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A city and river in pre-industrial East-Central Europe. Case study: Wrocław

Abstract. The aim of the article is to assess the relationship between living conditions in the city and the natural environment determined by a large lowland river. This problem was examined via the example of Wrocław, the main city in Lower Silesia, which developed on the border of cultural and political zones. The natural hydrographic network and the scope of anthropogenic changes are presented. Also analysed are aspects of the land's suitability for construction, water supply techniques for crafts and townspeople's houses, drainage techniques, protection of street and squares surfaces against mud, and the use of water for defensive purposes. The chronological framework extends from the beginning of settlement to industrialisation and the introduction of modern water and sewage techniques in the 19th century.

Keywords: city, Central Europe, Wrocław, natural conditions, river, pre-industrial period, anthropogenic changes, water supply, drainage, defence.

Introduction. The riverside city as a research problem

Location on a river is a feature of almost all major cities of the European Middle Ages (Ostrowski 1996, pp. 174–196; Benevolo 2000, pp. 327–541). The most outstanding among these are cities such as Paris, London, Vienna and Cologne. This trend also applies to Central and Eastern Europe, where Prague, Kraków, Toruń and Poznań are located on large rivers (1994). The benefits of the city's symbiosis with the river were described in the context of the history of this part of the continent, most fully recently by Urszula Sowina (2009, pp. 41–133; see also *Die Stadt* 1978; Kaniecki 2004; *Město a voda* 2005). Therefore, good access to water for households and crafts is emphasised, as are the values of river transport, waterwheel energy, fishing opportunities, and the value of water obstacles for city defence (Küster 1998,

pp. 312–316). A river can assist in maintaining a proper level of cleanliness in the city, but the price to be paid for this is water pollution discharge, with the discharged contents of cesspits, sewage from households, tanning, dyeing, metallurgy and slaughterhouses (Röber 2016). On the other hand, the proximity of a large lowland river is a burden for a city. They pose an inconvenience in terms of construction, soil moisture, as well as the risk of flooding and poor water quality in wells. The immediate vicinity of the river is an important factor in determining the relationship of a city resident and the natural environment. Researchers also emphasise that the significance of these relationships has not yet been sufficiently explored, and filling this gap is one of the most important postulates raised today (de Souza, Costa 2018, pp. 6–7). As a result of centuries of transformations, it is difficult to find rivers with completely natural courses and shapes. They have been constantly regulated, narrowed, divided, shortened or widened, directed to canals, drained, deepened, and fenced with barriers and dams. Some researchers even think that rivers so altered by man are actually cultural artefacts. This term, commonly used in anthropology, ethnology and sociology, is also used by archaeologists (Edgeworth 2011, p. 14).

Describing Wrocław as a city on a great river, we will not be original: both the positive and negative impacts of the river on the functioning of pre-industrial cities are generally accepted knowledge. However, each city has its own characteristics and separate ways of adapting to the conditions created by the river. The research methods applied to them are also diverse. For the authors, the presented article falls within the scope of extensive issues of the relationship between man and nature. The achievements of historians and archaeologists constitute only part of the knowledge built by geographers and geologists, environmentalists, landscape architects and representatives of the technical sciences (Everard, Moggridge 2012; Cengiz 2013; Brown 2015: *Rivers* 2017; *River cites* 2018). However, the problems they face today are often anchored in the historical development of cities. Their research results usually indicate that today's image of cities is largely the result of a centuries-old symbiosis with the river. The purpose of the current article is to refer to this fact by assessing the relationship between living conditions in the city and the natural environment determined by the river – its natural and man-made features – as well as an attempt to look into the details of the conditioning of city–river relations and to present changes that have occurred in this respect in the Middle Ages and in modern times, before the introduction of technical solutions appropriate to the 'industrial revolution' period. On the other hand, reconstruction of the early medieval landscape preceding urbanisation processes is crucial in determining the scale of these changes (Burnouf 2007, p. 167). Wrocław – the main city of historic Lower Silesia – is one of the many examples of a city both dependent on, and at the same time shaping, a river. Economic, political and social conditions, which changed from the 10th to the 19th century, military strategies and the development of technology have all resulted in a unique structure.

Wrocław's natural conditions, hydrographic network, city location conditions

The Odra River, one of the major rivers of Central and Eastern Europe, flows from the Odra Mountains at the eastern end of the Sudetes to the Szczecin Lagoon and the Baltic Sea, crossing Silesia from south-east to north-west. Wrocław lies at a special point on its lowland section. Here, the river flows in a wide depression, dividing into many channels that change course in a natural way. In the city, the Oława River flows into the Odra River, and in its vicinity there are another four rivers and many smaller streams. In their natural form, the Odra and its tributaries formed an extremely rich and unstable hydrographic network composed of living meandering arms and dead oxbow lakes with numerous low-lying islands. It is assumed that there could be six or seven basic riverbeds. They were typified by a shallow depth, averaging about 50 cm (Leonhard 1901; Badura 2010). Without human intervention, the islands were able to change their form with each of the frequent floods (Fig. 1). The intensification of settlement along the Silesian rivers in the 13th and subsequent centuries increased the frequency and strength of floods. According to some researchers, an acceleration of sedimentation in river valleys has been observed since the 12th century, including in the upper section of the Oława (Fokt 2012, pp. 219–220; Latocha 2006; Krajniak 2016).

The location of Wrocław on the Odra was not a result of a conscious decision based on the interests of the bourgeoisie (Piekalski 2013, p. 380). It was a consequence of another decision taken three centuries before the city was located, in different political and economic conditions. The factor determining the choice of place was the natural defence of the river island, later referred to as Ostrów Tumski (Cathedral Island). The placement of a small stronghold on it in the middle of the 10th century decided on the location of the later, accompanying settlers. The rapid development of the stronghold and its immediate surroundings to form a centre with central political, military and church functions meant that in its vicinity there was also a place for a large bourgeois commune. In this case, an important driving force was the will of Silesian dukes residing in the city of Ostrów Tumski, treating the city's establishment as an investment of great economic importance.

The dependence of the settlement structure formed around the stronghold on the hydrographic network and land morphology was already noticed in the early stages of the study of Wrocław (Knie, Melcher 1825, pp. 55–61; Partsch 1901, pp. 1–5; Enderwitz 1925; Geschwendt 1936, p. 5–10; Morelowski 1956, p. 21; Engelbert, Eistert 1958, p. 2; Pudełko 1978). According to Rudolf Leonhard (1901), during the formation of the medieval settlement structure, the main current of the river was located on the left side of the river valley. This channel flowed from

the south of Ostrów Tumski, separating it from Piasek (Sand) island, which was separated by another branch from the left bank of the river. Both of these islands and the left-bank zone adjacent to them played a key role in the development of Wrocław in the proto-town phase, in the 11th to early–13th centuries. Significant also for the settlement topography was the later-called Saint Vincent Odra, separating Ołbin – the north-eastern, right-bank part of the early agglomeration.

The graphic reconstruction of the natural water network presented by Leonhard became the starting point for research carried out by subsequent authors, both humanists and naturalists, aiming at determining the value of the area for settlement purposes (Maetschke 1935, pp. 30–31; Maleczyński 1948; Szczepankiewicz 1959, 263–286; 1972, 224–239; Kozaczewski 1959; Kaźmierczyk 1970, p. 12; Małachowicz 1981; Młynarska-Kaletynowa 1986, pp. 17–19, 33–36; Chmal *et al.* 1993; Buśko 1999a; Badura 2010; Marcinkiewicz, Piekalski 2018). Particular attention has been paid to the areas on the left bank of the Odra, i.e. in the Old Town. Tadeusz Kozaczewski (1959) presented the first significant results. He compared today's hypsometry with the results of ground boreholes, recording the thickness of anthropogenic layers deposited from the Middle Ages to the most recent times. In this way he obtained information about the original differences in the height of the terrain and about its usefulness for settlement purposes. He also attempted his own interpretation of the development of the oldest structure of the city, based largely on hypotheses, however. One can say that, based on concepts that are difficult to verify because they lack a source basis, this was a permanent feature of the early phase of research preceding the broad-scale excavations of the Old Town. These, however, were undertaken along with major construction investments after 1989.

The first conclusions based on strong empirical premises were obtained during the research of Dominikański Square in the south-eastern part of the medieval city, on the line of the older fortification circuit (Chmal *et al.* 1993). In the excavation with an area of about 0.7 ha, the original height of the area, its relationship to other city zones and the genesis of natural sediments were determined. The values recorded there were compared with data from the rest of the Old Town, which allowed us to identify a strip of terrain elevated above the surrounding area with an approximately parallel latitude, with a deviation in the north-west–south-east line (Fig. 2) (Chmal *et al.* 1993, Fig. 4). Its range covered the zone from today's Dominikański Square in the east, via the Market Square, to the church of St. Elizabeth in the west, reaching a length of about 800 m and a width of about 200 m[1]. The original height of the land on Plac Dominikański was set at a maximum of 118.3 m above sea level, under the presbytery of the church of St. Elizabeth. The original soil has a ceiling of around 117 m above sea level (Chmal *et al.* 1993, p. 383; Lasota, Piekalski 1997, Abb. 4). Guided by the results of the analysis of the geological composition

[1] Wrocław Spatial Information System, https://geoportal.wroclaw.pl/en/maps/mapa_podst/.

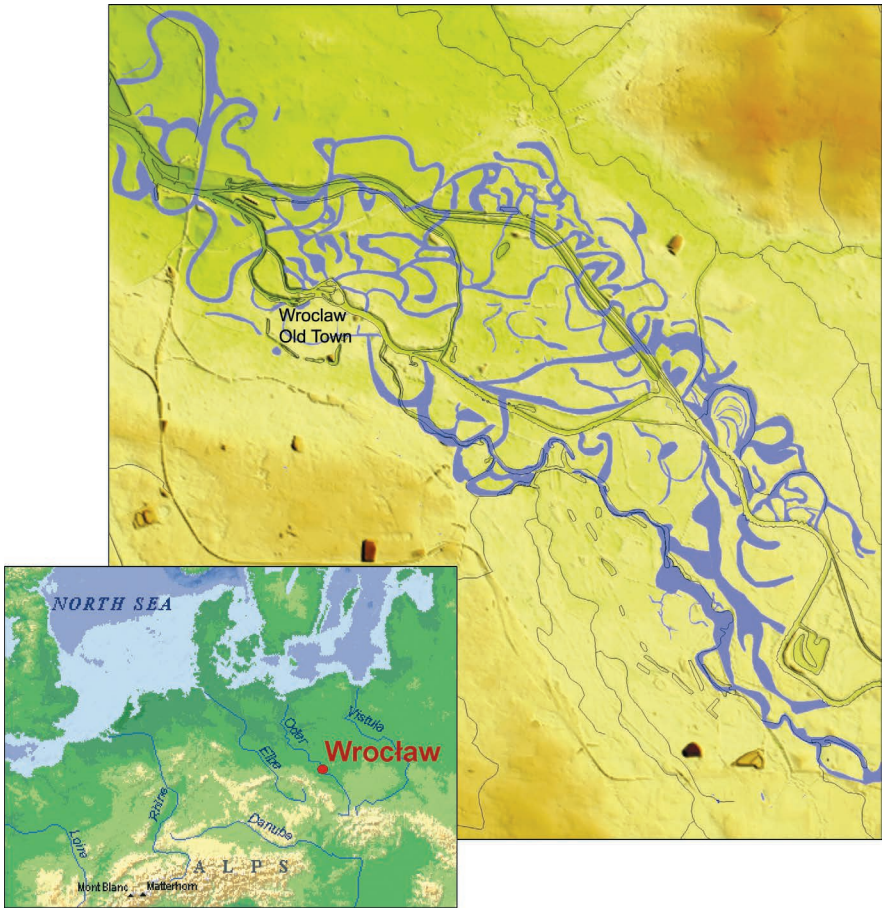


Fig. 1. Development of the hydrographic network in the Odra River valley in Wrocław (after Leonhard 1901; Badura 2010)

of the layers forming the elevation, they were interpreted as post-glacial upland inlier preserved in the Odra valley. The difference in the height of its ceiling to the bottom of the valley in the coastal zone was about three metres, and about seven metres to the water level in the river. The dry, flood-safe surface of the inlier created good conditions for settlement. The area north of it towards the main Odra riverbed, as well as to the south towards the next depression, had a lower value in this respect. This concept was repeated with minor modifications after further extensive research in the quarter between Kazimierza Wielkiego, Szewska, Ofiar Oświęcimskich and Łaciarska Streets, as well as in the Market Square (Chmal, Traczyk 1998; 2001).

Further progress of excavations allowed Cezary Buśko to attempt at the end of the 1990s to trace the details of the original hypsometry and changes in the height

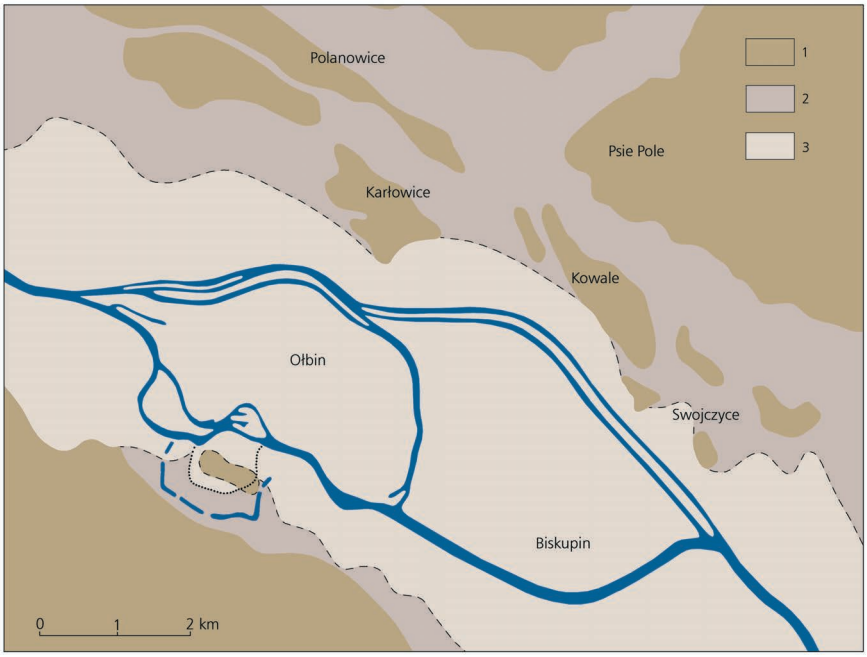


Fig. 2. Geomorphological sketch map of the Odra River valley bottom. 1 – Pleistocene moraine and fluvioglacial plateaus; 2 – bottom of the Odra River valley shaped in the Holocene by floodwaters; 3 – bottom of the Odra River valley shaped by meandering Odra River beds (after Chmal *et al.* 1993)

of the terrain after the first centuries of settlement history of the left-bank medieval zone of Wrocław. He used measurements of the height of native soil made in many parts of the city, both on the surface of the post-glacial inlier and on the terraces of the Odra (Buśko 1999a). He confirmed earlier findings, whilst improving their accuracy. He was the first to emphasise the phenomenon of anthropomorphic changes in hypsometry of the terrain, readable at the earliest in the north-eastern part of the Old Town. Low terraces were covered with settlement layers, caused by the 13th century levelling to the level appropriate for the above-mentioned inlier.

Repeated analysis of already known sources and their comparison against new materials obtained by both archaeologists and naturalists was undertaken by geologist Janusz Badura (2010). A significant part of previous findings concerning the original genesis of the Old Town area was questioned by him. Based on broadly understood research on the Odra river valley, he came to the conclusion that the range of this geological unit is much larger than previously assumed, and the entire area of medieval Wrocław lies within it, or more precisely within the Vistula glaciation terrace formed around 10 000–10 500 years ago. Later this zone was intensively processed by the meandering river (Badura 2010, p. 37–44).

The differences in the height of natural land cover before the implementation of the medieval settlement structure are the result of this activity. The Odra zone of today's Old Town was characterised by relatively low suitability for settlement purposes. The height of the native land there was about three metres above the reconstructed water level in the Odra, thus not providing sufficient protection against flooding. Especially in autumn and winter, the surface moisture must have been significant.

An attempt to reconstruct the geomorphological conditions of the eastern zone of the medieval city in the area of today's Nowy Targ Square, Piaskowa St. and St Katarzyna, was made by Andrzej Traczyk (2005). Using the results of research conducted in linear excavations, he traced changes in the height of the terrain in the north–south line, i.e. perpendicular to the course of the river. He determined that the Odra riverbed terrace is about 400 m wide here, and from the south it is limited by the edge of another fossil terrace, which according to Traczyk is Pleistocene. At the same time, it was found that the ceiling portions of the terrace form sands of variable sorting and silts. The soil cover is mostly flood mud (Fig. 3).

The results of geomorphological studies indicate that the form of the hydrographic network naturally shaped the development of early settlement in Wrocław. However, they also inform that the original height of the land was not the most important factor determining the place of settlement. The inconvenience associated with humidity of the area and its limited usefulness for permanent construction were not an obstacle to completely eliminating other conditions, including mainly political, administrative, religious, economic and communication factors. The earliest occupied area on the left bank of the Odra coincided with the low terrace in the area of today's Piaskowa Street and Nowy Targ Square. Referring to the medieval topography, we would say that it was the area between the main crossing of the Odra and the oldest left-bank church of St Wojciech and the coastal belt from the crossing towards today's university (Fig. 4). The crossing led to the stronghold with the duke's seat and cathedral, as well as to the northern part of the settlement complex developing on the right-bank Ołbin. The church of St Wojciech was built before the mid-12th century on an existing cemetery. The location of early settlement on the left bank of the Odra was thus conditioned by local needs. On the other hand, the relationship between the settlement and the most likely route of external roads is noticeable. This mainly concerns the *via regia* route from Germany through Lusatia to Wrocław and then to Kraków and Kiev, as well as crossing the route from Prague to Greater Poland. The joint section of both routes reconstructed in Wrocław coincides with the main axis of the proto-town craft-and-market settlement on the left bank of the Odra. The zone between the crossing and today's university overlaps with the probable course of the *via regia* route towards Lusatia (Piekalski 2010; Marcinkiewicz, Piekalski 2018a, p. 65, 130). The chartered town occupied the area located southwest of the proto-town settlement before the mid-13th century, which

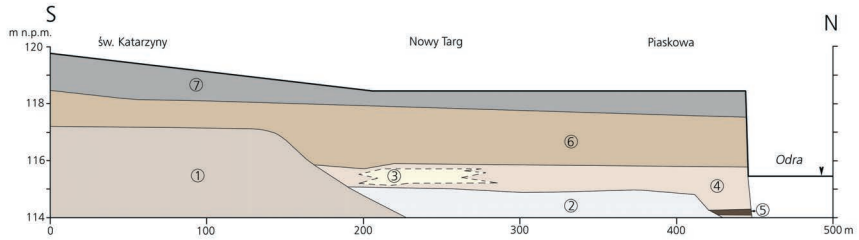


Fig. 3. Wrocław. Synthetic geological cross-section along Piaskowa St. – Nowy Targ Square – św. Katarzyny St. 1 – mixed-grained sand; 2 – river bed and gravel; 3 – riverbank fine- and medium-grained sand(?); 4 – silty sand (alluvial soil); 5 – turfs; 6 – humic sand (dung); 7 – sand with rubble, rubble (after Traczyk 2005)

was free from older buildings (Piekalski 2011). The main market square, referred to in Wrocław as the Ring (Rynek) Market Square, was marked out on the area about 117–118 m above sea level, i.e. about five metres above the water level in the Odra at that time, thus obtaining relatively good flood protection.

Protection of the city against the negative impact of the river

The natural hydrographic network of the Wrocław area, reconstructed by Rudolf Leonhard (1901), did not favour the stabilisation of settlement. Therefore, one of the conditions for its development was protection against the destructive force of the river. The first conscious action in this direction was the construction of a earth-and-timber embankment on Ostrów Tumski (Fig. 5). Apart from its primary defensive role, it also served as flood control and stabilising the island (Kaźmierczyk 1991 pp. 15–45; Pankiewicz 2015). The significance of the island's existence must have resided in its function against flooding, as evidenced by the fact that the oldest used level of the island to have been confirmed by archaeological research was only slightly higher than the level of the Odra at the time. Analysis of retention of undisturbed soil in a dozen or so archaeological excavations and geological wells established in Ostrów Tumski showed that in the 10th century, i.e. when the island was taken over by the action of its settlement and economic use, it had the form of a narrow sandy sandbar extending from south-east to north-west and culminating in its eastern part near the later church of St Giles. In this region, or more precisely within Excavation II, the ceiling of the natural layer reached 116.20 m above sea level, slightly above the water level in the river (Kaźmierczyk 1991, p. 14). The original utility level in the western part of Ostrów Tumski, in the area of the later duke's castle and the church of St Martin, was even lower: here it reached only 114.90–115.20 m above sea level and 'thus was close

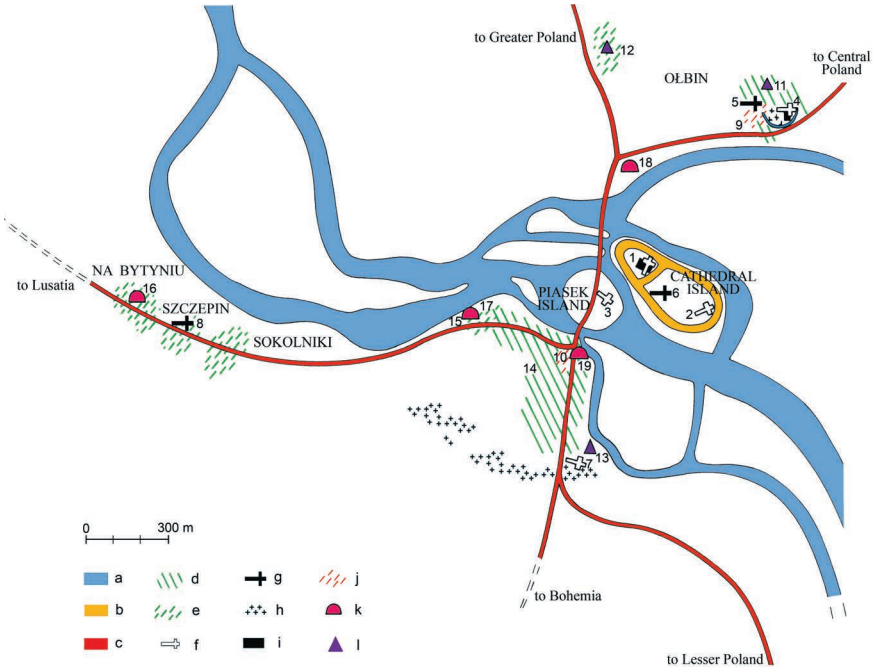


Fig. 4. Odra River in Wrocław in the 11th–12th centuries: a – river; b – castle rampart; c – main road; d – settlement documented by archaeology; e – settlement documented by written sources; f – church; h, g – church, approximate location; h – cemetery; i – ducal residence; j – market place; k – inn; l – noble residences, approximate location. 1 – castle precinct with St Martin's chapel; 2 – St John's Cathedral; 3 – Augustinian abbey with Our Lady's church; 4 – Premonstratensian abbey with St Vincent's church; 5 – St Michael's church; 6 – St Peter's church; 7 – St Wojciech (Adalbert's) church; 8 – St Mary of Egypt's church; 9 – St Maurice's church; 10 – St Nicholas's church; 11 – site of the annual fair in front of St Vincent's church; 12 – projected location of the marketplace in the left bank district; 13 – estate of the noble Włostowic family; 14 – estate of the nobleman Mikora; 15 – projected location of Gerung's estate (curia); 16 – crafts-and-market settlement; 17 – Jewish district; 18 – Walloon district; 19 – inn in the 'Na Bytyniu' district; 20 – the 'Birvechnik' inn; 21 – *ad fine pontis* inn; 22 – inn of the Augustinian abbey; 23 – St Mary Magdalene's church (edited by J. Piekalski, drawing N. Lenkow; after Młynarska-Kaletynowa 1986)

to the critical value at the average water level of the oldest stage of permanent development of this part of the island' (Kaźmierczyk 1991, p. 14). Such a picture of the island's original morphology and hypsometry was confirmed by later archaeological research undertaken in Ostrów Tumski, and was reinforced by subsequent premises (*Kształtowanie się grodu* 2015, pp. 55–64).

When deciding to establish a stronghold on the Odra island, its builders must have been aware of the practically permanent flood risk. Flooding with water

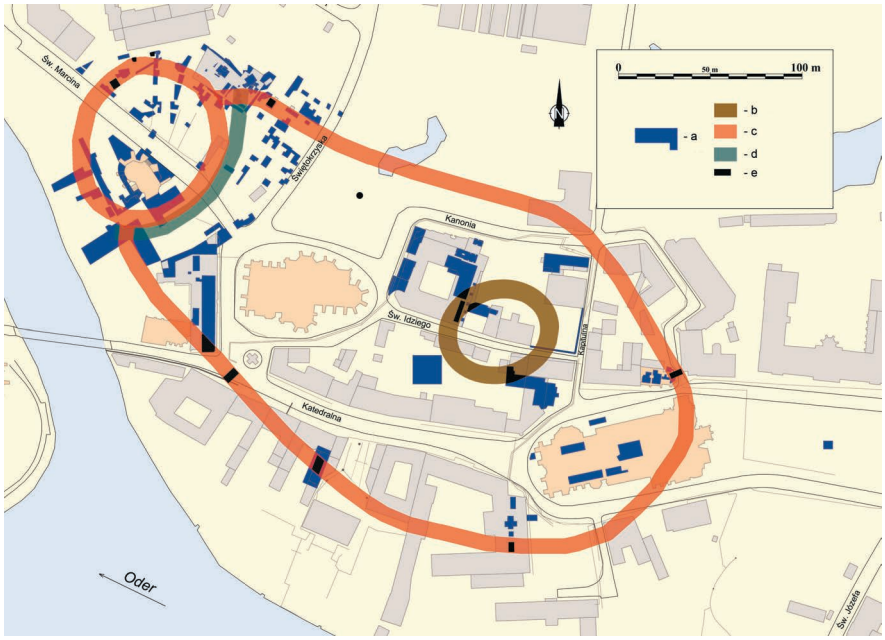


Fig. 5. Wrocław. Castle ramparts on Ostrów Tumski: a – research excavations; b – course of embankment, 2nd half of 10th century; c – course of embankment, end of 10th century; d – course of embankment, 11th century; f – uncovered sections of embankments (after Pankiewicz 2015)

threatened the inhabitants of the stronghold not only from the outside, directly by the river's waters, but also 'from below', that is, the soaking of the sandy ground with water on the stronghold. The material from which the island was formed was pure river sand, practically devoid of the clay fractions and natural clays that might slow water from penetrating the castle during high waters. The balance of profit and loss, however, was so favourable that it was decided to erect a stronghold on a low island built of poorly connected material. Undoubtedly, while erecting the stronghold's defensive structures, a number of engineering and technical measures were taken to protect future residents from the potential catastrophic effects of flooding.

The primary goal was certainly to protect the monumental earth-and-timber rampart of the castle against erosion and structural damage. A rampart of the Wrocław castle erected in a sandwich construction, and whose face was tied with a characteristic of the north-west zone of Western Slavic hook structure, was the most important element of the oldest castle in Ostrów Tumski. The rampart of the Wrocław stronghold, even at the base of 16 m wide, served not only for defensive purposes, but also for other purposes. Its body contained cuboid features – chambers with a purpose not yet fully understood (Kaźmierczyk 1991, p. 23).

There are many circumstances indicating that one of the ways the Wrocław rampart was protected was by covering virtually the entire sandy island surface, but especially those parts directly adjacent to wooden stakes that perhaps remained after works on the ramparts. These stakes, cross-laid in two or three layers, were then covered with a layer of sand up to 20 cm thick. Such a construction may have protected the rampart from being eroded by floodwaters. The destruction of this construction, in the form of black and dark grey streaks visible against the background of undisturbed soil, is treated in the literature on Ostrów Tumski as a relic of ploughing that preceded the construction of the rampart (perhaps even iconic or symbolic ploughing related to the castle stronghold). Such a concept cannot withstand criticism for obvious reasons – an investment carried out on such a scale as the construction of an embankment of such dimensions as Wrocław's fortifications must have completely destroyed any trace of earlier ploughing (not to mention, any ploughing in sand). After all, not only the embankment's outline but also the parts of the island adjacent to it were at that time simply a construction site, with workstations characteristic of such places, materials processing, but also mud and probably mess. Regarding the alleged ploughing, the conclusion sounds unequivocal – this relic must have been created after the rampart was erected, it is certainly younger, although only slightly, as in all cases it was observed directly on the sand of the undisturbed soil. It seems warranted to treat such traces as a relic of the laying out of the island's unstable sandy ground and protecting it from being washed away during floods.

Archaeologists have not yet discovered relics of former protection of the island's shores against the waters of the river and – in the winter and early spring – against the dammed river canyon. The only relic of such a wooden structure, in the form of a stake-wall palisade, was discerned in the 19th century by Professor Heinrich Göppert, a Wrocław botanist as the remains of a wooden structure protecting the southern embankment of a fragment of the Odra oxbow lake located in the Botanical Gardens. If we assume that it may actually be a remnant of an Early medieval investment, then this palisade would be about 80–100 m from the nearest confirmed section of the embankment. The research question may never be resolved, but the establishment of the construction chronology discovered in the Botanical Gardens and its chronological and functional connection with the corresponding phase of building fortifications of Wroclaw's Ostrów Tumski remains.

At the present time, we have no reason to believe that, in the phase preceding the establishment of the bourgeois commune, outside the castle grounds in Ostrów Tumski, actions were taken to stabilise the natural changes in the hydrographic network. We can speak about the construction of dikes, hydrotechnical devices, strengthening the banks and raising the level of terrain above the river of the 13th–14th centuries. The results of these activities are indicated by the results of excavations, and later also by written communications (*Breslauer Urkundenbuch*

1870, no. 85, 249; Piekalski 1991, pp. 11–17). A side effect of river regulation was the increase in the average water level, which was, however, offset by the increase in the organic anthropogenic layer. In the late Middle Ages and in modern times, the scope of regulation was systematically increased. New channels were dug to drain excess water from built-up areas (Leonhard 1901; Tietze 1915; Born 1948). Some flowing arms were cut off, turning the islands into mainland; many oxbow lakes were buried; marshes were drained. A significant part of the water was drained by an artificial channel that bypassed the city to the north. In the 18th and 19th centuries, the hydrographic network stabilised by humans changed significantly compared to the natural state (Fig. 6). Despite this, water was a permanent element of the Wroclaw landscape. No point in the city was more than 300 m from the moat or any of the riverbeds. Transportation in the city was conditioned by a large number of bridges and smaller footbridges: in the 19th century, there were more than 100 and in the first half of the 20th century, 300 (Łagiewski 1998, pp. 15–42).

The role of the river in the defence system

In medieval and modern defence systems, water obstacles played a fundamental role. It is no accident that the early medieval stronghold was founded in Wroclaw on a river island. Also, the municipal city was fortified using the opportunities provided by the Odra and Oława rivers in this respect. The city was founded on the left bank of the Odra, where it was joined by the Oława. The first fortification works probably began after 1242. They covered a deep semicircle with an area of about 40 ha, limited to the north by one of the main Odra riverbeds. The rapid development of this area caused the city to expand, with new land added to the south and west, probably in 1261 (Młynarska-Kaletynowa 1986, pp. 124–138; Konczewski *et al*. 2010, pp. 599–601). After this fact, the city's area increased to about 105 ha. Such an enlarged area was surrounded by new fortifications, which we refer to as external fortifications. The New Town was founded in 1263, allocating an area of several hectares for development to the east of the previously inhabited zones (Fig. 7). Stratigraphic analysis in Wroclaw allows us to conclude that digging the moat was the first stage in building fortifications. The excavated soil was heaped from the inside into a rampart, which after some time was replaced by a brick wall. Water was admitted to the outer moat from the Oława in 1291. Works on the construction of walls were carried out in stages spread over several decades, which means that some sections of the fortifications remained in a form limited to the moat and rampart for a long time (SUB 1984, no. 373; Goliński 1986; Lasota, Wiśniewski 1998, p. 20). We can assume that the inner city obtained full fortifications before the end of the 13th century, the outer city before the mid-14th century, and the New Town only in the 16th century (Konczewski *et al*. 2010, pp. 598–607).

Fig. 6. The river Odra in Wrocław in 1873, map by August Hoffmann (after *Atlas historyczny* 2001)

The introduction of new defence systems in modern times forced the adjustment of medieval moats to new requirements, which required extensive earthworks. The moat was widened, and adapted to the form of pentagonal bastions and ravelins. The construction of bastions within the covered sections of the medieval moat required proper preparation of the ground. Research results of the Krupniczy Bastion in the area of present-day Plac Wolności indicate that this work was done with a good knowledge of foundation construction on wet, unstable ground (Figs. 8–9) (Konczewski *et al.* 2010, pp. 609–611).

Water supply for the city: wells, beginnings and transformations of waterworks, location of tanneries

The results of archaeological research of Wrocław suggest that until the beginning of the 13th century water for the needs of the stronghold and the accompanying settlement complex was drawn directly from the river. The only well dated to the 12th century was discovered in the Benedictine Abbey in Ołbin

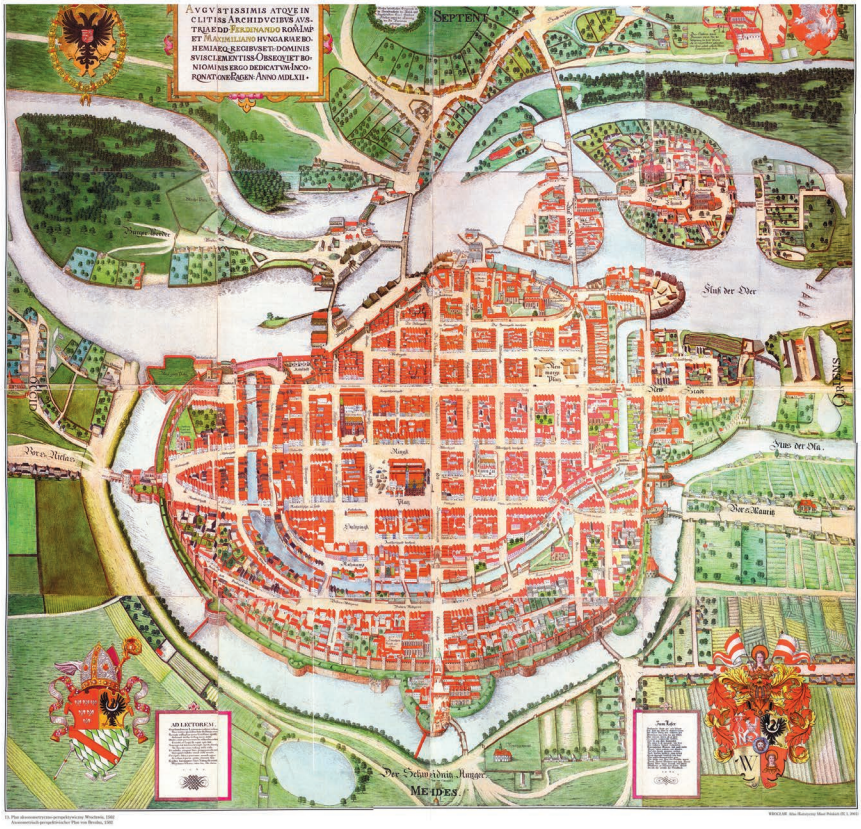


Fig. 7. Odra River, Oława River and city moats in Wrocław, panoramic view by Bartel Weyner from 1562 (after *Atlas historyczny* 2001)

(Piekalski 1991, pp. 129–130). This original water supply system was only abandoned upon the intensive development of the craft-and-market settlement, and then of the chartered town on the left bank of the river. The oldest wells appearing there date back to the first decades of the 13th century (Berduła *et al.* 1993, pp. 104–108; Buśko, Piekalski 1993, pp. 131–131; Piekalski 2004, p. 345; Marcinkiewicz, Piekalski 2018b, pp. 47–139). These were quite simple but characteristic devices assembled from four columns and boards placed horizontally behind them, stabilised by struts placed along the walls (Figs. 10, 11). This type of well also occurs in other centres of Central and Northern Europe, which suggests that they appeared in Wrocław in connection with migration from the West in the 13th century (Carelli 2004, p. 457; Mulsow 2004, p. 225; Spirgis 2004, pp. 386–387).

The dynamic development of the city, along with its economy, meant that a water supply based on private wells quickly became insufficient. The shortages must have particularly concerned the intensively-developing crafts of weaving, tanning, dyeing

Fig. 8. Krupniczy Bastion during excavation works. View of left flank, part of the face and projecting outwards, strengthened with posts, fascine platform (after Konczewski, Mruczek *et al*. 2010)

and beer production (Goliński 1991). Therefore, the construction of communal waterworks drawing water directly from the rivers was initiated – firstly from the Odra, and later also from the Oława. The discussion about their origins has been going on for a long time, and sources written and obtained by archaeological methods indicate varied dating. A clue suggesting an early dating of water distribution in the city is a fake document of the Silesian duke Henry Probus informing of the privilege that was to be granted to the townspeople in 1272 [...] *in ductione aquarum ei in eius usibus* [...]. This information becomes very important if we accept the dating of the counterfeit to the first half of the 14th century, i.e. as its publisher suggests (SUB 1988, no. 448). However, the oldest water supply device in Wrocław, referred to as *rota aque*, was mentioned later, only in 1386 (Goliński 1997, pp. 78–79). Subsequent messages allow them to be identified with a waterwheel, lifting water from the Odra that is then distributed in the city by the force of gravity. It was located near the Furty Młyńska, at the northern outlet of Kiełbaśniczej St. (Fig. 12: A). Water from them was distributed mainly in the affluent western part of the city – in the zone of Kiełbaśnicza St., the Market Square, Solny Square and Ofiar Oświęcimskich St. Citing older, unpublished results of Andrzej Kudła's research (based on the analysis of modern sources), Piotr Janczewski is inclined to extend the medieval range of this water supply also on Kotlarska St. and the southern frontage of Nowy Targ Square (Janczewski 2005, Fig. 1). Such an opinion seems to correspond with the description of Barthel Stein from 1512, which indicated that

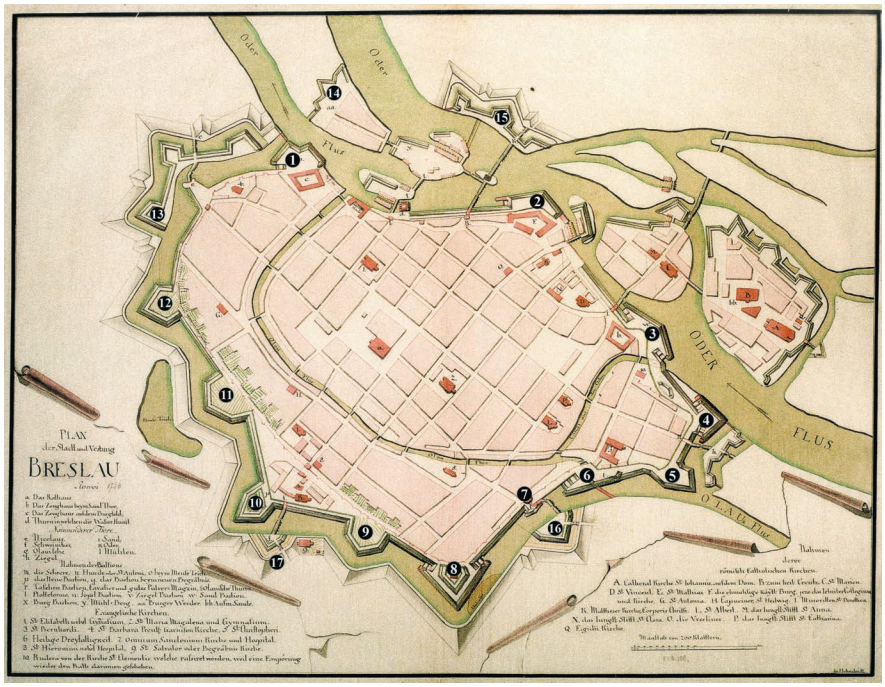


Fig. 9. Bastion fortifications in Wrocław by end of 17th century. Italian system, bastions: 1 – Kleszczowy, 2 – Zamkowy, 3 – Piaskowy, 4 – Ceglarski, 5 – Bernardyński, 6 – Hioba, 7 – flat bastion (*piatta-forma*) of Oławska Gate, 8 – Sakwowy. Dutch system, bastions: 9 – Międzymurze; 10 – Nowe/new work; 11 – Krupniczy; 12 – Psi; 13 – Mikołajskie crownwork; 14 – entrenchment of Góra Młyńska; 15 – Odrzańskie crownwork; 16 – ravelin of Oławska Gate; 17 – ravelin of Świdnicka Gate; 18 – Tumskie entrenchments (edited by N. Lenkow, Młynarska-Kaletynowa, Eysymontt 2001)

the entire water supply network in the city was fed by the *Wasserhaus* at the Mill Gate (Stein 1995, pp. 32, 35).

The oldest waterworks confirmed by archaeological methods were in the form of troughs made in an oak trunk and covered with timber. Józef Kaźmierczyk described them for the first time, based on his discoveries in the eastern part of the city. He dated it as early as the 13th century and connected it with the *rota aque* waterwheel (Kaźmierczyk 1970, pp. 68–69). Similarly, an early dating was suggested by Piotr Janczewski, giving further examples of troughs assembled from ridges (Janczewski 2005, p. 68, Fig. 5). New opportunities for analysis, including dating of the beginnings of Wrocław's waterworks, were brought by the Nowy Targ Square research conducted in 2010–2012 (*Rytm rozwoju miasta* 2018). In a large excavation, reaching an area of 0.4 ha, and thus giving good observational opportunities,

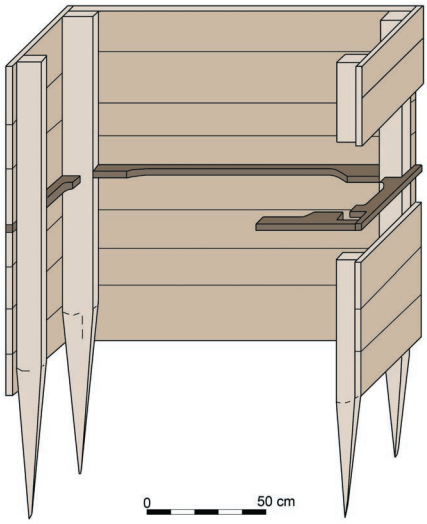


Fig. 10. Wrocław, ul. Więzienna 11. Construction of a well (drawing by N. Lenkow; after Buśko 1999)

Fig. 11. Wrocław, Nowy Targ Square, inside of the well. Js. 548 (photo by M. Mackiewicz)

significant sources were obtained that changed or enriched existing interpretations. It consists of a system of four water wells and water distribution pipes (Fig. 13). Wells do not reach the depth of the aquifer. Instead, they are connected to a system of water transport lines. In total, over 100 m of running oak and pine troughs connecting wells were discovered. The oldest of these devices were stratigraphically

Fig. 12. Wrocław on Barthel Weyner's panoramic map of 1562. A – the *Wasserrath* water house on the Odra by the Lesser Mill Gate (*Mühlpfort*); B – the water house by St Matthew Island; C – Ketzerberg (after *Atlas historyczny* 2001).

associated with the late medieval layer designated as stratigraphic unit 19, dated on the basis of movable monuments of the 14th century (Marcinkiewicz, Piekalski. 2018c, pp. 163–176). The acquired series of 30 dendrochronological dates specifies the construction time for wells and troughs for the first half of that century (Piekalski 2016; Krąpiec, Piekalski 2019, pp. 320–322). Therefore, a combined analysis of a diverse category of sources, findings made earlier by J. Kaźmierczyk (1970, pp. 68–69) and P. Janczewski (2005) and recent discoveries at Nowy Targ Square allow us to conclude that the decision to construct a municipal water supply was undertaken at a time close to that of other Central and Northern European cities. Earlier, monasteries used waterworks in former Roman provinces (Grewe 1991, pp. 13–47; Cembrzyński 2011, pp. 40–41). For bourgeois waterworks, good

Fig. 13. Wrocław, Nowy Targ Square. Fragment of wooden water pipe with well (photo by M. Mackiewicz)

points of reference are London and Lubeck, where the decision to build them was made at the end of the 13th century (Grewe 1991, p. 62; Grabowski, Mührenberg 1994; Sloane 2004, pp. 89–90). In the first decades of the 14th century, similar investments were made by the city councils of Schaffhausen, Freiburg im Breisgau, Prague, Nuremberg, Frankfurt am Main, Gdańsk/Danzig, and other important Central European centres (Grewe 1991, pp. 58–65; Cembrzyński 2011, pp. 41–42). Thus, the situation of Wrocław corresponds to the then general trends resulting from the economic needs of the city, natural environmental conditions and the state of technological knowledge available to cities of Central and Northern Europe.

The aforementioned *rota aque* of the *Wasserhaus* was not the only one in Wrocław. The increase in the demand for water, together with the increase in population, as well as the need to supply the entire city with a network, resulted in the construction of two more such devices. Some premises from written sources indicate that a second *Wasserhaus*, at Kacerska Górka/Ketzerberg, may have a medieval dating (Fig. 12: C), drawing water at the south-eastern edge of the city from the Oława through its inlet to the inner city moat (Goliński 1997, p. 208; 2001; Piekalski 2004, p. 13). A third water house drew water from the Odra at the exit of Szewska St., next to St Matthias island (Fig. 12: B). The *Wasserkunst* located there was the most modern, built in the 1630s (Grewe 1991, p. 65; Sowina 2009, pp. 281–282).

Each of these devices was modernised several times. The rebuilt *Wasserkunst rota aque* had a new waterwheel with 160 buckets from 1538. It raised water to a height of 28 feet and provided up to 500 litres of water per minute (Grewe 1991, p. 65). The *Wasserhaus* by Kacerska Górka acquired a modern form after 1596, after reconstruction carried out by master Hans Schneider von Lindau, previously active in Gdańsk. It was made up of two brick buildings at the time. The first was of one storey, erected on arches above the narrowed and fortified walls of the riverbed, and was used to collect water. Details of these constructions have been explained by archaeological research (Figs. 14–16) (Goliński 2001; Piekalski 2004, pp. 348–349). The second building, erected on the outer edge of the trough, housed a tank. This erection, known as the *Ketzerkunst*, operated until the mid-nineteenth century (it was demolished in 1857; Markgraf 1896, p. 88). Archaeological research carried out at the most recent water house, drawing water from the Odra at the exit of Szewska St., at St Matthias island, showed poorly preserved, brick foundations of the tower combined with the wall of the Odra embankment. We know that the water damming device was located in a building consisting of a multi-storey frame building and a tower with a tank not much higher than itself (Grewe 1991, p. 65).

Water distribution was carried through pipes installed by the commune and buried in the ground under the street surface. They were equipped with public wells on streets and squares, as well as private sections leading to bourgeois plots. Materials and techniques of pipe construction varied. The aformentioned wooden troughs were the oldest. In the second half of the 14th century, ceramic pipes appeared, consisting of 36–60 cm long sections made on a potter's wheel (Dwojak 1993, pp. 292–295; Piekalski 2004, pp. 14–17; Biel, Serwatka 2014). From the end of the 15th century, they were replaced with wooden pipes made of trunks made with a stem and with a drilled channel. Wooden pipes used in subsequent centuries were of varying quality. It happened that they were carefully hewn to a square section, and their length was up to three metres (about ten feet). They were discovered in many parts of the city, and the youngest of them are dendrochronologically dated after 1831 (Limisiewicz 1998, pp. 218–219; Janczewski 2005, p. 87). However, we know that as early as the 18th-century wooden pipes were replaced with iron, lead or ceramic ones (Berger 1926, p. 16).

Medieval, wooden water wells were replaced in modern times with stone and, more rarely, brick ones. From the 16th century, a well consisting of three or four segments forged from sandstone, elliptical or circular in cross section, became the standard. The bottom was modelled in the bottom segment. Such wells are discovered both in streets and on plots. An iron pipe is attached to such a well, as discovered on a patrician's plot at Rynek 6. The maker's mark placed on one of the sandstone segments dates the well to 1727 (Fig. 17). A similarly constructed segment of the well was also discovered at Nowy Targ Square. The date 1833 is carved on it (Chorowska *et al.* 2018, p. 261).

Fig. 14. Wrocław, the *Ketzerkunst* water house on an engraving by Heinrich Mützel from 1826

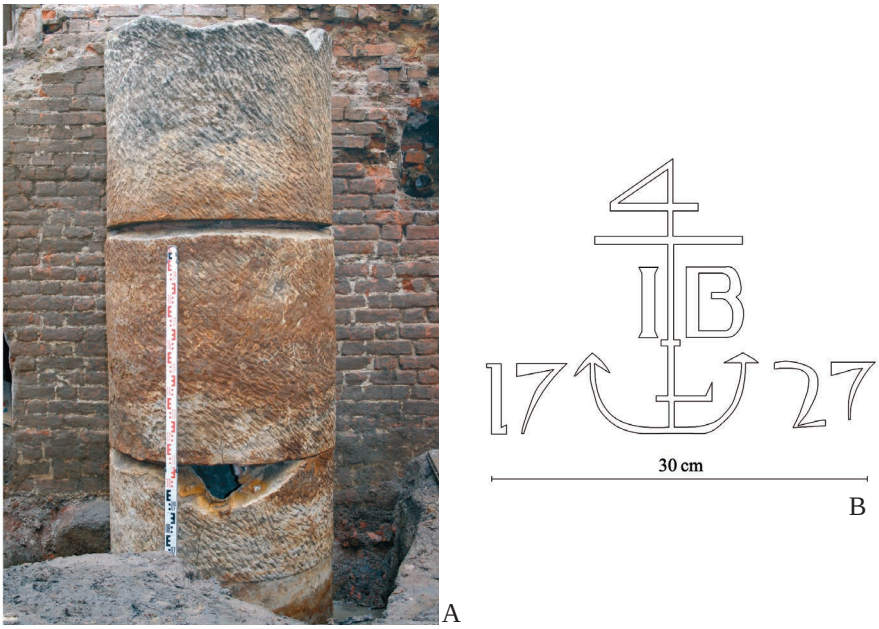
Fig. 15. Wrocław, *Ketzerkunst* water house, bottom and quay of moat from 16th century (photo by P. Konczewski)

Fig. 16. Wrocław, *Ketzerkunst* water house, interior of building above moat, visible inlets for fixing wooden structures (photo by P. Konczewski)

It seems that the systematically repaired and improved water supply supplied modern Wroclaw with sufficient water. The problem was that it was not always good quality. Water was drawn from lowland rivers exposed to natural seasonal pollution, but also contaminated with sewage from the city itself. The equipment at their disposal was used to accumulate and transport water, but did not purify it as in later periods. It is not surprising then, that traditional wells were also used. Water from them, taken from the ground, was not of high quality. However, it was considered better than the water supply (Berger 1926, p. 15; Brzezowski 2005, p. 306).

The river and the city's economy

The main economic benefit of the river in the city was the use of waterwheel energy. The scope of the archaeological recognition of this problem is, however, rudimentary. We know about the discovery of millstones or their fragments during rescue excavations carried out at the Odra riverbed on the northern edge of the medieval city (these, however, remain unpublished). Written sources convince us that this energy was used. In particular, the section of the river bank from the castle to the west was intensively used. In addition to the water house mentioned above, in the 14th century there were at least two wheat mills, a malting mill, a sawmill, and a grinding house (Goliński 1997, pp. 78–79). The so-called internal moat must



A B

Fig. 17. Wrocław, no. 6 Rynek (Market Square). A – well, B – maker's mark (photo and drawing by P. Konczewski)

have had a rapid current, fed with the waters of the Oława, since two large mills were placed above it – the *Ketzermühle* in its western section and another, known as the Mill of Seven Circles in the middle section, at the horse market (*Breslauer Urkundenbuch* 1970, no. 117; Goliński 1997, p. 157). We also have information from 1490 about the existence of a paper mill near Kępa Mieszczańska. It later changed location several times (Maleczyńska 1961, p. 23).

Another problem is the location of craft workshops that required large amounts of water were but also burdensome for residents. This was the case with the slaughterhouse, located directly on the Odra, at the north-western edge of the fortified area, supplying meat to slaughterhouses within the city (Goliński 1997, pp. 78–79). We can estimate that its location was determined by sanitary considerations. The arrangement of tanneries was similarly conditioned. Zones inhabited by tanners, also due to the low social position of this group of craftsmen, were often considered inferior (Cramer 1981; Ruckstuhl 1993). On the other hand, it is emphasised that the economic weight of tanning production was so great that, when deciding on the location, it eliminated the nuisance of odour associated with processing leather (Sowina 2009, pp. 81–82). In Wrocław, tanneries were located in the north and north-west of the city, near the Odra and the western section of the inner moat (Goliński 1997, pp. 149–152; Konczewska 2018, pp. 748–767). At two points they have been confirmed by archaeological methods. At number 11,

Więzienna St., tanning tanks were located within the building and in the middle of the plot (Buśko 1999b, pp. 92–95). The distance from the Odra did not exceed 100 m. The second workshop, also with preserved tanning equipment and waste, was examined in the zone between the old monastery of the Knights of the Cross with the Red Star (today the Ossolineum building) and the castle (today the main building of the university). Please note that the location of these elite buildings was not in conflict with the vicinity of the tannery (Konczewski, Lasota *et al*. 2010).

The river and sanitary conditions in the city

The sanitary conditions of the city were influenced by both natural and man-made factors. The former are mainly the height of ground water level, soil permeability and topography. On light soils with sandy or gravelly ground, when located on a slope, organic waste decomposed relatively quickly. The man-made factors are the density of buildings, the profile and intensity of economic activity, as well as customs and ordinance regulations.

In the case of Wrocław, natural factors were not favourable. Differences in the height of the land in the city and its environs were small. Significant parts of the city area, especially in the northern zone adjacent to the river, remained wet and exposed to flooding. The high level of groundwater, generally unfavourable to health conditions, hindered the decomposition of organic waste. Actions aimed at alleviating this inconvenience and adapting the area to use were taken in the 13th century, after the location of the city. On its significant surfaces, layers of sand were laid down, raising the level by about 50–60 cm, as in the Market Square and Nowy Targ Square (Bresch *et al.* 2002; Marcinkiewicz, Piekalski 2018c, p. 146). A side effect of settlement soon turned out to be the uncontrolled growth of the rubbish layer, which we read as a cultural layer: although raising the height of the land by up to about four metres, it was at the same time fatal for the sanitary conditions of the city and transportation conditions (Piekalski 2014, pp. 139–140). The regulation of rivers and the construction of water damming devices for economic purposes also had an adverse effect by raising the groundwater table (Sowina 2009, pp. 52–65; Badura 2010, pp. 40–44; Konczewski, Piekalski 2010, pp. 91–151). All this led to far-reaching physico-chemical transformations of the soil that are legible in cities with centuries-long histories extending to modern times (Wardas-Lasoń 2016). Problems with maintaining proper sanitary conditions in the city were compounded by the density of buildings. Especially in the older literature on the subject, it was usually assumed that medieval cities were largely overpopulated (Gruber 1942; Beresford 1967). Today we know that such views resulted from a retrospective analysis of the situation from modern times. Archaeological research covering the earlier stages of development indicated that each city requires

a separate analysis in this respect, and the actual density of buildings was usually lower than previously thought. In most cities, at least until the end of the Middle Ages, there were reserves of building land that could be occupied by burghers as required (Piekalski 2001, pp. 159–201; Clark, Menjot 2019). In overcrowded centres, so-called New Cities were established, thereby increasing a city's income (Słoń 2010). Wrocław seems to be a good example of this. The area of the original Old Town was surrounded to the south and west by a zone added to the townspeople in the 1260s. Plots were separated there, adjacent to the outer moat, which until modern times contained large green zones that were unused for construction (Fig. 7). The New Town with wooden buildings also remained underdeveloped (*Atlas historyczny* 2001, Figs. 4, 13).

Maintaining the street surfaces in a condition enabling transport in the autumn and winter was a great challenge for medieval Wrocław. The techniques used by the townspeople have already been described and we will not present them in detail here (Konczewski, Piekalski 2011). Let us only emphasise that the main problem was the rapidly growing cultural layer, which the autumn rains transformed into deep mud saturated with organic residue. Until the mid-14th century, the basic technique for strengthening the surface were wooden structures and cyclical sand pouring (Fig. 18). Wooden platforms laid on the pavement were reflected in the names of the streets, documented since the 14th century, especially in the northern part of the city. We will find there a *ponte fabrorum* – Schmiedebrücke, Schuebrücke, Oderbrücke (Markgraf 1896, pp. 143–144, 184–190; Stein 1995, pp. 20, 66). The effect of such street improvement was not permanent, and the results of archaeological research confirm frequent repairs and application of subsequent layers of ridges on a worn-out surface. What is more, this technique did not inhibit the growth of the layer, causing the structure to be covered with new layers of mud. On the other hand, stone pavements proved effective, combined with the obligation to clean the street in front of one's property.

Another problem was getting rid of the contents of the cesspits located on bourgeois plots. In the case of Wrocław, we do not have sources for an effective analysis of ways to clean the city of faeces. The excavated contents of the overcrowded cesspits could be buried elsewhere in the city, which gives the effect known to archaeologists as cloistered pits without construction (Piekalski *et al.* 1991; Buśko 1996; Niemiec 2007). It could be taken outside the city, paying the appropriate fee. Until the 19th century, a recognised way to get rid of troublesome ballast was to throw it into a river or moat (Dirlmeier 1981, pp. 140–143; Gechter 1987, pp. 247–248; Kühnel 2003, p. 56). It can be suspected that this was also done in Wrocław.

Despite all these inconveniences, the opinion about the city's permanently poor sanitation, especially in older literature, seems exaggerated (e.g. Borst 1983; Buśko 1995, p. 100). Maintaining the cleanliness of squares and streets was a matter of constant concern for the townspeople. Measures for its maintenance underwent

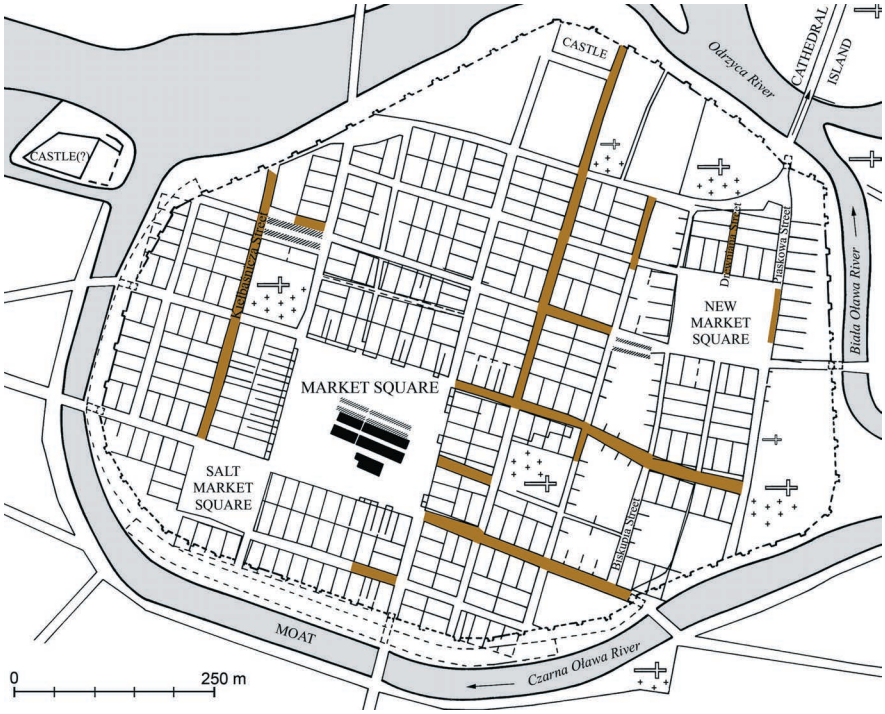


Fig. 18. Wrocław. Wooden streets confirmed by archaeological excavations (after Konczewski, Piekalski 2010)

changes, and the results of these measures can be described as variable (Kühnel 2003, pp. 58–64; Sowina 2005). Archaeological sources argue that the adverse effects of the population being concentrated in enclosed city spaces led to a reaction aimed at limiting this inconvenience. Filth and stench did not belong to city norms, and traces of daily activities show that pollution was treated as a highly negative phenomenon. Not all problems could be completely solved. The lack of bacteriological knowledge meant that many threats went unrecognised, e.g. the degree of groundwater pollution. We do not know to what extent sewage and faeces from cities affected river pollution. However, it can be assumed that the Odra and Oława flowing through Wrocław could accept urban waste without lasting damage. One could risk the thesis that the presence of rivers in this case had a positive effect.

In our opinion, the relatively good sanitary conditions in the city in the Middle Ages changed to a disadvantage in modern times. Progressive demographic development meant, that over time, the disposal of household waste became increasingly difficult. Factors beyond the daily activities of burghers and the competences of local government can be indicated as the main reason here. At the turn of the 16th century, fortifications adapted to changing techniques of warfare were introduced,

allowing the use of artillery (Piekalski 2007). It was the development of firearms that forced large investments in the city's defence in modern times. Bastion-type fortifications were permanently rebuilt and expanded throughout the period of interest to us. According to trends across Europe at that time, Wrocław, like other large cities, took on the role of a state fortress – firstly Habsburg in the Austrian Empire, and Prussian after 1740 (Gieraths 1961; Podruczny 2009). The new political and military situation conflicted with the interests of the city. It limited the independence of the City Council and practically blocked spatial development. The demographically growing city was closed within the boundaries set in the 13th century. At the beginning of the 16th century, about 20 000 people lived on a total area of approximately 140 ha. Based on written sources regarding city taxes, we can determine that they occupied about 2300 houses, or rather middle-class plots, on which next to the main house other, smaller buildings could also stand (Ziątkowski 2001, pp. 22–23). Thus, there is an average of 8.7 inhabitants per plot. At the end of the period we were interested in, the 1 787 tax censuses specify 3 388 houses inhabited by 50 975 people, i.e. an average of 15 people per household. Let us add that the tax records do not disclose all people present in the city, apart from the periodically employed residents of nearby villages in Wrocław, and homelessness is difficult to quantify. The population covering the same area of the city increased by over 150% from the turn of the 16th century to the end of the 18th century.

The organisation of removing dirt from bourgeois plots remained the same in the modern city as in the late Middle Ages. Therefore, the function of the sanitary facilities were mainly the courtyards of middle-class plots. Impurities were deposited on its surfaces or in cyclically cleaned cesspits. These plots, previously spacious, were divided into narrower ones, with borders fixed by brick tenement houses from the end of the Middle Ages. The results of archaeological research indicate that also the yards in the 16th–18th centuries were built-up mostly with back buildings and wooden structures. There was no room for backyard greenery, and the only structures present there are cesspits. Also, cesspit design had not changed significantly since the Middle Ages. They were still absorbent wood-lined pits that let the filth out into the ground. The high costs of emptying a cesspit meant that the majority of inhabitants did it rarely, once every few or several years (Piekalski 2004, Abb. 5; Brzezowski 2005, pp. 308–310).

Some liquid waste was discharged from plots into street gutters. The form of such devices had not changed significantly since the Middle Ages. They were shallow wooden troughs placed along the street and covered with boards (Piekalski 2004, pp. 352–354). Increasingly, they also took the form of a classic gutter formed in an appropriately profiled pavement stone. Gutters functioned gravitationally, and sewage drained into the Odra or urban moats. The fact that this system was imperfect and troublesome is evidenced by written communications – repeated legal regulations, disputes and neighbourhood quarrels resolved by the court, complaints

Fig. 19. Wrocław, Białoskórnicza Street. Inner moat in 1826, drawing by Heinrich Mützel (after *Ikonografia Wrocławia* 2008)

and petitions of residents coming to the Construction Office (Brzezowski 2005, pp. 307–312). They generally inform us that technical measures available and used for maintaining proper cleanliness of the city in Wrocław in the 16th–18th centuries were insufficient.

Despite the enormous amount of engineering work carried out from the Middle Ages to the 19th century, the backwaters of lowland rivers and their marshy shores, mud on streets and courtyards, and generally prevailing moisture had a negative impact on living conditions. Urban moats, especially those limiting the inner city zone, caused an increasing sanitary problem. Originally they had a significant width of about 45 m, and a depth of up to 4.5 m (Piekalski 2001, p. 191). After construction of the second, external line of urban fortifications, its military significance waned, and over time it ceased. In the 15th–16th centuries, its width was radically reduced, and the banks were stabilised by walls, thus creating an inner-city canal. Along its banks, residential buildings were built, as well as various technical devices, including platforms for washer women (Fig. 19). The presence of residential buildings in particular meant that bans on throwing waste into water could not be effective. On the banks of the canal, on each of the bourgeois plots created there, cesspits were built. There, wastewater from households was also drained. As a result, the purity of the water progressively worsened. It was considered that this channel contributed to the outbreak of cholera and was filled in after 1866 (Markgraf 1913, p. 62), creating a street in its place. Cesspits located on the edge of the plots recalled the old sewage character (Fig. 20). The solution to the problem of discharging faeces

Fig. 20. Wrocław, Zaułek Niski Street, former inner moat in early 20th century (post-card from the collection of P. Konczewski)

and sewage from the city did not occur until the turn of the 20th century, when construction of the sewage system began.

Conclusion

Wrocław is a city in which the interaction of the river and the inhabitants was continuous and particularly intense. It is a paradox that the choice of place for the functioning of the urban community that formed in the 13th century was not conscious. It resulted from Wrocław's three-centuries-long history – dating back to the founding of a small castle on a river island. The pre-industrial phase of the city's seven centuries of existence was a time of dependence on the rivers Odra and Oława and continuous adaptation to needs.

The original form of the hydrographic network significantly affected the layout of populated zones; especially in the early phases of development. On the other hand, however, the natural form of the meandering rivers was disturbed even before the foundation of the municipal commune by the construction of the massive,

earth-and-timber fortifications of the stronghold stabilising the form of the island later referred to as the 'cathedral'. Further intense interference continued from the 13th century onwards – the construction of a dyke, the strengthening of river banks, the installation of waterwheels. The excavation of urban moats fed with the waters of the Oława was a great investment. The next stages were the construction of a municipal water supply system in the 14th century and from the end of the 15th century to the 18th century, the permanent adaptation of the city moats to the requirements of the new fortifications.

The negative, difficult to overcome, or costly repercussions of the proximity of a large lowland river for urban life also need to be emphasised. They consist mainly of a humid and unhealthy microclimate, the low quality of drinking water, the need for continuous investments for flood protection and treating the area under construction, the humidity of coastal areas and problems with removing impurities.

Summing up the relationship between man and nature in Wrocław, it should be assumed that the scope of anthropogenic changes has turned out to be huge. The natural Odra and Oława rivers in the 10th century and the hydrographic network of the city in the 19th century are two different phenomena.

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Abbreviations

SA – Silesia Antiqua, Wrocław
SSA – Śląskie Sprawozdania Archeologiczne, Wrocław

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