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LOCATION ANALYSIS OF THE LANDFILL OF WASTE IN LOZNICA

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Abstract: The subject of this paper regards the landfill of municipal and industrial waste in Loznica, actually its location and environmental hazards. The research was carried out in order to show the consequences of careless and incomplete evaluation of the conditions for a locating of a landfill in the example of Loznica. Besides the fact that it is located at the floodplain of the Drina River, the landfill is normally located to the direction of predominant wind, which has a significant influence on environmental dispersion processes. The landscape where the landfill is located has been impacted by flooded and groundwater and predominant wind, but on the other side, the environment has also been impacted by pollutants which come from the new system landscape-landfill. The results of the laboratory analysis help to target a gradual process of the soil contamination by heavy metals from the landfill, and to detect the general direction of contaminant migration, from southwest to northeast. Therefore, it is necessary to start working on recultivation and rehabilitation of the landfill and to begin with regional waste disposal.

Key words: landfill, Loznica, dispersion, pollution, environmental protection measures

Introduction

The subject of this paper regards the landfill of municipal and industrial waste in Loznica, actually its location and environmental hazards. The aim of this research is to show how important it is to take into account the geographical knowledge when determining a landfill location, by means of Multi-Criteria analysis to the environmental impact issues in Loznica.

State of environment in the Municipality of Loznica was the subject of many previous researchers, but particular attention was not paid on the waste disposal problems, although it is well known that the waste disposal problem is the biggest environmental problem in the Municipality. During the analysis of the state of environment in the Municipality of Loznica (Filipović, Obradović, 2007), the research on heavy metals soil concentration in Loznica landfill surroundings was not taken into consideration. The mentioned research was carried out in Petnica Science Center in 2004, as a part of the program of Geology (Božović, Marković, 2004).

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Neogene sediments were the research subjects of J. Žujović (1893) and P. S. Pavlović (1898). The hydrogeological research on unconfined aquifer and its significance as a water resource is of particular importance for this research (Filipović, 1996).

The impact of the landfill of municipal and industrial waste on agricultural soil hasn't been investigated so far. Water quality control of the Drina River and wastewater was done by the central laboratory of the former chemical industry „Viscose". They also measured emission rates of carbon disulfide to the atmosphere and concentration of sodium hydroxide which was spilled in the Drina River by the wastewater canal (The Reports of the chemical industry „Viscose", 1990).

Although the new legislative framework regarding waste management has been established in the Republic of Serbia (The Law on Waste Management, Official Gazette of the Republic of Serbia, No. 36/09), the previous regulations will be applied before the new subordinate legislations come into force (for this paper, it is important to mention a previous regulation called Rules on criteria for determining the location and arrangement landfill waste matter (Official Gazette of the Republic of Serbia, No. 54/92). Some of those rules are following: the landfill can not be located at a distance of 0.5 km along the rivers; if located in permeable terrain, it should be protected by clay layer or impermeable foil; when determining the landfill location, the data about meteorological characteristics, such as wind rose, should be taken into account, etc.

Compliance of Serbian legal framework concerning waste management with EU laws was the subject of research of D. Savić (2009), who concluded that transposition of European directives in the legal system of Serbia doesn't mean merely copying text, but also mechanisms for its successful implementation and application (Savić, 2009).

According to the technical and operational requirements of Directive 99/31/EC on the landfill of waste, it is necessary to construct regional sanitary landfills for each region in Serbia, and to start with closure procedures and recultivation of existing dumps (Savić, 2009). Modern technology of waste management connotes the existence of the following parts of landfill: the bottom liner system, cells, the storm water drainage system, the leachate collection system, the methane collection system and the final covering or cap (Directive 99/31/EC on the landfill of waste, 1999).

Methods and materials

The investigated area is situated in the northwest of Serbia. In its narrow sense, it is the landfill of municipal waste, which has been managed by public utility company „Naš dom" since its establishing in 1968. The site covers a 8.7 hectares area in southwestern vicinity of the city of Loznica by the left bank of the Štira River (Figure 1). The landfill is connected to the category I state road M-4 by the internal road.

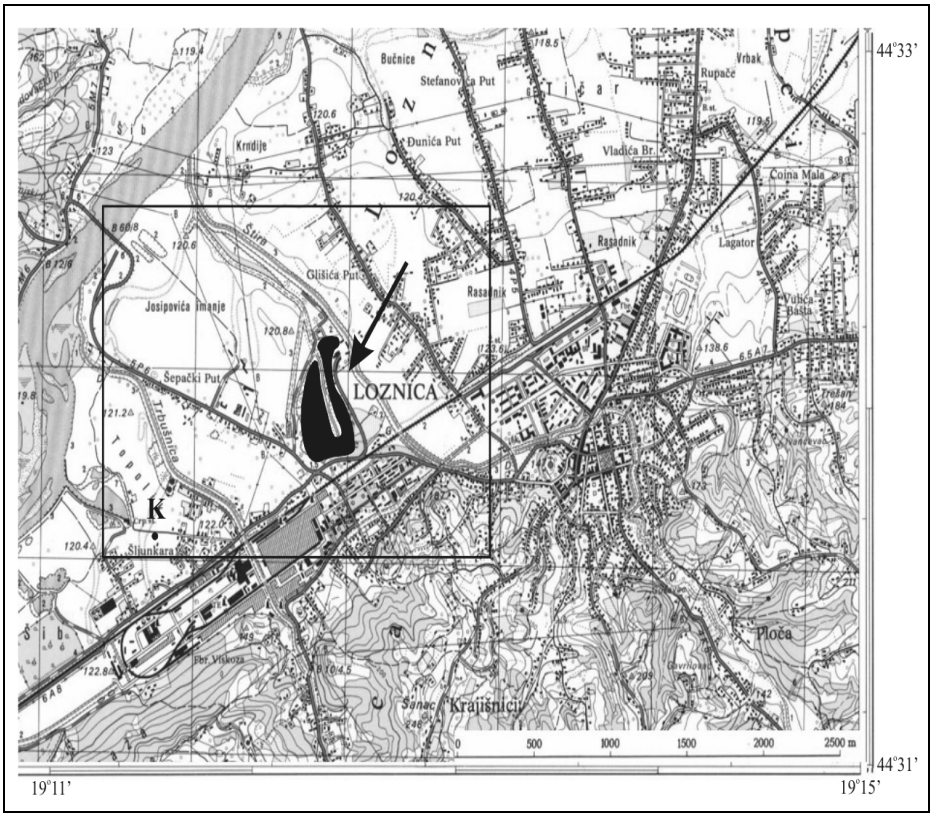

Figure 1. The landfill position in Loznica
(Source: Topographic map, Section Bijeljina 3-4, MGI, 1976)

Public land of the Municipality of Loznica covers a total area of 466.1 ha, of which 1.87% is the landfill area (Group of authors, 2006). Collection of municipal solid waste covers 15% of the municipality of Loznica (city and suburbs), or 50% of its total population, and also the municipalities of Mali Zvornik, Ljubovija and Krupanj (Lukić, 2009). Mandatory garbage collection

zone is constantly expanding, resulting in the constant expansion of the landfill area.

In addition to its essential role of municipal waste disposal, the landfill was used, for many years, as a landfill of industrial waste (ash and slag) produced by heating and steam power plant within the chemical industry „Viscose". Long-standing industrial waste disposal resulted in still existing sites: Old and New „pepelište". These sites are connected with today's landfill of municipal waste. A significant amount of industrial sludge from wastewater canal was also deposited at the landfill, when cleaning the canal during the 1980s. All of these kinds of waste contain various heavy metals that are of potential high risk to flora and fauna.

The current standard of operation of the landfill is unsatisfactory. The waste is not prevented from coming into contact with the ground because there are no landfill liner and clay or plastic cap. There is no leachate collection and treatment system, so the leachate directly comes into contact with a surface and groundwater used for water supply of Loznica. The fact that there is no landfill gas recovery system results in a potential danger of explosion. The measurement of waste was not noted. Waste separation was identified, but in disorganized form. Namely, a small group of citizens collected aluminium packaging, plastics and cellophane. Therefore, this is not a sanitary landfill, but rather a dumping site. The nearest group of houses is maximally 250 m away from the landfill, and the city center approximately 1 km.

Considering that the initial landscape where the landfill is located has been substantially modified, in this case we can actually talk about the newly developed natural and anthropogenic landscape. This can be defined as the state of entropy, which means:

– Potentially causing of landslide processes;
– Potential contamination of groundwater and surface water;
– Air pollution and changes in micro- and mesoclimate;
– Soil degradation;
– Causing damage to biodiversity;
– Causing aesthetic problems (Milošević, Markićević, 2003).

Multi-Criteria analysis of the landfill site in this paper takes into account geomorphology, the wind rose and environmental dispersion. When analyzing the environmental impact on determining a landfill microlocation, the primary importance was given to the floodplain as a prominent geomorphologic form and to the wind rose for Loznica. The wind rose diagram was created using

meteorological yearbooks of the Republic Hydrometeorological Service of Serbia and the data about the wind frequency for Loznica meteorological station for the period 1966 – 1985.

Final conclusions on the inappropriate positioning of the landfill were supported by the results on heavy metals soil concentration, obtained in 2004 using the Atomic Absorption Spectrophotometer method (Božović, Marković, 2004). According to spatial patterns of the area, Landscape-Directed Soil Sampling method was applied. Soil samples were taken along a SW-NE direction (Figure 2).

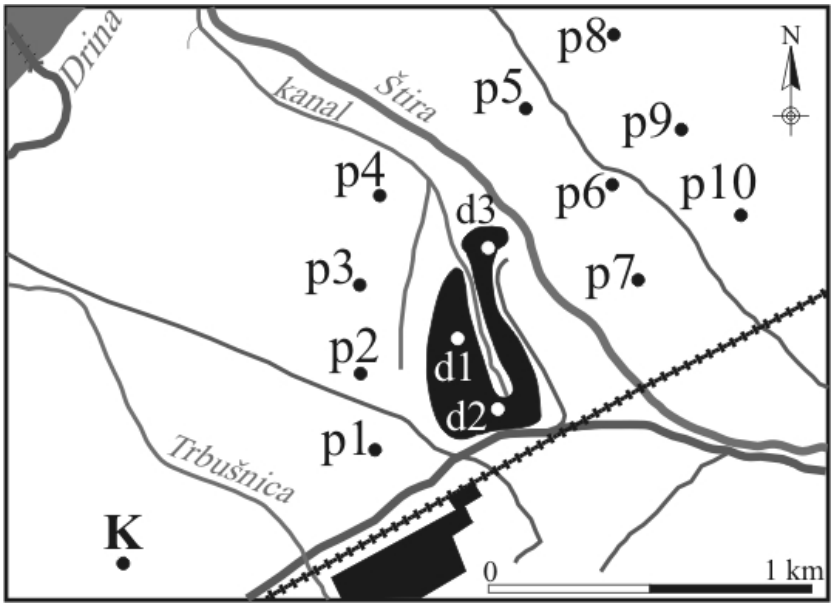

Figure 2. The landfill and sampling locations

Fourteen samples were taken from a depth of 25-40 cm. Three of these samples were taken inside the landfill: d1 – Old „pepelište" (ash and slag deposited up to 1989) – a sample of ash; d2 – New „pepelište" – a sample of ash and d3 – municipal waste – a sample of soil. Ten samples of soil were taken outside the landfill at the distance of: 200 m (samples p1-p4); 400 m (samples p5-p7) and 800 m (samples p8-p10). The control site sample (sample K) was taken at the distance of 1.250 m south west of the landfill, in order to determine background levels of heavy metals in the clean soil for comparison with the contaminated soil.

Apart from the soil sampling (2004), the field work involved the implementation of the method of observation and photography, while the cabinet work involved the processing of field and literature data and creating the wind rose diagram.

Results and discussion

Field observation showed that the landfill and the surrounding area are part of the floodplain of the Drina River, which consists of fluvial deposits – gravel and sands, which have high porosity. While satisfying a transportation availability standards, floodplains are environmentally sensitive areas and should be avoided when selecting a landfill site. Since the newly developed system „landscape-landfill" is a part of floodplain, it is potentially impacted by flooded water and groundwater. Gravel and sand, which are the geological formations underlying the landfill, have remarkable water-bearing properties and this is the reason why unconfined aquifer with its good water-yielding characteristics was formed. The direction of groundwater follows the general topography of the land surface and is generally the same as that of the Drina River (southwest-northeast). The groundwater level is in direct hydraulic connection with the Drina River, whose stage is a primary factor of groundwater level fluctuations. The groundwater depth ranges from 1 m to 2 m (Filipović, 1996). Therefore, there is a high risk of contamination from the surface.

The prevailing wind direction at the site is W and SW (Figure 3). This is generally the same direction as that of the category I state road M-4, by which the landfill is situated. Thus, besides the fact that the landfill is situated at the Drina River floodplain, it is also sited downwind of the residental area (Figure 3), causing the dispersion of odour and dust.

Considering that the landfill is not provided by liner system and plus there is no landfill cover, rainfall comes into direct contact with waste. The leachate continues to leach into the ground and contaminates nearby soil, the shallow aquifer and the water of the Štira and the Drina rivers. In this way, the problem of physical dispersion blends with chemical and biological dispersion problems, which leads to the chemical contamination of water and the spread of infectious microorganisms.

Regarding the above mentioned features of the system „landfill-landscape", we can conclude that floodplains have eliminatory importance when selecting a landfill site because they have the great environmental dispersion. This fact was also confirmed in the research on the evaluation of geomorphological processes

and forms in the function of optimal landfill microlocation determination (Milošević, Markićević, 2003).

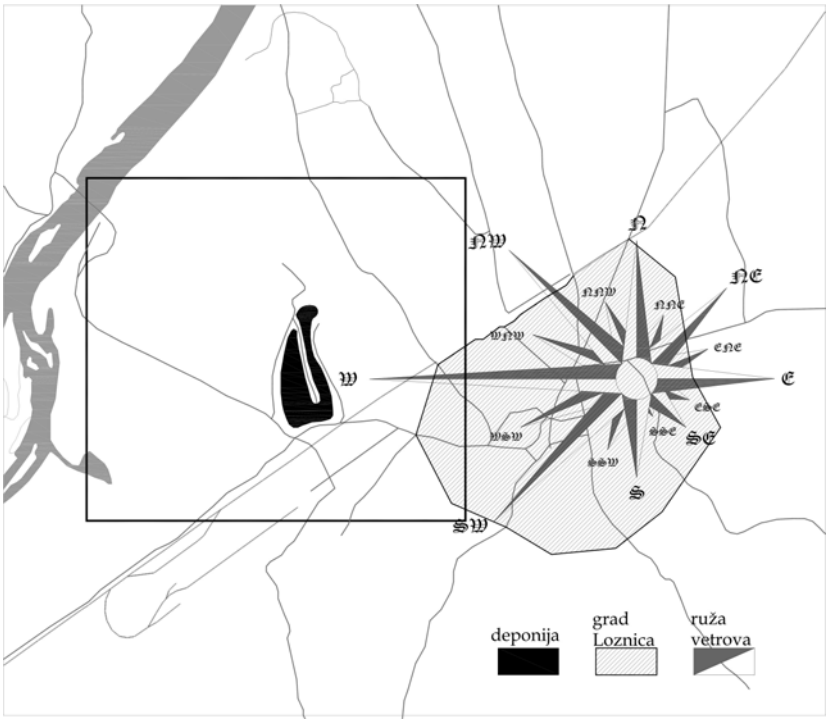

Figure 3. General representation of the wind rose diagram for Loznica (Period of data: Jan 1966 – Dec 1985) and the position of the landfill and the urban area (Source: RHSS and MGI, Belgrade).

The system „landscape-landfill" has been impacted by flooded and ground water and by the predominant wind, but on the other side, the environment has also been impacted by pollutants which come from the new system „landscape-landfill". Laboratory analysis of heavy metals soil concentration in landfill's surrounding environment is one of the aspects of the environmental impact of landfills. The results of this analysis are shown in the Table 1.

As shown in the Table 1, the concentrations of all heavy metals obtained in regular samples were signifficantly higher than the background concentrations in the control sample away from the pollution impact. Moreover, the metal contents of Pb (almost 10 times higher) and Cd (up to 7 times higher) in the soil samples were higher than other metals. Graphic representation of the change of concentration of Cd and Pb is given in the Figure 4.

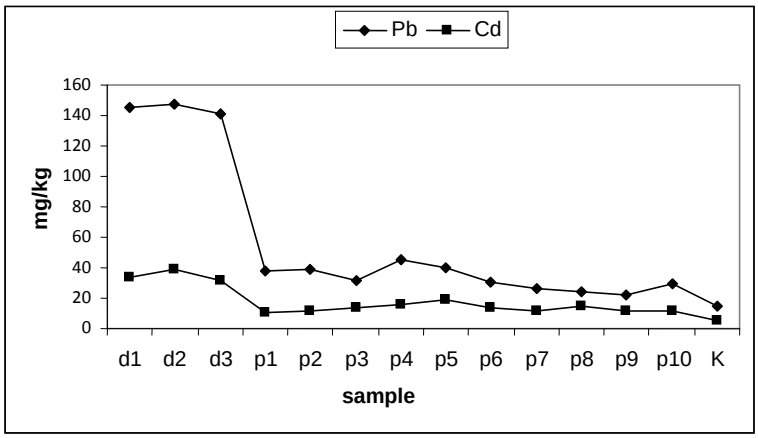

Figure 4. The graph of the change of concentrations of Pb and Cd

The concentrations of each heavy metal (apart from Pb and Cd samples taken inside the landfill) do not exceed the maximum permitted values, but exceed the value of the control sample (K). This indicates a gradual process of the soil contamination by heavy metals from the landfill, following the general topography of the land surface, the direction of groundwater and surface water flow and the prevailing wind direction.

Table 1. Heavy metal content (mg/kg)

	Zn	Pb	Fe	Cu	Ni	Cd	Cr	Mn	pH
	Maximum permitted values								
Sample	*700*	*50*		*600*	*500*	*15*	*500*	*1500*	
d1	150,0	145,0	14700	189,0	88,5	33,2	155,0	482,0	8,7
d2	150,0	147,0	17800	209,0	94,0	39,3	201,0	697,0	8,6
d3	135,0	141,0	15600	191,0	75,6	31,6	178,0	498,0	8,7
p1	49,7	37,5	11100	55,5	39,9	10,1	67,5	252,0	7,1
p2	53,5	39,3	12900	61,9	39,0	11,7	61,2	252,0	7,2
p3	57,3	31,3	11500	69,6	42,4	13,4	77,3	279,0	7,0
p4	64,1	45,4	13800	63,4	46,8	15,5	79,7	286,0	7,6
p5	77,9	39,6	12000	68,2	45,7	19,4	74,3	273,0	7,5
p6	61,4	30,9	10000	67,3	43,4	14,2	69,6	259,0	7,3
p7	59,9	25,8	11000	65,5	41,1	12,1	73,2	267,0	7,5
p8	57,4	24,0	11900	74,5	39,7	14,4	76,0	277,0	7,0
p9	49,9	22,1	11800	63,2	37,2	11,6	71,9	244,0	7,4
p10	43,9	29,4	10700	67,9	37,5	11,4	62,1	263,0	7,2
K	47,2	15,2	10000	53,3	39,9	5,47	61,1	235,0	7,0

Source: Božović, Marković (2004, modified)

Although the research was preliminary, it proved that the landfill was improperly located and that terrain configuration favours the transport of pollutants through the environment.

The results shown in the Table 1 point out the necessity of comprehensive analysis of the impact of numerous landfills on agricultural soil – one of the strategic resources of our country.

Conclusions

The results of Multi-Criteria analysis show that Loznica landfill causes environmental problems, mostly because it is situated in the Drina River floodplain (which consists of geologic materials of high porosity), where the groundwater is particularly close to the surface. It was also found that the landfill is situated downwind of the residental area, regardless of the distance from rivers. These results indicate the great environmental dispersion.

The values of the concentrations of heavy metals in soil samples taken inside and outside the landfill are indicative of the affinity of these contaminants to the soil. The contamination is most extensive down-gradient in the direction of groundwater and surface water flow and the prevailing wind direction, following the general topography of the land surface.

In order to reduce the risk of environmental problems, there is a need for urgent landfill rehabilitation and foccusing on regional waste disposal. New sanitary landfill site should be determined in accordance with the general principles and requirements of Council Directive 99/31/EC on the landfill of waste.

Waste separation and recycling are not well-developed processes not only in the Municipality of Loznica, but also on the entire territory of the Republic of Serbia. Dumps are still one of the widely used approaches for disposong solid waste in Serbia, in spite of its big environmetal problem. By irresponsible disposal of waste and its generation, it is impossible to achieve sustainable development, considering that future generations might not be able to meet their own needs. Therefore, it is necessary to provide strenghtening institutional capacity, raising environmental awarness and environmental education of the population.

The research expectations have been met, since this study illustrates the importance of geographical knowledge application when determining a landfill location. Careless and incomplete evaluation of the conditions for landfill site

selecting in Loznica resulted in the fact that the waste problem is the biggest ecological problem in the municipality.

However, in order to get detailed environmental impact assessment, it is necessary to analyze the concentration of heavy metals absorbed by plants, as well as to get data on surface water and groundwater quality and to determine potential gas emission from the landfill.

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References

Božović, D. & Marković, S. (2004). Heavy Metals in Agricultural Soil in Vicinity of Loznica Dumping Site. *Petničke sveske,* 57, 205-209.

Chemical industry „Viscose". (1990). *The Reports of the central laboratory of the chemical indusry „Viscose" about contaminants emission for the period 1980-1990.* Loznica: CI „Viscose".

Filipović, D. & Obradović, D. (2007). Environmental state on the territory of the municipality of Loznica – the basis of integral planning protection. *Bulletin of the Serbian Geographical Society, 87 (1)*, 163-172. (Филиповић, Д. & Обрадовић, Д., 2007. Стање животне средине на територији општине Лозница – основ интегралне планске заштите. *Гласник српског географског друштва, 87 (1),* 163-172).

Filipović, I. (1996). *Geological characteristics and potentiality of geological resources in the Kolubara, Mačva and Podrinje regions.* Belgrade: Geološki zavod „Gemini".

Fischer, J. (1999). *Council Directive 99/31/EC on the landfill of waste.* Visited on October 28, 2010 on the web page: http://ec.europa.eu/environment/waste/landfill_index.htm

Lukić, N. (2009). *State of the Environment report on June 9, 2009.* Šabac: The Ministry of Environment and Spatial Planning, Department in Šabac.

Milošević, V. M. & Markićević, M. (2003). Geomorphological processes and forms in the function of determination of optimal micro-location of the landfill. *Bulletin of the Serbian Geographical Society, 83* (2), 87-99. (Милошевић, В. М. & Маркићевић, М., 2003. Геоморфолошки процеси и облици у функцији детерминисања оптималне микролокације депоније. *Гласник српског географског друштва, 83 (2),* 87-99).

Official Gazette of the Republic of Serbia (1992). *Rules on criteria for determining the location and arrangement landfill waste matter.* Belgrade: Official Gazette of the Republic of Serbia, No. 54/92. (Службени гласник Републике Србије, 1992. *Правилник о критеријумима за одређивање локације и уређење депонија отпадних материја.* Београд: Службени гласник Републике Србије бр. 54/92).

Sarić, M. (1976). *Plant Physiology.* Belgrade: Naučna knjiga. (Sarić, M., 1976: *Fiziologija biljaka*, Beograd: Naučna knjiga).

Savić, D. (2009). European environmental values for the benefit of the citizens of Serbia, with special reference to the practice of waste management. *European standards in Serbia,* 64-78.

Official Gazette of the Republic of Serbia (2009). *The Law on Waste Management*. Official Gazette of the Republic of Serbia, No. 36/09. (Службени гласник Републике Србије, 2009. *Закон о управљању отпадом.* Београд: Службени гласник Републике Србије бр. 36/09).

The Military Geographical Institute. (1976). *Topographic map, 1: 25 000, Section Bijeljina*. (Map). Belgrade: The Military Geographical Institute (Војногеографски институт, 1976. *Топографска карта, 1: 25 000, Лист Бијељина*. (Карта). Београд: Војногеографски институт.

The Republic Hydrometeorological Service of Serbia. (1966-1985). *Meteorological yearbooks*. Belgrade. The Republic Hydrometeorological Service of Serbia (Републички хидрометеоролошки завод Србије, 1966-1985. *Метеоролошки годишњаци*. Београд: Републички хидрометеоролошки завод Србије)

Group of authors (2006): *The General Plan of Loznica.* Loznica: P. C. „Urboplan" (Група аутора, 2006. Генерални план Лознице. Лозница: ЈП „Урбоплан").