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EFFECTS OF GEOECOLOGICAL FACTORS ON VEGETATION OF THE GRUŽA BASIN

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Abstract - The paper presents the results of a study of the effects of geoecological factors on the vegetation of the Gruža basin (F=618.6 km²). In the first phase, geoecological factors were identified and their differentiation to physical geographic (geological structure, tectonics, relief, climate, waters, types of land) and anthropogeographic factors (activities of population) was carried out. In the second phase, their influence on vegetation was defined, and in the third phase, the condition in the Gruža basin was analyzed on the basis of topographic and thematic maps using GIS methodology.

Key words: Geoecological factors, vegetation, physical geographic characteristics, anthropogeographic influence, the Gruža basin.

INTRODUCTION

From the viewpoint of geoecology, the basin of the river Gruža is a specific territory connecting the mountains of the Šumadija Region and valleys of the Western Morava River that has undergone a certain physical geographical and socioeconomic transformation since the construction of the Gruža Reservoir in 1984. However, the vegetation cover of the Gruža basin is, due to its geographical position, natural characteristics, as well as the construction of the above-mentioned reservoir, very heterogeneous and, according to Veljović et al. (1990), characterized by the presence of different types of vegetation: thermophilic forests, mesophilic forests, the remains of flooded forests, valley meadows, mountain meadows, marshes, agrarian ecosystems etc.

MATERIALS AND METHODS

The Gruža is one of the longest rivers in the Šumadija region (L=61.6 km), with a basin area of F=618.6 km². The basin covers the area between Rudnik Mountain (1,132 m) in the north, Ješevac Mt. (902 m) and Kotlenik Mt. (748 m) in the west, the Gledić mountains (922 m) in the east and the West Morava River valley in the south and southwest, i.e. basins of the rivers: Jasenica in the north (F=1,343 km²), Lepenica in the northeast and east (F=638.9 km²), Čukojevačka (Great river) in the southeast (F=110.1 km ²) and Čemernica in the west (F=621 km²). The Gruža basin is elongated in shape and tilted in a NW-SE direction. The average basin altitude is H_{sr}=395 m and the average length of the basin is Ls=52 km. The average width of the basin is B=12 km ($B_{max=23}$ km; Bukovik Peak – Vučkovica Village).

The first phase of the research involved identifying geoecological factors and their differentiation according to genetic, qualitative and quantitative characteristics to: 1) physical geographical and 2) the anthropogeographical factors.

In *the second phase* of the research, the determinants and components of physical geographical and anthropogeographic factors were differentiated. The following physical geographical factors were analyzed: geological structure (types of rocks as the basis of pedological substrate and vegetation), geomorphic characteristics (alluvial plain, relief hypsometry, bordering mountains of the Šumadija region on the one side and the Western Morava River valley on the other), climate (average air temperatures, pluviometric regime), hydrography (the Gruža River and its tributaries), and types of soil. In the analysis of geological structure, the research of Antonović and Filipović (1977) was helpful; they studied the Cretaceous flysch (Gledić Mountains and Rudnik Mt.) and Neogenic volcanic rocks (Kotlenik and Ješevac Mts.). Also helpful was the research of Neogenic and Quaternary accumulative rocks by Brković et al. (1980), Marković and Pavlović (1967), Marković et al. (1968), and Pavlović et al. (1977). In the analysis of climatic and hydrographic parameters, the data of the National Hydrometeorological Institute of Serbia were analyzed (meteorological and hydrological annuals). Significant results in the field of water quality of the Gruža basin, as well as physical and chemical characteristics of water (Mihajlović et al., 2005; Ćurčić, 2005; Ostojić and Ćurčić, 2005; Čomić et al., 2005) were also used as a basis for the analysis of specific hydrographic features of the Gruža basin. The application of the statistical method in an analysis of climatic and hydrological data for the Gruža Basin has enabled the making of some general conclusions and interpreting the results of the statistical analysis. The representativeness of climate and hydrological data and the territorial analysis are the indicators of performing grounded results regarding climatic and hydrographic circumstances in the Gruža Basin, which are presented in the paper. The tabular presentation of the results is aimed at classifying the data and presenting the mathematical functions of statistical calculations, as well as changing values of these functions (growth, stagnation and decline in the value of pluviometric regime in a year and average monthly water levels of the Gruža in Guberevac Village).

The floristic richness of the Gruža Basin is manifested in the existence of numerous forest and grass communities formed as a result of various geoecological factors. The flora and vegetation of this basin were studied by Pančić (1980), Rudski (1949), Gajić (1967), Veljović (1967), Veljović et al. (1980, 1984, 1986, 1990), Ognjenović et al. (1990), Topuzović and Pavlović (2003, 2005), etc. Their works are the theoretical grounds for our research on the effects of geoecological factors on the vegetation of the Gruža Basin. According to Gajić (1967), the Gruža Basin is a "transitional zone between the sub-Mediterranean, Central European and Pontian area", i.e. the boundary between a more humid continental area of broadleaf deciduous forests in the west and a more arid continental area of broadleaf deciduous forests in the east. According to Veljović (1967), the Gruža Basin (isohyet 700 mm), separates more humid regions in the west from more arid regions in the east and is the border between the Moesian and Illyrian biogeographic zones.

Anthropogeographical factors include an analysis of the effects of human activities on the vegetation of the Gruža Basin. These effects are manifested through changes in land-use purposes, degradation of forests and agricultural areas (which indirectly affects erosion in the Gruža Basin), construction of the Gruža Reservoir (1984), which resulted in significant changes in the microclimate of the entire basin (increased relative air humidity, reduced amplitudes of summer and winter temperatures), as well as in the more intense development of certain vegetation types (for example macrophyte-hydrophilic vegetation in the largest part of the Gruža Reservoir) and the redistribution of other types, etc. Topuzović and Pavlović (2003, 2005) studied the temporal and spatial distribution of macrophytic vegetation in the Gruža Reservoir. Their research was related to the study of the relationship between the distribution, diversity and mass of macrophytes and environmental conditions (primarily the morphometry of the banks, depth of water in the reservoir and the influence of pollutants) at four locations in different parts of the reservoir. Their results were compared with the previous studies of Veljović et al. (1986), using the Sorenson similarity index S (Schwerdtfeger, 1975) to calculate a degree of similarity between the populations of macrophytes. They reached the conclusion that the highest diversity and number of species are in the shallower parts of the reservoir (jagged banks with a constant influx of nutrients from the adjacent arable land). A significant problem in the reservoir is the eutrophication process. According to Ostojić et al. (2005) and Ranković and Simić (2005), numerous studies treating the eutrophication process in reservoirs have indicated the exceptionally great importance of nitrogen and phosphorus (Kobayashi and Church, 1997; Kagalou et al., 2001), whose presence not only brings about changes in the composition of biocenoses (Maier, 1998), but also causes an increased production, primarily of phyto- and zooplankton (Hutchinson, 1967). This problem is evident in the case of water supply reservoirs (like the Gruža Reservoir or Bovan Reservoir in the paper by Zlatković et al., 2010), where an increase of the trophic stage can cause them to become unsuitable as sources of drinking water (Marques and Boavida, 1993; Scharf, 1999; Ostojić et al., 2005 etc). The ichthyofauna of the Gruža River and Gruža Reservoir was studied by Šorić (2005), autochthonous and allochthonous species in the fish community in the reservoir by Simonović and Marković (2005), a community of fungi in the lake by Ranković and Čomić (2005), etc.

The third phase of the research. Using GIS methodology, based on topographic and thematic maps (geological, pedological and orohydrographic maps), the changes in vegetation types of the basin were analyzed. The complexity of the subject matter required an interdisciplinary analysis of the published papers on the Gruža Basin from various scientific fields, but also the application of scientific methods suitable for setting up hypotheses, proving attitudes, testing and forming conclusions about the effects of geoecological factors on vegetation of the basin. For general methodological procedures, a general and statistical method was used, and for special procedures, the analysis, synthesis, comparison, generalization and cartographic method, which allowed for the incorporation of a larger number of parameters in the chorological-chronological relationship and the explanation of their different effects in the territory of the Gruža Basin. The application of a cartographic method based on data analysis from topographic maps 1:25,000 and 1:50,000 and their comparison with geological, pedological and orohydrographic maps achieved a spatial interpretation of relations and connections of all the analyzed geoecological indicators.

RESULTS

Geoecological analysis

The geological structure of the Gruža Basin is complex (sedimentary and magmatic rocks are most widely distributed). Cretaceous flysch occurs in the Gledić Mountains and Rudnik Mt., whereas Neogenic volcanic rocks dominate in the structure of Kotlenik and Ješevac Mts. (Antonović and Filipović, 1977). Neogenic and Quaternary accumulative rocks are mostly located in the central, lowest part of the Gruža Basin (Brković et al., 1980; Marković and Pavlović, 1967; Marković et al., 1968; Pavlović et al., 1977).

The geographical position of the basin at the junction of the Šumadija Mountains and valleys of the Western Morava River has influenced the climate to a great extent. The basin is characterized by internal microclimate differences, caused by the morphology of the terrain, altitude of the lowest (180 m, downstream of the Gruža) and highest (1,098 m; Belo Polje Village on Rudnik Mt.) parts of the basin, and the construction of the reservoir.

Up to 600 m above sea level, the average yearly air temperature is 9-11°C, and in the hypsometric belt between 600 and 1,098 m above sea level, it is 8-9°C. Air temperatures were mitigated after the construction of the reservoir. Namely, the temperature fluctuation is smaller at the daily and annual level (summer temperatures are lower and winter temperatures are higher by 1-2°C), air humidity is increased, as is precipitation. Likewise, the water in the reservoir gets more slowly heated and cooled than the ground, and water always warms or cools the soil on the banks,

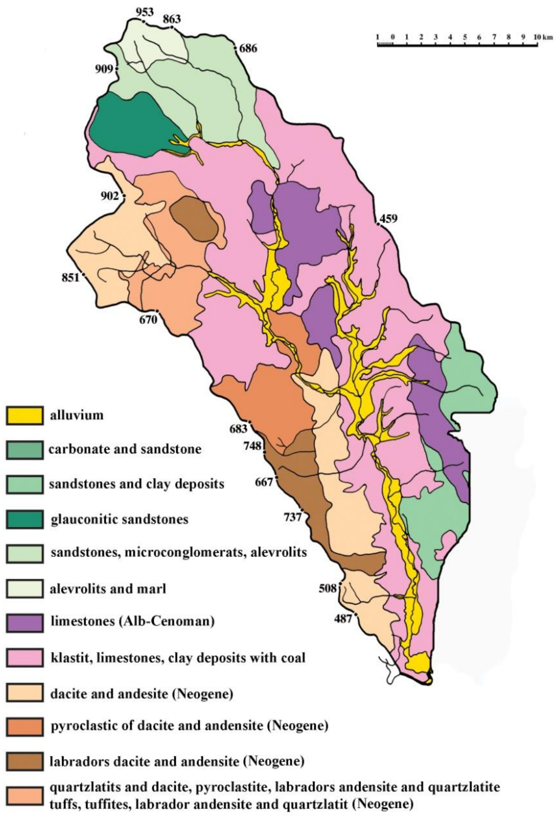


Fig. 1. – Geological map of the Gruža Basin

which leads to the frequent appearance of fog. The average precipitation in the Gruža basin is 750 mm.

The Gruža River, the main watercourse in the basin of the same name, springs on the southern slopes of Rudnik Mt. (560 m) in the foothills of Mount Vis (626 m). The Gruža River receives 87 tributaries. More important left-bank tributaries are the Vraćevšnička River (L=10 km), Kamenička River (L=13.5 km), Ribeš River (L=13 km) and Čestinska River (L=11 km). The longest and richest in water is the right-bank tributary of the Boračka River (L = 12.5 km). Its other right-bank tributaries have short courses: Minjuša (L=9.5 km), Kotlenjača (L=7.3 km), Konopljište (L=7 km) Duboki potok (L=7 km). Due to the low yield of springs, they occasionally dry up. The Gruža has a developed drainage network (D=1.55 km/km^2). Apart from the Gruža, all rivers in the Gruža basin are short, with a small catchment area and a developed drainage network. Between the villages of Vitanovac and Šumarice, the Gruža River flows into the Western Morava River.

Owing to the geological base, altitude of the terrain, diverse relief, exposure and slope angles and hydrographic peculiarities in the Gruža basin, several types and varieties of soil are represented. According to Tanasijević et al. (1966), the most common varieties are vertisol and eutric cambisol in the lowest hypsometric belt up to 500 m above sea level (the first four land capability classes), whereas the peripheral, borderline parts of the basin are dominated by litosols (Gledić Mountains), distric cambisol on an-

Table 1. – Average monthly and yearly precipitation in mm

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Yearly
Gornja Crnuća	62.5	50.6	54.1	68.0	83.8	105.6	83.2	62.7	56.9	59.0	62.8	63.0	812.2
Oplanić	40.9	35.5	37.9	47.7	67.4	90.2	68.9	65.8	51.5	52.0	47.1	44.9	649.8
Knić	45.8	36.7	42.7	49.5	72.9	86.5	69.9	59.3	55.6	52.9	53.2	46.2	671.2
Bumbarevo Brdo	40.7	36.8	40.0	44.1	71.9	91.9	64.5	77.4	54.0	48.3	54.0	30.3	653.9
Gruža	41.4	42.0	44.9	59.1	80.8	97.9	79.1	66.0	63.4	60.1	58.2	53.9	746.8

Source: Meteorological Annuals I. Republic Hydrometeorological Institute of Serbia, Belgrade, 1971-2010

Table 2. – Average monthly and yearly water levels of the Gruža in Guberevac in cm.

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Yearly
71	78	84	72	66	60	55	48	48	49	53	60	62

Source: Hydrological Annuals. Republic Hydrometeorological Institute of Serbia, Belgrade, 1971-2010.

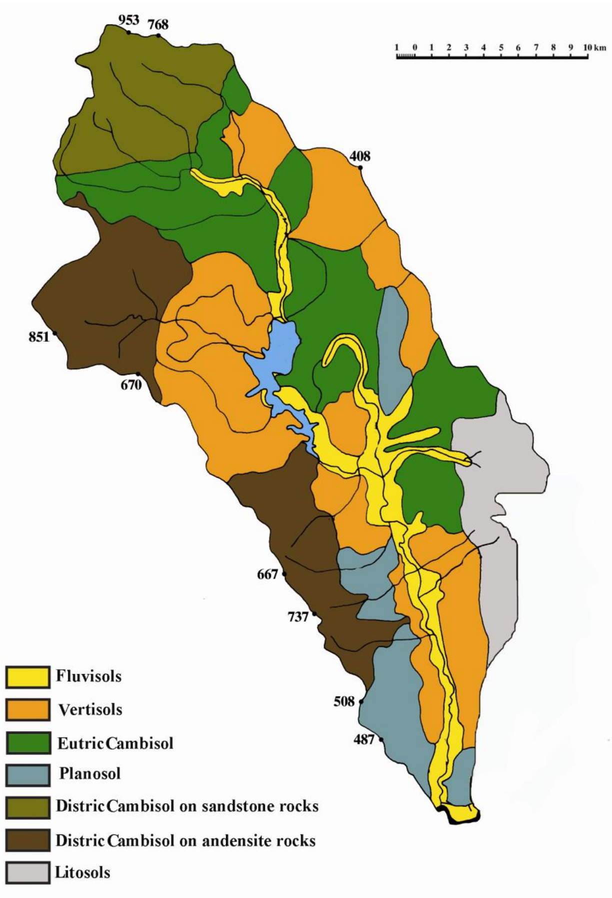
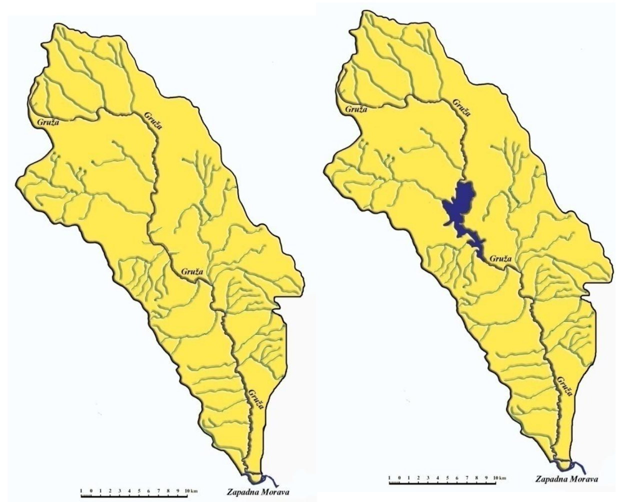


Fig. 2. – Pedological map of the Gruža Basin



(a) (b)

Fig. 3 – The Gruža basin before the construction of the reservoir (a) and after 1984 (b)

desite rocks (Ješevac and Kotlenik Mts.) and distric cambisol on sandstone rocks (Rudnik Mt.). According to Topuzović and Pavlović (2005), the flooded area (before the Gruža Reservoir was formed) had a well-developed pedological substrate and was one of the most fertile regions of Serbia.

The river Gruža, before the construction of the reservoir, overflowed and flooded the arable land (alluvial plain), which inflicted extensive damage on agriculture. After the construction of the reservoir (1984), the downstream of the Gruža River was protected from flooding. The Gruža Reservoir was constructed for the purpose of supplying Kragujevac and its surroundings with drinking water (Ostojić et al., 2005, Milinčić, 2009, Milinčić and Đorđević, 2011). For the construction of the reservoir, the epigenetic gorge Tucački Naper was used (3 km), where a dam was built (52 m in height and 288 meters in length).

According to Topuzović and Pavlović (2005), the Gruža Reservoir is 10 km long and 0.2-1.5 km wide, with a surface area of 934 hectares. Oscillations of the water level are 3-5 m. Their results showed that the maximum depth of the water, 500 m upstream from the dam, is 31 m, whereas two thirds of the reservoir are shallow (3-9 m). According to Ostojić et al. (2005), more than two thirds of the reservoir have the characteristics of lowland reservoirs, with shallow depth, an unfavorable ratio of trophogenic and tropholytic layers, and banks surrounded by meadows and cultivated land. The reservoir is surrounded by farmland, and receives wastewater from settlements. The large surface of the reservoir in relation to the small volume favors eutrophication (Čomić and Ostojić, 2005). At an air temperature of 19°C, the temperature of the reservoir water at the depth of 0.5 m is 22.2°C, and at the depth of 11 m it is 20.8°C. The lake water is odorless and green. Translucence is 150 cm, and the pH of the water decreases with depth and is between pH=8.0 at the depth of 0.5 m and pH=7.7 at the depths of 11 m and 22 m. The area of the basin reservoir is F=319.16 km² (51.6% of the areas of the Gruža basin).

Analysis of vegetation

Forests are the most significant representatives of natural vegetation cover. The Gruža basin belongs to the vegetation type of broadleaf deciduous forests of the moderate zone. The forest type of ecosystems is climatogene and climazonal. Forests cover 18,039 hectares (29.2%); pure and mixed stands of deciduous forests have the largest share. In the basin, there are two main types of distinctive forest landscapes: sub-Mediterranean-Balkan landscape with mostly dry deciduous forests (forest zone of Hungarian and Turkey oak up to 800 m above sea level) and the area of European landscape, with mostly deciduous forests (beech and sessile oak). Forest communities occur mostly in the northern exposures up to 1,000 m (Matvejev, 1973). The largest forest cover in the basin area is in the area of the Rudnik mountain (villages Kamenica 52.4% and Prnjavor 56.8%). Due to its filtration capacity, forestland is an important regulator of surface runoff and a natural filter for water purification. Preserving the properties of forestland is of special importance, because the forest landscapes (upstream of the reservoir) are important to the good quality water supply of the reservoir and protection from siltation.

Human activities have largely converted the basin into an agrarian area (farming, fruit growing and cattle breeding), barren land and rocky ground. The range of Balkan forests was reduced at the expense of enlargement of cultivated steppes. Floristic richness is manifested in the presence of numerous forest phytocoenoses. The higher the altitude, the greater the forest cover and floristic diversity of forest ecosystems. The lowest terrains, up to 400 m above sea level (sporadically up to 600 m), cover the flooded forests of willows and poplar, hygrophilous forests of pedunculate oak and alder and forests of Hungarian and Turkey oak. In river valleys, on recent alluvial deposits, flooded forests of willows and poplar are present (*Salici-Populetum*), the so-called soft floodplain forests. Some villages were named after the ancient forests of white willow and poplar: Gornja (Upper) and Donja (Lower) Vrbava (in Serbian word vrba means willow). The forest composition includes various kinds of willows – *Salix alba, Salix fragilis* and *Salix purpurea* as well as various kinds of poplars: *Populus nigra* and *Populus alba*. According to Tomić (1992), hygrophilous forests of pedunculate oak and alder (*Alno-Quercion roboris*), were formed in alluvial deposits and have been fully deforested. Maximum degradation of the forest ecosystems took place in the forests of pedunculate oak and narrow-leaf ash – *Querceto fraxinetum serbicum*. In the past, habitats of pedunculate oak and ash were located beside the river Gruža. These forests were probably deforested first, because they were on the most fertile land. There are only some remaining individual specimens of pedunculate oak (villages of Bare, Borač, Bečevica, Gruža, Guberevac, Grabovac, Guncati, Brnjica and Gornja Crnuća). Xerophilic and xeromesophilic forests of Hungarian and Turkey oak (*Quercetum frainetto-cerris*) are typical for the Gruža basin and Šumadija region. It is a climazonal and climatogene forest with deep, developed lands, outside the alluvial plains (Tomić, 1992). The main tree species are *Quercus frainetto*, *Quercus cerris*, *Fraxinus ornus*, *Acer campestre*, *Ulmus campestre*, *Sorbus domestica*, *Crataegus monogyna,* etc. Forests of Hungarian and Turkey oak used to cover a much larger area in the past and covered the terrain up to 600 m. These fields have been significantly deforested, because settlements were built on them and the arable land extended. Forests are rare, and they are best preserved in a difficult terrain. The floristic composition and original diversity are endangered by negative anthropogenic selection (mainly the felling of one species, such as *Quercus frainetto*, and leaving a lower quality *Quercus cerris* as timber and fuel). In this way, habitats of Hungarian and Turkey oak are dominated by stands of solely Turkey oak forests or other degradation stages.

The floristic composition of the upper parts of the basin is characterized by the presence of forest communities formed under the influence of local geoecological factors. In the belt 400-800 m in altitude, the mesophilic mountain forests of sessile oak (*Quercus petraea*) stretch. The forest occupies mostly southern exposures, appearing in northern ones together with beech trees. The sloping and steep terrain, litosols, cambisols on andesite and sandstone rocks are suitable. The better quality sessile oak forests are found in the basin of the Vraćevšnica and Kamenička Rivers on Rudnik Mt. These are usually sessile oak and hornbeam community (*Querco-Carpinetum typicum*). This forest was replaced by a considerable acreage of cultivated fields and meadows. Beech forest occurs in the basin at different altitudes depending on the altitude, geographic location of the mountain and vegetation relationships on the mountain itself. According to Vujadinović and Gajić (2005), the strong relief dissection, silicate surface, deep river valleys, dense river network, and particularly, the influence of moist air masses from the west, are suitable for the forest. Beech is the dominant species on Mt. Rudnik and it occurs at altitudes between 480 and 1,130 m (Panić, 1966). Beech forests are of better quality than oak forests, which are more endangered. The altitude zone of 250-600 m, and up to 800 m on Mt. Rudnik, is characterized by submontane beech forest (*Fagenion moesiacae submontanum*). It benefits from the cooler and fresh habitats. At lower altitudes, the appearance of beech is orographically conditioned. In addition to beech and oak, *Acer pseudoplatanus*, *Fraxinus excelsior*, *Ulmus campestris*, *Tilia argentea*, *Pirus piraster*, *Prunus avium*, *Malus silvestris* etc. are found in the forests (Tomić, 1992). Montane beech forest (*Fagenion moesiacae montanum*) occurs above 800 m, which makes it the most preserved forest in the basin (Vučićević, 1984). It is most spread on the Rudnik and Gledić mountains. In terms of timber, it is the richest forest in the Gruža basin.

The meadows in the Gruža basin are complex ecosystems of anthropogenic and azonal character. They are most present on the rim of the basin, where they interchange with cultivated fields and orchards. Meadows cover 6,425 hectares (10.4%). They benefit from various types of vertisol and eutric cambisol, as well as the slopes over 20%. High quality natural meadows cover small areas, while artificial meadows were made on cultivated fields (Vujadinović and Gajić, 2005). In the river valleys, mostly on alluvial deposits, small areas are covered by natural valley meadows that are flooded during high water levels of the Gruža River and its tributaries. Long water retention in microdepressions is a consequence of the morphological characteristics of the basin, river regime and shallow riverbed. Based on the floristic composition, Veljović (1967) distinguished three communities in the valley meadows of the Gruža Basin: association *Trifolietum resupinati prov.*, which belongs to the type of extremely moist valley meadows with dominant species *Trifolium resupinatum*; association *Betonica-Alopecuretum pratensis* belonging to a new type of temperate moist valley meadow with characteristic species *Alopecurus pratensis* and *Betonica officinalis*; association *Lathyro-Galietum veri.* that belongs to the type of dry valley meadows, with dominant species *Galium verum* and *Lathyrus pratensis* (Veljović, 1967). Valley meadows occur mainly along the Gruža Basin (villages of Ljuljaci, Bare, Grivac and Balosave) and the Balosavska River. The floristic composition usually consists of: *Poa pratensis*, *Festuca pratensis*, *Alopecurus pratensis*, *Lathyrus pratensis*, *Trifolium pratense*, *Trifolium resupinatum*, *Trifolium patens*, *Trifolium repens*, *Trifolium hybridum*, *Agrostis alba*, *Lotus corniculatus*, *Symphytum officinale*, *Ranunculus repens*, *Plantago lanceolata*, *Carex vulpina*, *Mentha aquatica*, *Rumex crispus*, *Taraxacum officinale*, *Convolvulus arvensis*, *Euphorbia virgata* etc. The share of mentioned species changes depending on the hydrological conditions of the habitat. Common to all three types of valley meadow is a noticeable presence of weeds. Extremely moist valley meadows today have no economic significance. At higher altitudes, mountain meadows are found on the sites of former oak forests. The species most often encountered are *Drosera rotundifolia*, *Mentha piperita*, *Bromus racemosus*, *Anthoxanthum odoratum*, *Trifolium repens*, *Hypericum perforatum*, *Matricaria chamomilla* etc. The common weed species are *Cirsium arvense*, *Arctium lappa*, *Euphorbia palustris*, *Euphorbia carniolica*, *Urtica dioica*, *Taraxacum officinale,* etc. Artificial meadows have the greatest economic significance, as they provide the highest quality forage and positively affect physical and chemical soil properties. Grassing over cultivated fields is usually done by *Trifolium pratense*, *Medicago sativa*, as well as by a mixture of *Poa pratensis*, *Festuca pratensis*, *Agrostis alba* and *Lotus corniculatus*.

The pasture zone spatially coincides with the highest parts of the Gruža basin, although also appearing in lower terrains where the forest has been reduced. Pastures cover 5,502 hectares (8.9%). On large areas, pastures were degraded, due to weed infestation and erosion. The floristic composition is poor, and the share of useful herbs is insignificant, which negatively affects the yields. The most common therapeutic types are *Achillea millefolium*, *Thymus serpyllum*, *Matricaria chamomilla*, *Hypericum perforatum* and *Salvia officinalis*. Pastures are often degraded and turned into barren land.

Meadows and pastures are natural resources, whose proper use can ensure the production of high-quality forage. In agriculture, a proper place could be found for weed species because many of them are medicinal and melliferous. However, grass vegetation is at a risk of erosion and land abandonment by man in large areas. Depopulation and extensive agriculture have contributed to the degradation of meadows and pastures and their floristic impoverishment. This phenomenon is especially evident in the hilly and mountainous peripheral parts of the basin.

Macrophyte vegetation occurs sporadically and in conjunction with local hydrophilic conditions. Macrophyte-hydrophilic vegetation is especially developed in the largest part of the Gruža Reservoir, at parts where the banks are low, muddy and the water shallow. The degree of development of vegetation in the Gruža Reservoir was influenced by several factors: water depth, the character of shoreline, pollution etc. The low average depth of the lake has resulted in frequent oscillations of the lake water levels and shoreline displacement in the range of 200-300 m. The reservoir flooded 934 hectares of arable land. The largest part of the lake remained surrounded by fertile land, from which the nutrients and chemicals are constantly run off. Depending on the hydrothermal and photic regime in the littoral belt, the vegetation is differentiated into three ecological groups: emersal, floating and submerged. The siltation degree is considerable, lake area and depth reduction evident, and the shoreline is extremely overgrown with macrophyte vegetation. The phenomenon of eutrophication, inevitable biological and ecological process in this water system is accelerated because of the shallow water and increased anthropogenic impacts (wastewater, pesticides, bathers, fishing, transport, etc.).

As regards the hydrophilic vegetation, mostly represented is emersal vegetation that develops on muddy surfaces, rich in organic matter, in a narrow part of the shoreline, between the minimum and maximum water level (Topuzović and Pavlović, 2005). At places where water is maintained throughout the year, *Typha angustifolia*, *Typha latifolia* and *Alisma plantago-aquatica* are found. Less common types are *Mentha aquatica*, *Lycopus europaeus*, *Stachys palustris*, *Lythrum salicaria*, *Epilobium palustre,* etc. The habitats that are only dry in summer are characterized by considerable floristic richness. About 50 species are found and the most common are the species of *Carex*: *Carex vulpina*, *C. riparia*, *C. distans* (Veljović, 1967). Apart from *Carex*, there is a considerable presence of *Rorippa sylvestris*, *Bidens tripartita*, *Eleocharis palustris*, *Iris pseudacorus*, *Salix alba*, *Mentha aquatica*, *Lysimachia nummularia*, *Lemna gibba*, *Symphytum officinale,* etc. A considerable presence of meadow types indicates the proximity of valley meadows and especially *Circium arvense* as a dominant weed type (Topuzović and Pavlović, 2005). According to Vujadinović and Gajić (2005), emersal vegetation is, besides the reservoir, also found in the river Gruža and its tributaries' valley (locality Bare between the downstream of the Zakutska and Gruža Rivers). Floating vegetation is poorly developed and represented by a low number of species. The main representative is *Polygonum amphibium*, a species that occurs in the form of islets. In shoreline areas, there are *Lemna minor* and *Lemna gibba* (Topuzović and Pavlović, 2005). Submerged vegetation is floristically impoverished and poorly developed (*Ceratophyllum demersum*, *Najas marina*, *Potamogeton crispus*). The mentioned species appear further from the banks. One of the problems in reservoirs is accelerated eutrophication (Straškraba et al., 1999). Growing human influence on the reservoir has led to the introduction of ever-increasing quantities of nutrients (Wetzel, 1983;

Krebs, 1994). The distinguished representatives of submerged vegetation near the shoreline are *Myriophyllum spicatum*, *Potamogeton pusillus,* etc. Based on the structure of the hydrophilic vegetation, an objective assessment of the intensity and degree of eutrophication is possible, because in the ecosystem of the Gruža Reservoir, macro-vegetation appears as one of the serious problems in the processes of healing and transformation of the lake. In order to preserve the water quality, a constant development control of vegetation is necessary, because the amount of organic matter would otherwise be increased in the reservoir.

DISCUSSION

The Gruža Basin is characterized primarily by an agrarian, plain/mountain landscape, where the villages are surrounded by forests and agrarian ecosystems. There is a homogenization of various agricultural structures present. Arable land covers 34,177 hectares (55.2%). Under the influence of anthropogeographical factors, there have been some changes in the use of land. They are most distinctive in the central part of the basin, which spatially coincides with the territory of the municipality Knić (66.8% of the Gruža basin). Agricultural areas in this part of the basin were reduced in the period 1974-2008 by 2,006 hectares, and the share in the total area by 4.8%. The arable land was most reduced (1,867 hectares), while reduction of areas under pastures amounted to 139 hectares. The largest decline in arable land was registered in cultivated fields (1,949 hectares), while the decrease in vineyards was 140 hectares, and in orchards 120 hectares. The exceptions are the areas under meadows that increased by 342 hectares. The changes in the area structure were influenced by several factors, primarily by the construction of the reservoir (the largest part of the submerged land belonged to the second and third land capability class). Negative demographic processes (depopulation, emigration, unfavorable age structure), correlated with economic underdevelopment (extensive agriculture, abandoning agricultural land), have led to the degradation of agricultural ecosystems in recent decades. In higher terrain (300-500 m), cultivated fields, vineyards and orchards have gradually been turned into meadows, and then into primary forest vegetation. In the lowest part of the basin (180-300 m), the abandonment of cultivated fields resulted in the spreading of weed communities. In the overall structure of the area, there was an expansion of infertile areas, which were increased by 1,414 hectares, mostly as a result of the construction of the reservoir rather than due to expansion of construction land and traffic communications. Forests were enlarged by 592 hectares and afforestation of cultivated fields, meadows and pastures of weak production capabilities had a far-reaching positive geoecological effect for the entire basin.

Human activities negatively affected the condition of vegetation in terms of deteriorating the conditions in habitats and impoverishment of flora. The forests in the Gruža basin are of poor quality and degraded under the influence of abiotic, biotic, primarily anthropogenic factors, which disturbed their biogeocenotic balance. Simultaneously, due to the degraded habitat, the condition of forests was aggravated, their value and survival threatened (Krstić, 2006). The forest structure is unfavorable given that sprout forests have the largest share. According to the data of the State Enterprise for Forest Management "Srbijašume", their share in the national forests amounts to 53.7% (Forest Management Kragujevac), or 47.1% (Forest Management Gornji Milanovac). The exceptions are trees in the Forest Management Kraljevo, where high forests dominate (49.7%), while sprout forests are represented by 29.9%. If we analyze the structure of the total forests at the level of management units that belong to the Gruža basin, the situation is even worse, because high forests participate with only 8.9% (Gledić Mountain Management Unit) or 6.3% (Kotlenik Management Unit). The exploitation of forests in the Gruža basin was done at the expense of biodiversity and natural regulation of water and climate and has led to changes in autochthonous habitat conditions and the occurrence of erosion. The occurrence of erosion in the Gruža basin was influenced by both natural (geological background, relief, climate, soil and vegetation character), and anthropogenic (soil cultivation on slopes, degraded forests and pastures) factors. The sandstones of the Rudnik and Gledić mountains are not resistant to erosion, and precipitation in the form of rain showers greatly enhances its intensity. The andesitic-dacitic and pyroclastic rocks of Kotlenik and Ješevac Mts. are also subject to erosion. Shallow lands – litosols on slopes over 30%, are very susceptible to erosion. Oak forests, because of poorly developed forest floors and high exploitation, inadequately protect the land from erosion. In the central, lowest part of the basin, erosion is sporadic and poorly developed, and it mainly occurs in the form of surface runoff on arable land. In the higher parts of the basin (300-500 m), there is furrow erosion. Erosion is most present in the mountainous part of the basin where there are often gullies, ravines and torrents, especially on the western slopes of the Gledić mountains and on the eastern slopes of Kotlenik Mt., south from Tucački Naper Dam. Frequent torrents in the Gruža basin are a consequence of the steep slope and deforestation of the terrain and of the poor resistance of the geological surfaces (sandstone, marlstone, clays and eruptive rocks). The most common measure applied in order to protect the land from erosion is afforestation of land (on steep slopes) of sixth and seventh land capability classes.

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