3. Physical-geographical factors relevant for the development of Ljubljana

Darko Ogrin

3.1. Natural transport openness at the contact of diverse landscape units

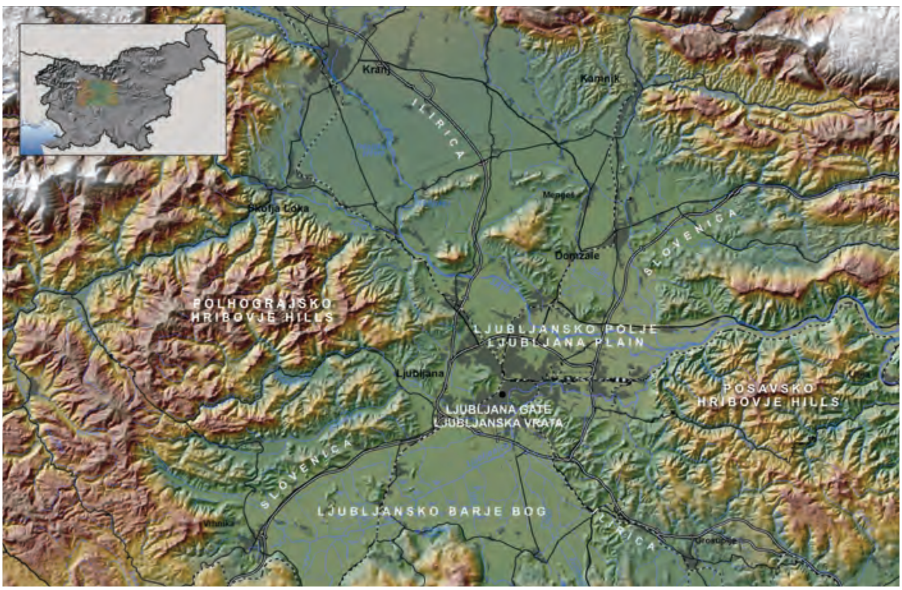
In view of large physical-geographical units that make up Slovenia, Ljubljana lies in the area of the sub-Alpine regions which, as a mountainous crescent, rim the Julian Alps, the Karavanke and the Kamnik-and-Savinja Alps. This crescent is not continuous; the large tectonic depression of the Ljubljana basin divides it into the Eastern- and the Western sub-Alpine mountain ranges. The Ljubljana basin is the largest continuous plain in Slovenia, 60 km long and 20 km wide. Its bottom rises in the SE – NW direction, from the initial 260 m to 550 m above sea level. The sinking of the basin began as early as the Oligocene (from 36 to 23 million years ago), when it was filled up by the sea pouring in from the eastern side, i.e. the Pannonian sea. The sinking continued in the Neogene. The last ice age (Pleistocene, from 1.6 million years to 10.000 B.C.) was particularly decisive for its present image, owing to the very intense weathering caused by great temperature oscillations. The rivers, the Sava in particular, accumulated large amounts of glacial material in that period, so that the layers of gravel and conglomerate are up to 100 m thick at some places.

Ljubljana was founded in the southern part of the Ljubljana basin, at the contact of the Ljubljansko Polje plain (hereinafter: Ljubljansko Polje) and the Ljubljana Marsh (also Ljubljana Bog, hereinafter Ljubljansko Barje or just Barje), and at the transition of the Polhograjsko Hribovje hills to the Posavsko Hribovje hills. The Ljubljansko Barje is usually regarded as a part of the sub-Alpine regions, though its hydrological features strongly resemble the karst poljes, therefore in some physical-geographical divisions of Slovenia (e.g. Gabrovec et al., 1998) it is ranked among the Dinaric-karst regions which border its southern edge. Ljubljana developed along the 1.5 km wide Ljubljana gate (298 m a.s.l.), where the river Ljubljanica had broken through the low hilly barrier of carbonate schists between the hills Rožnik (394 m) and Šišenski Hrib (429 m) in the west and the hills Grad (366 m) and Golovec (450 m) in the east.

Due to the recent tectonic sinking which has been active in the eastern and southern parts of the basin all until the present, the Ljubljana basin became a confluence area of the powerful water streams which cut the hilly rim and made feasible the natural transport openness in all directions, except in the direction of the Karavanke. The valleys of the Črna and the Nevljica and the Črni Graben valley connect the Ljubljana basin with the Celje basin and the Upper Savinja valley. Along the Sava valley in the Posavsko Hribovje hills transport is possible towards Zagreb and Celje, and along the Dolenjsko Podolje system of valleys transport runs towards the Krško basin and the Croatian Posavina region. Through the Upper Sava valley the Ljubljana basin is connected with La Valcanale valley, and across the saddles of less than 900 m a.s.l. roads run across the Škofjeloško Hribovje hills to the Soča region, and across the Postojna gate (609 m a.s.l.) towards the Adriatic sea.

Because of the favourable transport position between the Apennine Peninsula and the Donava drainage basin the antique settlement Emona, the predecessor of the present Ljubljana, developed on the prehistoric foundations in the southern part of the Ljubljana basin. In the later centuries, the favourable transport position made possible for Ljubljana to develop faster than other Slovenian towns. An intensified economic development began after the mid-19th century, when the railway line was constructed between Vienna and Trieste. This was also the the time when Ljubljana became the political and cultural centre of the Slovenians. The southern part of the Ljubljana basin, i.e. Ljubljana, is also the crossing point of modern transport routes. The Illirica (the Sava route), running in the NW-SE direction, connects West- and Central Europe with South-East Europe, and the Slovenica, running in the NE-SW direction, connects the Mediterranean with East Europe. The Slovenica also makes part of the European transport corridor number V (Venice–Trieste–Ljubljana–Budapest), and the Illirica makes part of the corridor number X (Villach–Ljubljana–Zagreb–Belgrade).

Figure 3: Position of Ljubljana at the contact of major physical-geographical units and transport routes.



3.2. Rock structure and landforms as the factors of urban development

The antique settlement, Emona, developed on the southern edge of the present city centre, at the transition of the Ljubljansko Polje gravel accumulation to the Ljubljansko Barje soft sediments, while the Medieval Ljubljana developed under the hill Grad along the banks of the Ljubljanica. Both settlements mainly spread on rock basis of higher carrying capacity where the building process was less complicated. On the marshy Ljubljansko

Barje of lesser carrying capacity, the town began to spread more intensely only after the 2nd World War, because the building process on the marshy ground is more demanding and more expensive due to sanding and piling, in spite of the lower prices of building plots. The present town mainly extends over two level landscape units, the Ljubljansko Polje and the Ljubljansko Barje, which offer different conditions for urban development. The Ljubljansko Polje, where the northern part of the town lies, is not a monotonous plain, but is dissected by fluvial terraces which play an important role in the settling process and the agricultural use. It was formed by the river Sava through its accumulation and erosion processes, and is about 20 km long, up to 6 km wide, lying at the altitude between 265 and 320 m. It is situated between the Ljubljana gate and some isolated hills, i.e. Šmarna Gora (669 m a.s.l.), Rašica (631 m a.s.l.), Straški vrh (452 m a.s.l.) and Soteški Hrib (450 m a.s.l.), which demarcate the Ljubljansko Polje from the Skaručensko Polje plain, or the Kamniško-Bistriška Ravnina plain, and form a link between the Polhograjsko hribovje hills and the Posavsko hribovje hills.

The basis of the Ljubljansko Polje consists of firmly consolidated conglomerate which is covered with thick accumulations of mainly limy gravel. In the slightly inclined surface which drops from the NW towards the SE and the S, the Sava formed a series of terraces, and at some places it also eroded the pre-Quaternary bottom (e.g. at Tacen and the bridge at Črnuče). In the past times, the Sava frequently shifted its riverbed in the central part of the plane, made accumulations and eroded its own sediments and was a threat to agriculture, transport connections and the population. Its channel was straightened and made deeper with the regulation works and the transport capacity of the river thus increased. There is an extensive alluvial plane along the river, dissected into several terraces which are overgrown with pioneer and forest vegatation. The gravel terraces of older origin are mainly cleared, settled and transformed into fields, although their brown soil is shallow and gravelly.

Old agrarian villages emerged along the NE edge of the gravel terrace on the slope above the Sava plane on the right side of the Sava between Medno and Zalog (Vižmarje, Savlje, Ježica, Stožice, Tomačevo, Šmartno, Zadobrova) and on the left side between Tacen and Dolsko (Črnuče, Šentjakob, Brinje, Beričevo, Videm, Dol). Another series of villages developed at the foot of the hills between Medno and Sostro, where the brooks from the northern fringes of the Polhograjsko Hribovje hills and Golovec covered the gravel plain with clay (Stanežiče, Šentvid, Dravlje, Šiška, Štepanjska vas, Hrušica, Bizovik, Dobrunje). The numerous old settlements developed into suburban areas of Ljubljana, because the conditions for house building are more favourable here than on the neighbouring Ljubljansko Barje; thus the Ljubljansko Polje ranks among the most densely populated regions in Slovenia.

The Ljubljansko Polje is the most intense traffic area of the Ljubljana basin. The transport routes converge in the narrow area between Rožnik and Golovec (the Ljubljana gate) and form the centre of the so-called Slovenian transport cross. On the NE, Ljubljana has the transport linkage with the sub-Alpine route Graz – Maribor – Celje – Trojane, which continues along the northern edge of the Ljubljana Marsh towards the Postojna gate and the Mediterranean. The Sava valley allows transport openness towards the NW and slightly less so towards the SE, in which direction the railway line runs along the narrow valley. Important road connections towards the Krško valley run along the NE edge of the Barje and cross the Dolenjsko Podolje system of valleys. The Ljubljansko Polje is also a very important source of drinking water, since its groundwater provides as much as 90 % of the water supply for Ljubljana (pumping stations: Šentvid, Kleče, Jarški prod and Hrastje). Even today the groundwater of the Ljubljansko Polje is regarded as a quality resource, although the results of analyes have already shown the increasing impact of environmental pollution (Brečko Grubar, 1999).

Figure 4:
Cross-section of gravel accumulations of the Ljubljansko Polje plain. The depth of gravel accumulations and deep water table make feasible the construction of several-storey basements.

Photo: D. Ogrin.

The southern section of Ljubljana (south of Aškerčeva cesta street) spreads to the Ljubljansko Barje. This is the southernmost and in terms of tectonics the youngest part of the Ljubljana basin. It comprises about 160 km2 of the plain between the slopes of the southwesternmost part of the Posavsko hribovje hills to the east, the Polhograjsko hribovje hills to the north and northwest and the Dinaric plateaus with Mt. Krim (1108 m) and Mt. Mokrc (1059 m) to the south. The major part of the plain lies at the altitude between 288 and 290 m above sea level, and rising above it up to about 300 to 400 m a.s.l. are several isolated hills (Sinja Gorica, Blatna Brezovica, Bevke, Kostanjevica, Plešivca, Grič, isolated hills at Vnanje Gorice) which are the less sunken parts of the bottom of the Ljubljansko Barje. The isolated hills mainly consist of Triassic dolomite and to a lesser degree also of limestone, just like the bottom of the Barje basin and its southern and SW fringes.

The origin of the Ljubljana Marsh dates back to about 2 million years ago when the sinking began along the tectonic faults, which has been going on until today. This sinking was most intense during the ice age. The basin which appeared due to the sinking was currently filled by the streams, the Ljubljanica in particular, and when the sinking was faster than sedimentation, a lake emerged. The rate of the sinking was rather high, since in 500 years the bottom was lowered by 1 meter, and the present annual rate amounts to as much as 5 to 25 mm per year (Lovrenčak, Orožen Adamič, 1998). Due to the intense sinking of the Barje, the deposits of gravel, sands, clay and loam are very thick, reaching up to 100 m in its western half, and over 150 m in its eastern, deeper part. The composition of sediments in the Barje basin is rather heterogeneous. On the surface, there is up to 20 m thick layer of clay-silt sediments with remains of vegetation (peat), and at the edge of the Barje plain, also sand-clays and silt, and lying under all of these are sandy-gravel Pleistocene aquifer sediments, which are separated in two parts by impermeable clays. Clay-gravel sediments only occur on the surface of the alluvial fans of the Iška and the Gradaščica, while the alluvial fans of the Želimeljščica, the Škofeljščica and the Borovniščica rather rapidly sink under the impermeable boggy sediments (Mencej, 1990).

Times ago, the Ljubljansko Barje was the southernmost European raised bog (which also gave the name to the landscape: bog = barje) and the only case of the blanked bog in Slovenia. It was rich in peat which had originated from the accumulated dead marshy vegetation being anaerobically weathered and carbonized. In the 19th century the digging of peat and its economic use began in the Ljubljansko Barje, which continued until a few years after the end of the 2nd World War. The peat has mainly been exploited by now and is no longer allowed to be dug. Because of the regulation and drainage works of the Barje, it no longer grows while minor peat areas and living peat bogs have only been preserved near Bevke (Mali Plac), Črna Vas, Goričica and Grmez.

In comparison with the Ljubljansko Polje, the settling of the Barje is thinner and also of younger origin. Old villages emerged on the dryer margin of the marsh on the "compact soil" of better carrying capacity, where also the transport veins ran. In the central area of the Barje the first settlements occurred only in the 19th century (Črna vas, Lipe), after the boggy ground had become suitable for agriculture, partly at least, upon the long-lasting drainage works. Ljubljana did not spread to the Barje until the 1st World War; only after it, the first town quarters began to emerge here (Galjevica, Sibirija). However, despite the unfavourable conditions for building (piling) and poor furnishing with communal infrastructure, the Barje underwent an expansion of urbanization after the 2nd World War, when numerous illegal houses were also built (Rakova Jelša).

Figure 5:
Due to the poor carrying capacity of the surface, the building of houses on the Ljubljansko Barje requires the piling.

Photo: D. Ogrin.

3.3. Seismic hazard due to active recent tectonics

Typical of the southern part of the Ljubljana basin, including the Ljubljansko Barje, is active recent tectonics which results from the sinking of the Barje along numerous faults. Along the faults running in the Dinaric, i.e. NW–SE direction (in the area of the Barje these are: the Dobrepolje-, the Želimlje-, the Mišji Dol- and the Borovnica faults; Pavšič, 2008, 6), and those that run rectangularly to this direction (the Vič- and the Podpeč faults), and along the thrust structure running in the Alpine, east-west direction across the centre of the Barje numerous small and greater earthquakes continuously occur. The faults are mainly shallow (up to 10 km), therefore the epicentres also lie close to the surface. Although in general the earthquakes in our country are not of higher magnitude values, their effects might be quite serious due to shallow epicentres (Vidrih 2002).

According to the offical map on seismic hazard in Slovenia for the recurrent earthquake period of 500 years (Ribarič, 1987), the anticipated intensity of earthquakes in Ljubljana and its surroundings could be of degree VIII acc. to the EMS, which means building collapse earthquakes. In the recent years a new, modern map on seismic hazard was made (Lapajne et al., 2001) showing the calculated design ground acceleration and flexibility spectres of response for diverse types of ground instead of the maximum intensity of earthquakes. According to this map, too, the area of Ljubljana, together with the Upper Soča region, ranks among the areas of the greatest earthquake risk in Slovenia. As the maps of Intensities and magnitudes of earthquakes in Slovenia from 567 A.D. onwards (Vidrih, 2008, 53) show, at least two earthquakes with the intensity of VIII-IX, or IX degree with the magnitude above 6, and five earthquakes with the intensity of VII-VIII or VIII degree with the magnitude 5.1 to 6.0, have struck the wider area of Ljubljana in addition to numerous earthquakes of minor intensities.

Of all the earthquakes in Ljubljana, the one of 1895 marked a real turning point. The results were not only negative, but also positive. Parallel to urbanistic and architectural restoration of the town, an investigation into the building-technical standards was also made, which provided the first guidelines for the seismic-safe building techniques. Two years after the earthquake, a seismic observation post started to operate in Ljubljana, the first one in the Austro-Hungarian monarchy. The Ljubljana earthquake of 1895 had the magnitude of 6.1, the epicentre was in the depth of 16 km, and its effects were the most intense – between VIII and IX degrees acc. to the EMS – in the town area, on the Ljubljansko Barje and up to Vodice in the north. The earthquake caused enormous material damage; about 10 % of the buildings were damaged which were mainly pulled down later on. Under the ruins, seven people died in Ljubljana and three at Vodice (Vidrih, 2008).

Since the Ljubljana area belongs to the areas with the highest seismic hazard in Slovenia, a microseismic regionalization was made for it (Figure 5). According to this regionalization, almost half of the territory of the Ljubljana municipality is relativelay safe from earthquake. This is mainly the hilly area in the east of the municipality and the northern part of the town lying on the higher terraces of the Ljubljansko Polje. Falling within the medium earthquake risk is more than a third of the municipality (lower terraces along the Sava and the Ljubljanica). The area of the greatest hazard (degree IX earthquakes) is the Ljubljansko Barje and its transition to the Ljubljansko Polje in the Ljubljana gate, where the city centre also lies. This area occupies about 15 % of the municipality where almost 10 % of the inhabitants live (Orožen Adamič, Hrvatin, 2000).

3.4. Flood hazard and water resources

Ljubljana is closely related to the Ljubljanica, the river which springs from numerous karst sources near Vrhnika and has an extensive karstic and non-karstic drainage basin. Typical of it and its numerous tributaries on the Barje (the Ljubija, the Bistra, the Borovniščica, the Iška, the Ižica, the Gradaščica, the Mali Graben) is a very small vertical drop, lesser than 2 ‰, which has a strong impact on the drainage conditions and flood occurrence on the

Ljubljansko Barje and in the south parts of the town. Important for flood occurrence are also explicit seasonal oscillations. The lowest discharges are lesser than 10 m3/s (late summer), while the extreme discharges exceed 300 m3/s (usually in autumn at precipitation extremes). On the northern side, the town has spread all to the Sava and beyond it. The hydrological regime of the Sava differs from that of the Ljubljanica, and they have separate flood areas. Prior to the regulation works at the beginning of the 20th century, extensive flood areas extended along the Sava, with numerous meanders, oxbow lakes and groves. After the flow had been regulated and the channel straightened, the riverbed deepened and flood occurrence reduced. The built-up areas and transport infrastructure began to spread over the onetime riverine belt; in spite of it being so, these areas are less endangered by floods than the southern part of Ljubljana. Fortunately, also the causes of floods by the Sava and of those on the Barje are different, so – as a rule – Ljubljana does not face concurrent floods on both of these areas.

Throughout the history Ljubljana has had to cope with floods in the town and on the Barje. Extensive drainage works were started on the Barje as early as the end of the 18th and the beginning of the 19th century. In order to reduce flood hazard in the very town, the relieving Gruberjev Prekop channel was dug between Grad and Golovec hills in the years 1772 – 1782. It cut through the Ljubljanica meander around Grad hill, and the runoff capacity at high waters was increased. In spite of extensive drainage works on the Barje (the total length of drainage ditches amounts to over 600 km), the Barje can still be flooded periodically. Exposed to flood hazard is also the southern part of the town, which is intensely spreading into the area of flood risk, because the technical solutions are overestimated while the flood risk is underestimated. The latest big flood (of which no accurate data have yet been available in time of preparation of this book) occurred in September 2010. It resulted from extremely heavy rains, when more than 200 mm of precipitation fell in the central part of Slovenia within a spell of three days only. Floods occurred in numerous parts of Slovenia and caused extensive material damage. In the Ljubljana area, the greatest damage occurred in the SW and S parts of the city (along the rivers of Gradaščica, Mali Graben, Ljubljanica and Ižica) and in the Ljubljansko Barje moor area. Big flood occurred also in October 1994 along the Mali Graben, a tributary to the Ljubljanica, when more than 100 family houses of mainly recent origin were flooded (Starec, 1996). In the case of disastrous floods in the Ljubljanica drainage basin, which – as a rule – are causes by exceptional rain showers when more than 300 mm (or even less, as in the aforementioned example from September 2010) of precipitation falls in a single day, 2500 to 3000 hectares of urban areas in the southern part of Ljubljana (6 % of the inhabitants, 11 % of the buildings) are exposed to flood hazard, which is the largest endangered urban area in Slovenia (Orožen Adamič, Hrvatin, 2000). Such a disaster affected Ljubljana in the year 1926.

Floods on the Ljubljansko Barje, which also used to endanger Ljubljana in the past, are most frequent in autumn and winter; they last up to 5 days, cover about 15 % of the area, and at high inflows even up to half of the Barje. They are mainly caused by the limited runoff from the Barje, which amounts to about 600 m3/s, while the inflow during the powerful precipitation amounts to almost 800 m3/s. In such cases the swollen Gradaščica with the Horjulščica and the Ižica block the draining of the Ljubljanica from the Barje, thus causing the flood (Kolbezen, 1985).

Figure 6:
Floods at Lipe on the Ljubljansko Barje.

Photo: D. Ogrin.

The Ljubljanica is a moderately polluted river, which is mainly the consequence of large amounts of insufficiently purified waste waters discharged into it, and only partly the consequence of its modest self-purifying capacities due to its low vertical drop (Brečko, 1999). Fortunately, it runs on the impermeable sediments of the Ljubljansko Barje, thus having no hydrological connection with the groundwater. Ljubljana needs large quantities of drinking water, so the groundwater of the Ljubljansko Barje remains an important source of it. To protect this water resource as well as the groundwater of the Ljubljansko Polje, which is the key resource for the supply of Ljubljana, is an important strategic objective, since quantitatively rich water resources represent an important factor of development.

Owing to its geological history, the Ljubljansko Barje is a complex aquifer system consisting of a larger number of intragranular and fissure aquifers. It is very important from the viewpoint of the water supply of Ljubljana that these aquifers are very permeable and rich in water. The investigations performed so far have shown that individual aquifers are hydraulically interconnected, and most of the groundwater that is close to the surface results from the direct infiltration of precipitation water, while in deeper parts the groundwater is resupplied with the water from the hills that surround the Barje. It is anticipated that the possible intensified pumping of groundwater from the deeper parts of the aquifer could also affect the water quantity in the shallower parts of the aquifer, which would consequently reduce water quantities in the upper sections of the aquifer system. The final result could be that the already considerable sinking of the Barje surface might further increase (Brenčič, 2008). This threat is one of the restricting factors to exploiting the groundwater of the Ljubljansko Barje for the needs of water supply of Ljubljana.

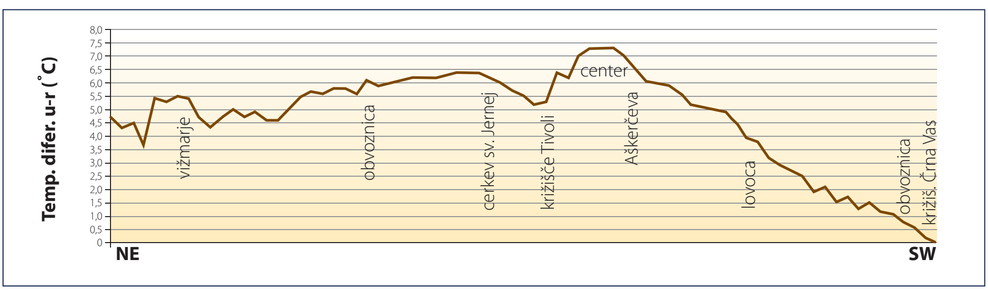
For the time being, the aquifer of the Ljubljansko Barje is only exploited by the water-pumping station Brest, which supplies water to the southern part of Ljubljana. This station pumps water from the shallow Holocene aquifer of the Iška alluvial fan and from the lower deep Pleistocene aquifer (Brenčič, 2008). The water-pumping station Brest supplies about 10 % of the water used in Ljubljana, and the remaining 90 % are provided by the pumping stations on the Ljubljansko Polje (Hrastje, Kleče, Jarški prod, Šentvid). Because of the proximity of settlements where the communal sewage system is not organized, the water from the pumping station Brest must be chlorinated, which is not necessary for the water from the pumping stations on the Ljubljansko Polje, though its aquifer lies – to a larger extent – under the urbanised areas of Ljubljana. The groundwater of the Ljubljansko Polje occurs in gravel-sand and conglomerate layers that are up to 100 m thick and the water table runs mainly at 15 to 25 m under the surface; about one half of the dynamic reserves are mainly restored through the inflitration of the Sava water. As to the geological and hydrogeological features of the Ljubljansko Polje, its groundwater is rather well protected, but the soil-based protection is rather poor, because shallow and light soils prevail which are well-permeable for water and enable fast percolation of water into the aquifer. Investigations have shown that the groundwater of the Ljubljansko Polje is sensitive to chemical pollution in particular, since the precipitation water, with no larger surface runoff, infiltrates through the lythologically diverse unprotected zone into a rather shallow water table, thus becoming, in addition to the surface water of the Sava, a powerful medium of spreading pollutants from the heavily polluted surface into the groundwater (Bračič Železnik et al., 2005). This fact is also evident from the pollution with metals, nitrates, pesticides and organic solvents, which has still been within the permitted limits in most of the cases (Plut, 2007).

3.5. Urban climate and the quality of air

Ljubljana as a medium-size town has quite explicit features of urban climate, typical of which are: the urban heat island, lower relative air humidity, poorer windiness and more heavily polluted air. So it proves to be a relevant factor which should be taken into consideration in the subsequent development of the town and the implementation of town-planning steps. Some negative features of urban climate are further intensified by the location in the basin, which hinders aeration and causes frequent temperature inversions which are mainly accompanied by fog and low cloudiness in the cold season. The main characteristics of the urban climate of Ljubljana that are presented in the following paragraphs were taken from the study Mestna klima Ljubljane (The Urban Climate of Ljubljana) (Jernej, 2000).

The study shows that Ljubljana has a stable single-cell urban heat island. In stable anticyclonic weather when the urban heat island is most explicitly developed, temperature differences between the centre and the fringes in the first half of the night amount to 4 to 6 degrees. In winter, when the surrounding areas are covered with snow, while it is removed from the town, and when slightly later fog occurs, these differences can increase up to 10 degrees. The coldest is the Barje part of the town. The intensity of the heat island depends greatly on the density of the building up. The highest temperatures occur between the Aškerčeva street and the railway station and between the Grad hill and the Šišenski Hrib hill, where the density of the buildings is evenly balanced (Figure 7).

Figure 7: Temperature differences in Ljubljana along the profile from Vižmarje to Črna Vas on the Ljubljansko Barje (26 December 1998; 23:00).



Source: Jernej, 2000.

Ground inversions prevail in the town centre at night. The inversion air layer is between 200 and 400 m thick, therefore the hilly fringe of the town reaches above the inversion air layer. The percentage of ground inversions is slightly lower in winter, while the percentage of elevated inversions, into which the ground inversions are transformed due to the urban heat island, increases. The elevated inversions prevail in daytime. Important from the viewpoint of air pollution is the fact that the transformation of ground fog into elevated fog, due to the anthropogenous input of heat and the mixing of ground air layer, first takes place in the town centre, while in winter, for example, ground fog on the Ljubljansko Barje remains throughout the day. This means that the possibilities for attenuation of polluted air above Ljubljana are very limited (the mixing layer is from 200 to 300 m thick), which is especially problematic when the inversion weather type lasts for a longer span of time. In such a case, the pollution of air intensifies from day to day.

In anticyclonic type of weather the closed basin position of Ljubljana intensifies the development of local winds. The local air circulation is weak but important as regards air pollution which is most intense in such weather. Temperature differences resulting from the urban heat island cause a slight convergence of air from the surroundings towards the town centre during the night. A certain role in these flows is also played by pressure and temperature differences between the Ljubljansko Barje and the Sava valley along which the cold air converges. These air flows from the surroundings convey fresh air, unburdened with pollutants, into the town centre at the ground; it rises above the centre and, at the height of a little more than 100 m, flows as the reverse flow back to the town fringes. This system of centripetal flows should be taken into consideration in urbanistic regulations and the planning of urban activities, thus providing the areation of the town along the green corridors (along the Ljubljanica, between Dunajska cesta and Šmartinska cesta streets, along Zaloška cesta street), since one of the typical features of the climate in Ljubljana is a rather high burdening of air with harmful substances in winter due to the basin position, poor aeration, and high percentage of inversions which occur in more than 60 % of all weather situations.