from such features is that it can be very hard to identify how the identified pollen types ended up in the cesspit because of the many possible sources from which these pollen types can originate (Greig, 1982a,b, 1994).

The few published pollen analyses of medieval and post-medieval cesspits and latrines however suggest that, despite these constrains, a large amount of information can be obtained by analysing pollen from such archaeological features. Moreover, this information seems to be largely complementary to the results obtained by the analysis of botanical macro-remains (e.g. Greig, 1981, 1982b, 1994; Knights et al., 1983; Jankovská, 1987; Kuijper and Turner, 1992; Horrocks and Best, 2004; Kalis et al., 2005; Deforce, 2010). This paper now presents the results of pollen analysis of medieval and post-medieval cesspits and other archaeological structures containing human faecal remains from northern Belgium. Issues like the possible origin of specific pollen types, possible taxonomic identification levels and the complementarity of pollen analyses with analysis of botanical macro-remains are discussed. The results are not only important for future analysis of cesspits but can also be useful for the study of gut contents, coprolite analysis and urban archaeological deposits in general.

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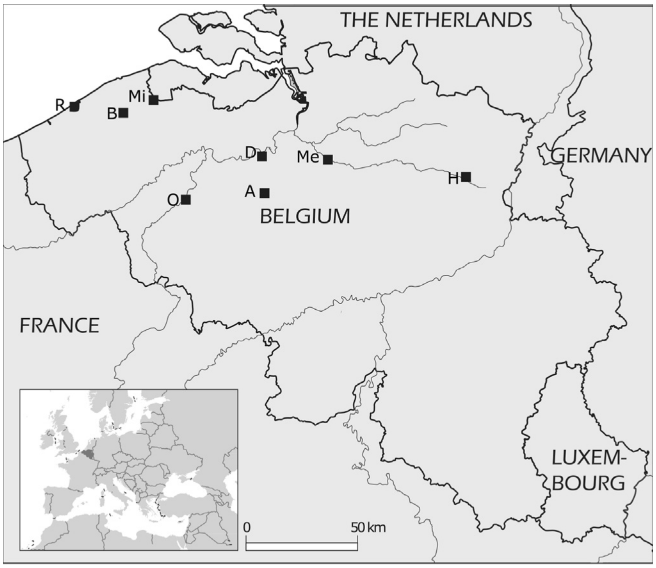

Fig. 1. Location of the studied sites. A: Aalst (including Aalst – Hopmarkt and Aalst – Stadhuis), B: Bruges, D: Dendermonde, H: Herkenrode, Me: Mechelen (including Mechelen – Begijnenstraat, Mechelen – OLV and Mechelen – Het Steen), Mi: Middelburg, O: Oudenaarde, R: Raversijde.

2. Material and methods

A total of 40 samples from 23 features originating from 11 different sites from northern Belgium, which date from the 12th to the 17th century, have been studied. All studied sites are located in Northern and Central Belgium (Fig. 1). From every studied structure, one or more samples were taken from that part of the fill that consisted of 'pure fecal material', avoiding layers of coarse debris and other waste that had been thrown in the cesspit.

The studied feature type and age are given in Table 1. More detailed context information on the different sites and the archaeological structures analysed are given by De Groote et al. (2004) for Aalst – Stadhuis I and De Groote et al. (2009) for Aalst – Stadhuis II, Deforce et al. (2007a) for Brugge, Beeckman and Van Hecke (2016) for Dendermonde, De Groote (in press) for Herkenrode; De Groote et al. (2011) for Aalst – Hopmarkt, De Groote (2008) for Oudenaarde - Kasteel, Troubleyn et al. (2009) for Mechelen – het Steen, De Clercq et al. (2007) for Middelburg and Pieters et al. (2013) for Raversijde.

Samples were processed using standard techniques for pollen analysis (Moore et al., 1991). Identifications of pollen and spores are based on Moore et al. (1991), Beug (2004), Valdés et al. (1987), Reille (1992, 1994), Punt et al. (1976–2003), and a reference collection of modern pollen and spores, stored at the Flemish Heritage Institute (Brussels). Percentages are based on the sum of all pollen types (ΣP). Spores and intestinal parasite eggs are excluded from this sum. Intestinal parasite eggs have been studied using the same slides as for pollen analysis. Most intestinal parasite eggs have dimensions comparable to pollen and are resistant to the chemicals used for pollen preparations (Wharton, 1980; Bouchet et al., 2003a). As a consequence, pollen slides can also be used for the study of intestinal parasites (e.g. Brinkkemper and Van Haaster, 2012) although some taxa might be lost or underrepresented using standard pollen preparation techniques (e.g. Dufour and Le Bailly, 2013). The identification of intestinal parasite eggs is based on Thienpont et al. (1979).

3. Results

Results from 6 sites have previously been published (see references in Table 1) and only the presence of some specific pollen types in the pollen assemblages of these samples are presented here (Table 1). New results from 19 samples collected from 11 different features and 7 sites are presented in Table 2.

Table 1
Mean value (*) and presence (v) of selected pollen types and macro-remains in the studied archaeological features.

Site	Feature	Feature type	Age	Reference pollen	nb of analysed samples	Cerealia (%)*	*Fagopyrum*	*Anthriscus cerefolium*	*Borago officinalis*	*Capparis spinosa*
				Pollen						
Aalst-Stadhuis II	SP58	unlined cesspit	12B	De Groote et al. (2009)	1	44	–	v	–	–
Aalst-Stadhuis II	SP110	unlined cesspit	12d–13a	De Groote et al. (2009)	2	34	–	–	–	–
Aalst-Stadhuis II	SP116	unlined cesspit	13b–d	De Groote et al. (2009)	1	48	–	–	–	–
Mechelen-Grote Markt	SP2	brick-lined cesspit	13c–14a	Troubleyn et al. (2009)	3	36	–	v	v	–
Mechelen-Grote Markt	SP4	brick-lined cesspit	13c–14a	Troubleyn et al. (2009)	2	31	–	v	–	–
Aalst-Hopmarkt	II/I-26	unlined cesspit	14a–d	This publication	2	52	–	v	–	–
Brugge-Prinsenhof	XIV/113-1	brick-lined cesspit	14d–15d	Deforce (2010)	2	24	–	v	v	–
Brugge-Prinsenhof	XV/68-3	brick-lined cesspit	14d–15d	Deforce (2010)	2	35	–	v	v	–
Oudenaarde-Kasteel	SP289	barrel-lined cesspit	15b	This publication	2	57	–	–	v	–
Aalst-Hopmarkt	XIV B/A6	brick-lined cesspit	15d	This publication	3	35	–	v	v	v
Oudenaarde-Kasteel	SP225	garderobe chute	15a–d	This publication	1	37	–	–	v	–
Raversijde	655	barrel-lined cesspit	15a–d	Deforce (2006, 2013)	1	10	v	v	–	–
Raversijde	1554	barrel-lined cesspit	15a-d	Deforce (2006, 2013)	1	27	v	v	–	–
Raversijde	418	barrel-lined cesspit	15a–d	Deforce (2006, 2013)	1	11	v	–	–	–
Aalst-Hopmarkt	4	unlined cesspit	16A	This publication	1	45	v	v	–	v
Aalst-Stadhuis I	6	brick-lined cesspit	16a	De Groote et al. (2004)	2	36	v	v	–	–
Dendermonde	WP1	brick-lined cesspit	16a–c	This publication	3	26	v	v	v	v
Herkenrode	SP212	brick-lined cesspit	16d–17a	This publication	2	20	v	v	v	v
Mechelen-OLV	SP193	unlined cesspit	16a–d	This publication	1	33	–	v	–	–
Mechelen-OLV	SP37	brick-lined cesspit	16a–d	This publication	1	41	v	v	–	–
Middelburg	chute B	garderobe chute	17a	De Clercq et al. (2007)	3	9	v	v	v	–
Mechelen-Begijnenstr.	WP2	brick-lined cesspit	17a–d	This publication	2	20	v	v	v	v
Brugge-Prinsenhof	IX/1	brick-lined cesspit	17a–d	This publication	1	25	v	v	–	v

The pollen assemblages of all samples are characterised by low arboreal pollen values (1.6%–32.5%), a high taxonomic diversity and a high number of insect-pollinated taxa. Cerealia and Poaceae show high percentages in all analysed samples. *Anthriscus cerefolium*, Myrtaceae, Brassicaceae, *Calluna vulgaris*, *Centaurea cyanus*, *Matricaria* type, *Rumex acetosa* type and *Trifolium repens* type are also abundant in most of the analysed samples. *Capparis spinosa*, *Sambucus nigra* type, *Genista* type and *Gratiola officinalis* show exceptionally high values, but always in samples of one individual feature only.

4. Interpretation and discussion

4.1. Possible sources for the identified pollen types

4.1.1. Food

Despite its high nutritional value, pollen has most probably never been part of the European tradition of eating habits, as it has among native American cultures (Linskens and Jorde, 1997). Nevertheless, a large part of the pollen present in the cesspits is likely to result from the consumption of food, being that the pollen was ingested unintentionally. Most vegetable food will contain pollen from the food plants themselves, even long after the flowers have withered and vanished, but potentially also a small number of pollen from other plants that grew in the vicinity of that plant (Greig, 1994). Also many other food types (e.g. drinks, honey, …) can contain considerable amounts of pollen. Once ingested, the outer wall (or exine) of most pollen types will pass the human digestive tract morphologically unaltered (Linskens and Jorde, 1997; Dean, 2006; Kelso and Solomon, 2006).

4.1.1.1. Cereals and other staple foods. All samples are dominated by pollen of Cerealia (cereals), or at least have high percentages of this pollen type. Within the group of Cerealia, only *Secale cereale* (rye) has been identified to species level. High percentages of Cerealia pollen are a common feature of medieval and post-medieval cesspits which is generally explained by the consumption of cereal-based food such as bread or porridge (Greig, 1981; Jankovská and Kratochvílová, 1988; Troubleyn et al., 2009; Deforce, 2010). As most cereals are autogamous, a large number of pollen remains in the hulls. Pollen analysis of recent ears and mature seeds of cereals showed not only high amounts of Cerealia pollen but also lower numbers of pollen from the surrounding vegetation, especially arable weeds (Robinson and Hubbard, 1977; Jankovská and Kratochvílová, 1988; Joosten and van den Brink, 1992). Part of this pollen ends up in cereal based food products after cereal processing and food preparation. Cereal based drinks like beer can also contain considerable amounts of Cerealia pollen (Rösch, 2005) and is also a potential source of this pollen type.

Another explanation for the high percentage of Cerealia pollen would be straw or threshing debris that has been thrown into the cesspit (Greig, 1981; Deforce et al., 2015). If this was the case, large amounts of chaff would have been present as well which was not the case in the analysed features presented here.

Fagopyrum (buckwheat) is not a cereal but is also a farinaceous staple food, and it is used in a similar way as cereals. *Fagopyrum* pollen occurs in low percentages only, in samples from the 16th century onwards. As *Fagopyrum* is an entomophilous plant with low pollen production and poor dispersal capacities (Cawoy et al., 2009; de Klerk et al., 2015), the presence of this pollen type is most likely to be explained by the consumption of buckwheat. Macro-remains of *Fagopyrum* have been recorded in some of the cesspits as well, which confirms that this plant was most probably consumed. In some of the cesspits, macro-remains have been found but no pollen, which is probably due to the low pollen production of this plant (Table 1).

Fagopyrum is known to be cultivated in the region from c. 1400 AD onwards (Leenders, 1987; Mücher et al., 1990) though it might have been present as a weeds or cultivated on a very small scale since earlier times (de Klerk et al., 2015), which might explain for the macro-remains that have been found in a cesspit from Aalst –

Beta vulgaris	*Spinacia oleraceae*	Cistaceae	Myrtaceae	*Pulmonaria obscura* type	*Fagopyrum*	*Anthriscus cerefolim*	*Borago*	*Capparis spinosa*	*Beta vulgaris*	*Spinacia oleraceae*	Cistaceae	Myrtaceae	*Pulmonaria*	Ref. Macroremains
Pollen					Macro-remains									
–	–	–	–	–	v	–	–	–	–	–	–	–	–	De Groote et al. (2009)
–	–	–	–	–	–	–	–	–	–	–	–	–	–	De Groote et al. (2009)
–	–	–	–	–	–	–	–	–	–	–	–	–	–	De Groote et al. (2009)
–	–	–	–	–	–	–	–	–	–	–	–	–	–	Troubleyn et al. (2009)
–	–	–	–	–	–	–	–	–	–	–	–	–	–	Troubleyn et al. (2009)
v	v	v	v	–	–	–	–	–	v	–	–	–	–	Cooremans (in prep.)
v	v	v	v	–	–	–	–	–	–	–	–	–	–	Van Haaster (2006)
–	–	v	v	–	–	–	–	–	–	–	–	–	–	Van Haaster (2006)
–	–	v	v	–	No data									
v	v	v	v	v	v	–	–	–	v	–	–	–	–	Cooremans (in prep.)
–	–	v	v	–	No data									
–	–	v	v	–	No data									
–	–	v	v	–	No data									
–	–	v	v	–	No data									
–	–	–	v	–	–	–	–	–	–	–	–	–	–	Cooremans (in prep.)
–	–	v	v	v	–	–	–	–	–	–	–	–	–	De Groote et al. (2004)
–	v	–	v	–	v	–	–	v	–	–	–	–	–	Cooremans (2016)
–	v	–	v	v	no data									
v	–	–	–	–	no data									
–	–	v	v	–	no data									
–	–	–	–	–	v	–	–	–	–	–	–	–	–	De Clercq et al. (2007)
v	v	–	v	–	no data									
v	v	–	v	v	v	–	–	–	–	–	–	–	–	Van Haaster (2006)

Table 2
Pollen assemblages from the studied cesspits.

Site	Aalst Hopmarkt		Oudenaarde Kasteel			Aalst Hopmarkt			Dendermonde			Mechelen OLV		Aalst Hopmarkt	Herkenrode		Mechelen Begijnenstr.		Brugge Prinsenhof
Feature	II/I-26		225	289		XIV B/A6			WP1			37	193	4	212		WP2		IX/1
Sample	A	B	A	A	D	A	B	C	A	B	C	A	A	A	A	B	A	B	A
Age	14th c.		15th c.						16th c.								17th c.		
Cultivated plants																			
Anthriscus cerefolium	0.2	–	–	–	–	2.7	1.3	0.6	0.7	–	0.5	7.0	1.3	3.7	0.8	1.5	0.4	5.2	0.9
Beta vulgaris	0.6	0.9	–	–	–	1.7	–	1.5	–	–		–	1.1	–	–	–	0.2	0.4	0.4
Borago officinalis	–	–	0.9	0.2	–	0.9	–	–	–	0.2	–	–	–	–	0.2	0.2	–	0.6	–
Bifora radians type	–	0.2	–	–	–	0.3	0.7	–	0.4	0.2	–	1.9	0.7	–	0.2	0.5	–	0.9	0.4
Cannabis/Humulus	–	–	0.5	–	0.4	0.9	0.6	0.2	0.2	0.5	0.7	–	–	–	0.2	0.2	–	0.4	–
Capparis spinosa	–	–	–	–	–	1.9	0.2	–	0.9	1.4	3.9	–	–	0.7	2.5	1.7	8.2	38.3	1.7
Cerealia undiff.	51.8	46.3	34.8	47.1	64.2	30.9	31.6	35.8	21.1	32.1	24.8	41.2	32.5	44.3	20.3	19.8	15.9	21.8	24.7
Fagopyrum	–	–	–	–	–	–	–	–	0.1	0.7	0.7	0.2	–	0.2	0.5	0.3	2.1	0.4	0.4
Juglans regia	–	–	0.2	–	–	1.1	–	0.4	0.1	0.5	0.2	–	–	–	–		–	–	0.8
Myrtaceae	–	0.7	0.9	0.7		2.2	1.5	0.2	0.6	3.3	2	0.8	–	1.1	0.2	0.3	8.6	0.7	1.3
Pimpinella anisum	–	–	–	–	–	0.2	0.2	–	–	–	–	0.2	–	–	–	0.2	0.9	–	–
Pisum sativum	–	–	0.2	–	–	0.3	0.2	0.2	0.1	–	–	0.2	–	–	–	0.2	–	0.2	0.2
Ribes undiff.	–	–	–	–	–	–	–	–				–	–	–	0.2		–	–	–
Ribes rubrum type	–	–	–	–	–	–	–	–	–	0.7	–	–	–	–	–	–	–	–	–
Ribes uva-crispa	–	–	–	0.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2
Secale cereale	0.4	0.2	1.7	1.4	1.5	1.6	2.4	3.5	0.4	1.6	2.7	0.2	0.4	0.4	0.3	0.8	1.4	1.5	1.5
Spinacia oleracea	–	0.2	–	–	–	0.3	–	–	0.3	–	0.5	–	–	–	–	–	19.1	–	0.2
Vicia faba	–	–	0.2	0.2	–	–	–	–	0.1	–	–	–	–	0.4	–	–	–	–	–
Vitis vinifera	0.6	0.2	0.5	0.7	–	0.2	–	–	0.2	–	0.2	0.2	0.2	0.2	0.5	0.3	–	0.4	0.4
Wild plants																			
Trees and shrubs																			
Acer	0.2	–		0.2		–	0.2	–	0.1	–	–	0.2	0.2	0.2	–	–	–	–	–
Alnus	1.4	5.0	2.8		0.4	2.2	1.3	1.5	1	3.0	3.4	1.1	3.1	0.9	0.5	1.5	0.4	0.6	4.7
Arbutus unedo	0.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.0
Betula	0.6	0.2	0.5	0.7	0.4	0.8	3.4	0.9	0.7	4	2.3	0.2	0.9	0.4	0.2	0.5	0.2	0.2	4.6
Buxus sempervvirens	–	–	–	–	–	0.3	–	–	–	–	–	–	–	–	–	–	–	–	–
Carpinus betulus	0.2	0.5	0.2	–	–	0.2	–	0.2	0.1	0.2	0.5	–	–	–	–	–	–	–	–
Castanea sativa	0.2	–		–	–	0.2	–	–	–	–	–	0.6	–	–	0.2		–	–	0.4
Cistaceae undiff.	0.4	–	0.2	–	–	0.3	–	–	–	–	–	0.4	–	–	–	–	–	–	–
Cistus ladanifer	–	–	0.2	0.3	–	0.2	–	–	–	–	–	–	–	–	–	–	–	–	–
Cornus sanguinea	–	–	–	–	–	0.2	–	–	–	–	–	–	–	–	–	–	–	–	–
Corylus avellana	1.0	1.1	2.2	–	0.4	0.6	0.7	0.2	0.2	1.6	0.5	0.4	2.6	0.4	0.3	1.3	0.5	0.4	4.7
Fagus sylvatica	0.4	0.9	–	–	–	–	–	0.4	–	0.2	0.2	–	0.4	–	–	0.3	–	–	0.2
Frangula alnus	–	–	–	–	–	–	0.2	–	–	–	–	0.4	–	–	–	0.7	–	–	–
Fraxinus excelcior	–	–	–	–	–	0.6	0.2	–	0.1	–	0.2	–	–	0.2	–	–	–	–	0.2
Hedera helix	0.4	–	0.2	0.3	–	–	–	–	–	–	–	–	–	–	–	–	0.2	–	–
Helianthemum	–	–	0.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Phillyrea	–	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–	–	–	–	–
Pinus	0.2	0.2	0.3	–	0.2	–	0.2	–	–	0.2	0.2	–	0.2	–	0.2	–	–	–	1.3
Prunus type	–	–	–	–	–	–	–	–	0.1	–	0.5	–	–	–	0.2	0.2	–	–	–
Quercus	0.8	3.0	1.2	0.2	0.2	1.2	1.3	1.1	0.3	0.9	0.5	0.4	2.6	0.4	0.3	1.0	0.4	0.4	5.3
Salix	–	–	0.7	0.5	–	0.8	0.6	0.7	0.1	1.2	0.5	–	0.7	1.1			–	0.2	0.4
Sambucus nigra type	–	–	–	–	–	–	–	–	0.1	–	0.7	–	–	–	30.4	3.0	–	–	0.2
Tilia	–	–	–	–	–	1.1	0.2	0.6	–	–	0.5	–	0.2	–	0.2	0.2	0.2	–	–
Ulmus	–	–	0.3	–	–	–	–	–	–	–	0.2	–	0.5	–	–	–	–	–	–
Total trees and shrubs	6.2	10.9	9.1	2.0	1.6	8.6	8.2	5.6	2.7	11.4	10.0	4.0	11.3	3.5	32.5	8.7	1.8	1.7	22.0
Herbaceous plants																			
Agrostemma githago	0.2	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2	–	0.5	–	–
Apiaceae undiff.	2.3	0.5	0.3	0.5	–	3.3	0.9	0.6	0.3	0.2	0.2	1.3	0.5	3.3	0.3	0.2	0.7	0.6	0.8
Artemisia	0.2	0.4	–	0.2	–	1.1	0.4	0.7	0.1	1.2	0.9	0.6	0.2	–	–	–	–	0.2	0.9
Asteraceae liguliflorae	0.4	2.3	1.7	0.5	0.2	0.6	1.5	0.9	0.2	0.5	0.7	1.9	1.1	2.8	–	0.5	1.3	0.9	1.5
Astragalus type	–	–	–	–	–	–	0.2	–	–	–	–	–	–	0.7	0.2	–	–	–	–
Boraginaceae undiff.	–	–	0.3	–	–	–	–	–	–	–	–	0.4	–	–	–	–	–	–	–
Brassicaceae	5.6	5.5	4.3	7.5	–	3.6	4.7	2.0	0.7	0.9	0.9	4.4	11.3	0.6	0.8	0.2	2.9	1.3	2.1
Callunua vulgaris	0.8	4.1	1.2	0.2	–	1.1	0.7	1.7	0.1	0.5	0.9	2.7	2.9	–	0.2	0.3	0.7	2.0	0.2
Caryophyllaceae undiff.	0.6	0.7	0.2	–	–	–	0.4	–	0.2	–	–	–	0.2	0.4	–	0.2	0.2	0.2	0.2
Centaurea cyanus	7.0	8.6	1.6	2.4	0.6	1.6	2.6	2.0	0.8	1.9	2.5	4.9	1.5	8.7	0.9	0.7	2.0	1.7	1.3
Centaurea nigra type	0.4	0.4	0.2	–	–	0.0	0.4	0.2	0.1	0.5	–	0.2	–	0.4	0.2	0.2	–	–	0.6
Chenopodiaceae undiff.	0.8	0.7	2.1	1.0	0.6	2.0	3.7	0.9	0.6	0.2	1.4	0.4	1.3	1.9	0.6	0.7	1.8	0.4	4.4
Cirsium	0.2	0.2	0.3	0.2	0.8	–	0.7	–	0.1	–	0.7	0.4	0.2	0.4	–	–	0.2	0.2	0.9
Convolvulus arvensis	0.4	0.4	–	0.2	0.2	–	–	0.4	–	0.2	–	0.2	–	0.2	0.2	–	–	–	0.2
Cyperaceae	–	0.4	0.3	0.3	0.2	0.5	0.6	0.2	0.1	–	–	–	–	0.2	–	–	0.2	–	0.4
Echium	0.4	–	–	0.9	–	0.2	–	–	–	–	–	0.2	–	–	–	–	–	–	–
Ericaceae undiff.	1.9	0.7	1.7	1.1	0.4	0.8	2.2	0.7	0.3	1.2	–	1.7	0.2	1.5	0.3	0.5	0.7	0.6	0.2
Fabaceae undiff.	0.6	–	0.5	1.9	0.6	0.6	–	–	–	0.2	–	1.9	–	–	0.6	0.5	0.7	0.2	–
Fallopia	–	–	–	0.3	–	–	–	–	–	1.4	0.2	–	–	–	–	–	–	–	0.2
Filipendula	–	–	0.2	0.2	–	0.3	–	–	–	–	0.2	–	0.7	–	–	–	–	–	0.4
Galium type	–	–	–	0.2	–	0.2	0.4	–	0.1	–	0.2	–	–	0.2	0.2	–	–	0.4	0.2

Table 2 (*continued*)

Site	Aalst Hopmarkt		Oudenaarde Kasteel			Aalst Hopmarkt			Dendermonde			Mechelen OLV		Aalst Hopmarkt	Herkenrode		Mechelen Begijnenstr.		Brugge Prinsenhof
Feature	II/I-26		225	289		XIV B/A6			WP1			37	193	4	212		WP2		IX/1
Sample	A	B	A	A	D	A	B	C	A	B	C	A	A	A	A	B	A	B	A
Age	14th c.		15th c.						16th c.								17th c.		
Genista type	0.2	–	–	–	–	0.3	–	0.4	–	–	–	–	–	–	25.0	47.8	19.5	–	–
Geraniaceae undiff.	–	–	0.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2
Gratiola officinalis	–	–	–	–	–	–	–	–	43	5.8	7.7	–	–	–	–	–	–	–	–
Iris germanica type	–	–	–	–	–	–	0.2	0.4	–	–	–	–	–	–	–	–	–	–	–
Jasione montana type	0.4	–	0.5	–	–	0.2	0.4	0.2	0.2	0.2	–	1.3	–	–	–	–	–	0.4	0.2
Knautia arvensis type	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–	–	–
Lamiaceae undiff.	–	–	–	–	–	0.3	–	–	–	–	0.5	0.4	–	–	–	–	–	–	–
Lavendula stoechas type	–	–	0.3	0.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lotus type	–	–	1.0	0.9	0.2	0.6	0.7	–	1.3	0.7	0.5	0.4	0.4	0.2	0.2	0.2	0.4	0.4	0.2
Malvaceae	–	–	–	–	–	–	–	0.2	–	–	–	–	–	–	–	–	–	–	–
Matricaria type	3.1	2.7	1.4	3.0	3.2	3.0	4.1	3.0	0.4	2.3	1.1	2.1	3.3	3.3	0.5	0.8	0.9	0.7	1.9
Mentha type	–	0.7	0.2	–	–	0.6	–	–	0.1	1.2	0.2	0.2	1.1	0.6	0.2	–	–	0.4	0.4
Orlaya grandiflora	0.4	0.5	–	0.2	–	–	–	–	–	–	–	–	–	–	0.2		–	–	–
Papaver rhoeas type	–	–	0.3	–	–	–	–	0.4	–	–	–	–	–	0.6	–	0.2	–	–	–
Phyteuma type	–	0.2	–	–	–	–	0.6	–	–	–	–	0.2	0.2	–	–	–	–	–	–
Plantago lancealata	1.0	1.3	1.4	1.4	0.2	0.2	1.3	1.1	–	0.7	0.2	–	0.9	0.7	–	–	0.4	0.2	1.9
Plantago major/media	0.4	–	–	0.2	–	0.3	0.2	0.4	–	0.5	0.5	–	–	–	–	0.2	–	0.4	–
Poaceae	13.4	10.4	15.9	16.1	21.8	21.5	22.2	26.9	19.1	14.0	19.1	10.4	16.3	17.2	5.9	6.3	5.9	8.7	20.7
Polygnum aviculare type	0.4	–	0.7	0.3	1.1	0.2	0.4	–	–	0.2	–	0.2	–	1.5	–	0.2	0.4	0.2	0.4
Polygonum persicaria type	–	–	0.2	–	–	–	–	–	–	0.2	0.2	–	0.2	0.2	–	–	–	0.0	–
Potentilla type	0.4	–	–	–	–	0.2	0.2	–	0.3	0.2	–	–	0.2	–	–	–	–	0.2	–
Pulmonaria obscura type	–	–	–	–	–	0.2	–	–	–	–	–	–	–	–	0.2	0.5	–	–	0.2
Ranunculus acris type	0.4	–	–	0.2	–	0.6	1.1	1.9	0.3	0.7	0.7	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.2
Rosa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2	0.3	–	0.2	0.4
Rosaceae undiff.	0.4	1.4	1.9	0.2	–	0.6	0.9	1.3	0.2	0.5	0.2	1.3	0.4	0.4	–	–	0.5	0.9	–
Rubus	–	–	–	0.3	–	–	–	–	–	–	0.2	–	–	–	–	0.2	–	–	–
Rumex acetosa type	0.6	0.9	2.1	1.2	0.9	3.3	2.2	1.9	1.6	9.8	11.1	7.8	7.7	0.9	0.8	2.7	3.8	7.0	0.8
Senecio type	–	–	0.9	–	0.8	2.5	0.4	0.2	0.1	–	–	0.4	0.2	0.9	0.3	–	–	–	0.8
Sparganium type	–	–	0.3	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–	–	0.2
Spergula arvensis	0.2	–	–	–	–	–	–	–	–	–	–	–	0.5	–	–	–	–	–	–
Succisa type	–	–	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–	–	–	0.2
Thalictrum	–	–	0.2	–	–	–	0.2	–	–	–	–	–	–	–	–	–	–	–	–
Trifolium pratense type	0.2	–	0.2	0.2	0.2	–	0.6	0.6	0.2	–	–	0.4	–	–	–	–	–	0.7	–
Trifolium repens type	2.9	0.2	0.7	1.0	0.4	1.2	3.4	3.5	1.8	1.6	1.6	4.0	1.5	2.2	0.3	0.3	0.4	1.3	2.1
Typha latifolia type	–	–	–			–	–	–	–	–	–	–	–	0.4		0.2	–	–	–
Urtica dioica type	–	–	0.2	0.7	0.2	0.3	0.4	2.2	0.2	–	1.1	–	–	0.4		0.2	–	–	–
Vicia type	–	–	–	–	0.2	–	0.2	–	–	–	–	0.4	–	–	0.2	–	–	–	0.2
Sum	485	560	580	573	533	641	535	539	1132	430	440	473	547	540	645	601	559	541	527.0
Ferns and mosses																			
Anthoceros punctatis type	–	0.2	–	–	–	–	–	–	–	–	–	–	–	0.4	–	–	–	–	–
Filicales	0.2	0.2	1.2	0.2		–	–	–	–	0.7	0.2	–	–	–	–	0.2	0.2	–	1.3
Polypodium vulgare	–	–	0.7			–	–	–	–	–	–	0.0	0.2	–	–	–	–	0.2	0.2
Pteridium	–	0.2	–	–	–	–	–	–	–	–	–	0.2	0.4	–	–	–	–	–	0.2
Sphagnum	3.7	7.3	2.1	–	–	0.3	0.4	–	–	–	0.5	–	1.8	0.2	–	–	–	0.2	3.0
Pediastrum boryanum	–	–	–	–	–	–	–	–	–	–	0.2	–	–	–	–	–	–	–	0.2
Indeterminata	3.9	2.5	3.4	3.5	2.1	3.7	5.4	3.9	1.3	4.2	2.5	3.6	2.6	4.3	3.4	1.2	3.4	4.1	2.7
Intestinal parasites (n)																			
Nematoda																			
Ascaris	20	13	125	486	422	136	127	13	–	91	58	167	25	20	7	–	194	53	23
Capillaria	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–
Trichuris	145	116	349	867	623	280	235	143	77	140	147	140	136	87	39	2	206	133	99
Trematoda																			
Faciola hepatica	–	–	–	–	–	–	–	–	1	–	1	–	–	–	–	–	–	–	–

Stadhuis dating to the 2nd half of the 12th century (Table 1; De Groote et al., 2009). The results suggest that it was probably not a popular food plant until before the 16th century. As *Fagopyrum* is a bee-pollinated plant (Cawoy et al., 2009), the consumption of honey is also a possible source for this pollen type.

Pollen of *Vicia faba* (broad bean) and *Pisum sativum* (pea) occur regularly in the analysed samples, though always with low percentages (Table 2). As both plants are low pollen producers and have poor pollen dispersion capacities, this is likely to result from the consumption of these plants, as peas and broad beans do contain small amounts of pollen (Greig, 1982b). This is confirmed by macro-remains of both taxa that have been found in the cesspits (De Groote et al., 2004; Van Haaster, 2006; Troubleyn et al., 2009).

4.1.1.2. Arable weeds. Weeds typically growing in arable fields, such as *Centaurea cyanus* (cornflower), corncockle (*Agrostemma githago*) and white lace flower (*Orlaya grandiflora*) occur frequently in the pollen assemblages of the studied cesspits. These have most likely the same origin as the Cerealia pollen i.e. they have been harvested and processed together with the Cerealia and got incorporated in cereal based food products. This is supported by the presence of seed fragments from these taxa in the cesspits as well, which are often highly fragmented (Van Haaster, 2006; Troubleyn et al., 2009;

Cooremans, 2016). Other pollen that have been found and which include possible arable weeds are Asteraceae-Liguliflorae, Brassicaceae, *Papaver rhoeas* type, *Polygonum aviculare* type, *Polygonum persicaria* type, *Rumex acetosa* type, Caryophyllaceae and Chenopodiaceae (Behre, 1981). These pollen types also include taxa that grow in other habitats as well however, such as fallow land, meadows and pastures, and some of these (e.g. Brasicaceae, Chenopodiaceae) also include possible food plants.

There are many other possible sources for pollen from cornfield or grassland weeds however, such as flooring material, hay, straw and animal dung, that might have been thrown in the cesspits (Greig, 1994).

4.1.1.3. Leafy-vegetables. Pollen of several vegetables have been found in the analysed cesspits. *Anthriscus cerefolium* (garden chervil) is by far the most common, present in almost every studied cesspit and with percentages up to 7%. Also clusters of this pollen type sometimes occur in the samples (Fig. 2). Pollen of *Anthiscus cerefolium* has also frequently been found in other medieval and post-medieval cesspits in NW Europe (e.g. Van Den Brink, 1988, 1989; van Haaster, 2003; Brinkkemper, 2013; Meurers-Balke et al., 2015) indicating that this was a popular food plant during this period.

No botanical macro-remains of *Anthriscus cerefolium* have been found in the analysed cesspits.

Pollen of *Beta vulgaris* (beetroot/chard) and *Spinacia oleracea* (spinach) have been identified in several samples as well. Both belong to the Chenopodiaceae family. Contrary to most other members of this family, pollen grains of both plants can be differentiated from other NW European genera within this family (Beug, 2004) and are regularly identified in samples from medieval and post-medieval cesspits in NW Europe (see overview in Hallavant and Ruas, 2014).

Macro-remains of *Beta vulgaris* have been found in only a few of the studied cesspits and *Spinacia oleracae* is absent in the dataset (Table 1).

4.1.1.4. Flowers/flower buds. The frequent occurrence and/or high percentages of pollen from taxa, such as *Borago officinalis*, Myrtaceae, *Capparis spinosa*, *Sambucus nigra* type and *Genista* type in the investigated cesspits are most likely to be explained by the consumption of flowers or flower buds from these respective plants.

Pollen of *Borago officinalis* (borage) occurs in many of the analysed cesspits. *Borago officinalis* originates from the western Mediterranean region and was introduced to the Low Countries during the Middle Ages where it was cultivated as a kitchen herb and vegetable (Van Haaster, 1997). The flowers and sometimes also the leaves of this plant are eaten which explains for both the occurrence of *B. officinalis* pollen in most of the studied archaeological features and for the absence of botanical macro-remains in the same samples. Pollen of *B. officinalis* has also been found in medieval cesspits in other regions in NW Europe (e.g. Greig, 1981; Van Haaster, 2008; Brinkkemper, 2013).

The identified Myrtaceae (myrtle family) pollen can most probably be attributed to *Syzygium aromaticum* (cloves), a tree native to the Moluccas, a group of islands in the eastern part of the Indonesian archipelago. Cloves are the dried flower buds and therefore contain large amounts of pollen. Morphologically, pollen from *S. aromaticum* cannot be differentiated from many other members of this family however, of which some could have been used in NW Europe during (post)medieval times, such as *Myrtus communis* (common myrtle) and *Pimenta dioica* (allspice) (Jankovská, 1995). No botanical macro-remains from the Myrtaceae family have been found in the studied cesspits (Table 1). As from both *Myrtus communis* and *Pimenta dioica* the fruits are used, this would have resulted in the presence of botanical macro-remains from these plants. Moreover, *Pimenta dioica* is native to central America and was introduced in European cuisines only in the 16th century (Purseglove et al., 1981). All finds of macro-remains of *P. dioica* in NW Europe date to the early modern times or later (e.g. Badura, 2003; Ansorge and Wiethold, 2005).

Both the pickled flower buds and fruits of *Capparis spinosa* (capers) are eaten. The observed high percentages of pollen of this plant in some of the cesspits must be attributed to the former. The presence of seeds of *C. spinosa* in one the cesspits indicates that also the fruits have been eaten, though probably far less frequently than the pickled flower buds (Cooremans, 2016) (Table 1).

The high percentages of pollen of *Sambucus nigra* type (black elder type) and *Genista* type (broom type) in two of the studied cesspits (Table 1) are also believed to result from the consumption of the flower buds of these respective plants. The pickled flower buds of both elderberry and broom can be eaten and were used during medieval and post-medieval times as a locally produced substitute for capers (Dodoens, 1644; Tack et al., 1999).

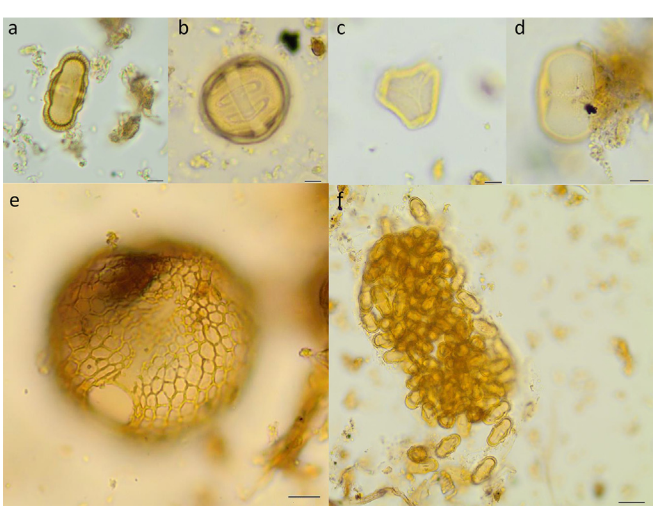

Fig. 2. Pollen types that are frequently found in medieval and post-medieval cesspits: *Anthriscus cerefolium* (a), *Borago officinalis* (b), Myrtaceae (c), *Pulmonaria obscura type* (d), *Cistus ladanifer* (e), cluster of *Anthriscus cerefolium* pollen. Scale bar: a, b, c, d: 5 μm; e: 10 μm, f: 20 μm.

4.1.1.5. Other food plants. Other identified pollen types that are likely to result from the consumption of food plants are *Bifora radians* type, *Pimpinella anisum*, *Ribes rubrum* type and *R. uva-crispa*.

Bifora radians type comprises *B. radians* (wild bishop) and *Coriandrum sativum* (coriander) (Punt, 1984). *Bifora radians* is not native to NW Europe, but only casually naturalized. *C. sativum* has been introduced by the Romans in NW Europe and cultivated as a herb since (Pals, 1997). Therefore it is likely that the pollen of *Bifora radians* type belongs to *Coriandrum sativum*. This is supported by the numerous seeds of *C. sativum* that have been found in some of these the cesspits (De Groote et al., 2004; Van Haaster, 2006).

Pollen of *Pimpinella anisum* (anise) has been found in several of the studied cesspits. Also *Pimpinella anisum* is a Roman introduction (Van Haaster, 1997) and pollen have been found in a Roman age latrine in the Netherlands (Kuijper and Turner, 1992). For the Middle Ages, it is missing in both historical and archaeobotanical records until the 15th century (Van Haaster, 1997).

4.1.1.6. Honey. The pollen assemblages of the studied cesspits are characterised by a high number of insect-pollinated taxa. Many of these taxa are common components of honey, e.g. *Acer*, *Castanea*, Brassicaceae, *Frangula alnus*, *Echium*, *Hedera helix*, *Tilia*, *Trifolium* (Bucher et al., 2004). Honey was very popular in the medieval and early post-medieval cuisine as it was the only widely available sweetener, sugar being rare and expensive (Galloway, 2000). Honey also contains large amounts of pollen (Sawyer, 1988; Bryant, 2001). Therefore, the consumption of honey is a likely origin for many of these pollen types. Honey has been suggested before as a source for part of the pollen assemblages from human coprolites (Hadorn, 1994; Moe and Oeggl, 2014) and cesspits (Jankovská, 1987; Van den Brink, 1989; Greig, 1994; De Groote et al., 2004; Gauthier, 2006; Meurers-Balke et al., 2015) based on high numbers of insect pollinated taxa. However, as there are several other possible sources for these taxa, such as food plants, arable weeds, pharmaceutical plant use or atmospheric pollen deposition, this is very hard to prove. Strong indications for the use of honey based on pollen analysis of medieval cesspits where found in Bruges (Deforce, 2010). Here, a whole range of Mediterranean taxa have been identified, for which an origin other than the consumption of honey can be excluded (Deforce, 2010). Also in several of the cesspits presented here, pollen of some typical Mediterranean taxa have been found. *Arbutus unedo*, *Buxus sempervirens*, *Cistus ladanifer*, *Helianthemum*, *Lavandula stoechas* type (comprising *L. multifida*, *L. stoechas* and *L. viridis* (Valdés et al., 1987)) and *Phillyrea* all show a typical Mediterranean distribution (Tutin et al. 1964–1980) and these taxa are known to be important elements of modern honeys from this region (e.g. Gómes Ferreras and Sáenz de Rivas, 1980; Maia et al., 2005). No macro-remains of these plants have been found in the studied cesspits. The most obvious explanation for the presence of these pollen types would be the use of honey, or honey based products, from the Mediterranean region, as both plant food and atmospheric pollen deposition can be excluded for these taxa.

Recently, Cistaceae pollen have also been identified from several (post)medieval cesspits in the Netherlands (Van Haaster, 2010, 2011, 2012) indicating that the use of (products containing) honey from the Mediterranean region in NW Europe was probably common.

4.1.2. Drinks

Part of the pollen assemblages from the studied cesspits might result from the consumption of drinks. Beer and wine can contain considerable amounts of pollen of Cerealia and *Vitis vinifera* (grape) respectively (Rösch, 2005; Arobba et al., 2014). Wine can also contain other pollen types from the local and regional vegetation of the wine production area (Arobba et al., 2014).

Drinking water is another possible source of pollen. High numbers of pollen from aquatic plants dominating the pollen assemblages from coprolite samples from a Korean mummy have been interpreted to result from drinking water, tea or soup consumption (Arguelles et al., 2015). The few pollen grains of *Sparganium* type (bur-reed type), the only pollen type of an aquatic plant that was recorded in the studied cesspits, suggests that (drinking) water was not an important source of pollen in the study presented here. This is confirmed by the low frequency and low percentages of coenobia of the green algae *Pediastrum*.

4.1.3. Pharmaceutical plant use

The pharmaceutical use of specific plants is very hard to identify based on pollen analysis of cesspits. Many of the plants that are included in the identified pollen types might have been used for their pharmaceutical properties. But most of these plants can also have been used as normal food plants (e.g. *Sambucus nigra*, *Pimpinella anisum*, …) or have ended up in the cesspit in another way. For a few plants of which pollen has been found in the analysed cesspits, pharmaceutical use is the most likely source for the pollen however. Pollen of *Pulmonaria obscura* type (Suffolk lungwort type) has been found in four of the studied cesspits. This pollen type contains *Anchusa officinalis* (common bugloss) and several *Pulmonaria* species including *P. officinalis* (common lungwort) (Clarck, 1980). These plants all are small pollen producers and pollinated by bumblebees and solitary bees (Brys et al., 2008). *A. officinalis* is also visited by honey bees (Chwil and Weryszko-Chmielewska, 2009). A possible explanation for the frequent finds of *P. obscura* type pollen in (post)medieval cesspits is the use of *P. officinalis*, which was planted in gardens and used as a treatment for lung and respiratory diseases since the Middle Ages (Dodoens, 1644; Meeus et al., 2013). *P. obscura* type pollen has also been found in a 17th century cesspit in Oxford (Greig, 1994).

No macro-remains have been found of these taxa in the studied cesspits.

Also the occurrence of *Gratiola officinalis* (hedge hyssop) pollen, with percentages up to 43% in a 16th century cesspit from Dendermonde (Table 1), is likely to be the consequence of the medical use of this plant. *G. officinalis* is native to central Asia and South, central and some parts of W Europe. It is very rare in Belgium and most other regions in NW Europe (Weeda et al., 1990; Van Landuyt et al., 2006). *G. officinalis* is a poisonous plant but has several pharmaceutical properties (Zia-Ul-Haq et al., 2012), and also in late and post-medieval times, this plant was well known for its medical use (Dodoens, 1644).

It has also been found with similar high percentages in a 17th century cesspit in Oxford (England) (Greig, 1994) and in a 15th century cesspit in Utrecht (the Netherlands) (Van Beurden, 2011).

No macro-remains have been found of *G. officinalis* in any of the analysed cesspits.

4.1.4. Atmospheric pollen deposition

Latrines were mostly located inside small buildings and covered with a lid for hygienically reasons and to avoid unpleasant smells and the attraction of flies (Van Oosten, 2015). Therefore, direct deposition of pollen through the atmospheric pollen rain, both from the local, regional and extra-regional vegetation is not likely to have been important. People inhale pollen from the air while breathing however. This pollen sticks onto the mucous membranes in the oral and nasal cavity and the oropharynx, and is ingested through swallowing (Wilson et al., 1973). The ingested pollen will pass the digestive tract to eventually end up in the cesspit. The observed low numbers of arboreal pollen in the cesspits, which in most landscape types in NW Europe, including cities, make out the bulk of the pollen assemblage of the atmospheric pollen load (Ziello et al., 2012) suggests that the atmospheric component is not very important in the pollen assemblages from medieval and post-medieval cesspits.

4.1.5. Peat

The co-occurrence of *Sphagnum* and *Calluna vulgaris* in many of the studied cesspits (Table 2) are an indication for the presence of remains of peat fuel extracted from oligotrophic bogs (Deforce et al., 2007b). This is supported by the occurrence of macro-remains of plant typically growing on raised bogs, like *Andromeda polifolia*, *Erica tetralix*, *Eriophorum* and *Rynchospora alba* in the studied archaeological features (Van Haaster, 2006; De Groote et al., 2009; Troubleyn et al., 2009). Also the occurrence of *Pediastrum kawraiskyi*, a green alga from oligotrophic aquatic biotopes, in the late 13th – early 14th century cesspit from Mechelen – Het Steen (Troubleyn et al., 2009) corroborates this interpretation.

In N-Belgium, peat was extracted on a large scale and transported over long distances for use as fuel between the 12th and 15th century AD (Deforce et al., 2007b; Jongepier et al., 2011). The results of the pollen analyses indicate that peat and/or peat ashes was used to cover the surface of the cesspit to reduce unpleasant smells and to avoid the attraction of flies. The use of ashes would also help to desiccate the manure and raise the pH, which effectively kills pathogens (Doelle, 2001) and acts as an insecticide (Hakbijl, 2002).

At Mechelen-Begijnenstraat, several partially charred peat bricks have recently been found in a 14th century barrel lined cesspit. These peat bricks were also mainly composed of remains from plants growing on raised bogs, such as *Sphagnum austinii*, *Sphagnum* sec. *acutifolia*, *Erica tetralix*, *Calluna vulgaris*, *Eriophorum vaginatum*, *Andromeda polifolia* and *Rhynchospora alba*, which confirms the presence of peat fuel remains in this kind of archaeological features (Van Der Meer, 2015).

The addition of peat to the fill of the cesspits must have resulted in the input of a whole range of other pollen types as well, not only from plants that grew on the bog surface during peat formation, but also from the regional vegetation at that time. Moreover, this peat, and the pollen assemblage it comprises, is likely to be hundreds to several thousand years older than the contents of the cesspits, as most of the peat in the area was formed between 5000 and 2000 BP (Pons, 1992).

4.1.6. Mosses

Next to mosses originating from remains of peat-fuel that has been thrown in the cesspit, mosses can also have been used as the medieval equivalent of toilet paper. This has been suggested for a number of medieval cesspits with abundant mosses in the fill (e.g. Krzywinski et al., 1983; Ford and Robinson, 1987; Dickson, 1996; Wiethold and Schulz, 1991; Wiethold, 1999; Smith, 2013; Meurers-Balke et al., 2015).

Mosses function as a natural pollen trap as they capture and retain the pollen rain at the site where they grow (Cundill, 1985, 1991; Boyd, 1986). The deposition of mosses in the cesspit will thus result in an input of pollen originating from the vegetation that grew at the site where these mosses have been collected (cf. Vanhoutte et al., 2009; Deforce et al., 2014).

4.1.7. Other possible sources

Other possible sources for the identified pollen types in the studied medieval and post-medieval cesspits are plant material (hay, straw, brooms…), kitchen waste, animal dung and other rubbish that might have been thrown in the cesspits. Cesspits were not exclusively used for the deposition of human faecal material but all types of domestic organic waste was thrown into these pits (Greig, 1982b; Arndt, 2000; Van Oosten, 2015). Also pieces of textile, which were sometimes used as toilet paper, can have been a source for pollen (Wiltshire, 2006; Zavada et al., 2007; Boi, 2015).

4.2. Pollen vs. botanical macro-remains

As demonstrated above, the pollen assemblages of the studied cesspits include a whole range of plants that most likely have been used as food plants, as pharmaceutical plants or which pollen have ended up in the cesspits as a result of the consumption of honey. Macro-remains of these plants, e.g. *Anthriscus cerefolium*, *Beta vulgaris*, *Borago officinalis*, *Capparis spinosa*, *Gratiola officinalis*, Myrtaceae, *Pulmonaria* and *Spinacia oleracea*, are missing in most or even in all of these cesspits (Table 1). A similar observation is made by Badura et al. (2015), who compared archaeobotanical (macro-remains only) and historical records of edible and useful plants for the 14th and 15th century Gdansk (Poland). They conclude that a whole range of vegetables and spices, such as *Beta vulgaris*, *Coriandrum sativum*, *Pimpinella anisum* and *Syzygium aromaticum*, occur in historical manuscripts but are missing in the archaeobotanical records. This is because these plants are harvested and used as food before they produce seeds (Greig, 1996; Badura et al., 2015). The results presented here now show that the use of these plants indeed is not or little visible in the botanical macro-remains, but that it can easily be detected using pollen analysis. The same holds true for several plants of which flowers or flower buds have been consumed, for the pharmaceutical use of some plant taxa and for the consumption of honey.

4.3. Intestinal parasite eggs

Eggs of *Trichuris* (whipworm) and *Ascaris* (roundworm) have been found in all of the studied cesspits indicating that these must have been very common infections during medieval and post-medieval times. These are also common in medieval and post-medieval cesspits in other regions in Europe (e. g. Wiethold, 1999, 2000; Bouchet et al., 2003b; Brinkkemper and Van Haaster, 2012; Florenzano et al., 2012) and in other types of archaeological deposits from this period (e.g. Kozáková and Pokorný, 2007; Święta-Musznicka et al., 2013; Deforce et al., 2015). *Cappilaria* sp. (hairworm) and *Fasciola hepatica* (common liver fluke) occur only in one of the analysed features each (Table 2). Both taxa are less frequent finds in medieval and post-medieval cesspits indicating that infection rates might have been lower, compared to *Ascaris* and *Trichuris* (Bouchet et al., 2003b).

5. Conclusions

Compared to the analysis of botanical macro-remains, pollen analysis of cesspits is seriously hampered by a general lower taxonomic identification level and difficulties in identifying the origin of the different pollen types. Studying pollen from a number of medieval and post-medieval cesspits, we demonstrated that despite these constrains, pollen analyses of such archaeological features does provide a lot of information. The results show that the consumption of a whole range of food plants, such as *Anthriscus cerefolium*, *Beta vulgaris*, *Borago officinalis*, *Capparis spinosa*, *Fagopyrum*, *Spinacia oleracea* and *Syzygium aromaticum* can easily be demonstrated by pollen analysis of cesspits. Also the potential pharmaceutical use of certain plant taxa and the consumption of honey can be identified using pollen analyses of cesspits. Moreover, many of these types of plant use cannot be identified studying the botanical macro-remains from cesspits. Therefore, pollen analysis should be an integral part of archaeobotanical studies of medieval and post-medieval cesspits and other structures containing human faecal remains.

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