

# USE AND REGULATION OF KARST POLJES IN YUGOSLAVIA

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## Abstract

The traditional use of karst poljes in different parts of Dinaric karst is presented from the efforts for water regime change in order to dry up the poljes as well as to retain periodically or permanently the water for agricultural, touristical, energetical and complex hydro-economy use. The attempts for protection of karst poljes natural properties within the frame of regional karst park are mentioned.

## Extrait

On y présente l'emploi traditionnelle des poljés karstiques dans les différentes parties du karst Dinarique et tous les efforts de changer le régime hydrique, ainsi dans la direction du dessèchement comme dans celle de la retenue permanente ou périodique de l'eau pour l'exploitation agricole, touristique, énergétique et pour l'économie hydraulique complète. On y mentionne les efforts pour la protection permanente des caractéristiques naturelles des poljés karstiques dans le cadre du parc karstique régional.

Big karst depressions with flat, alluvial bottom and sinking streams which are in the geographical literature the most frequently defined as karst poljes (Cvijić, 1895; Šerko, 1947; Melik, 1959; Roglić, 1964; Gams, 1978), according to Šerko there are more than 200 of them in Yugoslavia, are the only bigger, fertile and inhabited oases in the middle of the Dinaric karst. Man exploits them from the beginning of settling by different ways, adapts to their natural properties, more or less successful he tries to change them according to his own wishes and needs. In the last decades in Yugoslavia quite a big progress was attained.

## 1. Traditional use of karst poljes

According to morphogenetical and hydrographical criteria the karstologists divided karst poljes into several types (Lehmann, 1959; Gams, 1973). Regarding their economic geographical properties,

it means the situation, size, water conditions and climate and regarding the manner of economic use the dinaric karst poljes can be divided into following groups:

- 1.1. Permanently flooded lake poljes on low above the sea level altitudes without an important agricultural surface and urban function, convenient for natural reserve, tourist exploitation and natural reservoir of water; such are Vrana on island Cres, Vransko jezero near Šibenik, Bačinska jezera near Neretva, Skadarsko jezero, etc.
- 1.2. Submediterranean, periodically, partly or completely flooded karst poljes with fertile agricultural surface, which can be intensively cultivated in the dry half of the year when the water flows off. Their use depends on size and lasting of flood. Mediterranean climate with favourable temperatures accelerates the agrarian production, but summer aridity diminishes it. Permanent settlements and communication system are situated on the border of the flooded surface, agricultural land lies in the flood area too. Such poljes are: Imotsko, Popovo, Rastok, Jezero, etc.

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- 1.3. Dry karst poljes in submediterranean belt are regarding the size smaller but more fertile; the lack of water diminishes their economic value (Dugo polje, Dicmo, Ljubinje).
- 1.4. Temporary flooded poljes in the mountainous continental part of Dinaric karst are regarding the climatic and productive conditions more suitable for cattle-breeding, either exclusively as grassland and pasture ground or supplementary agricultural surfaces for mainly cattle-breeding oriented farms. The way of economic use is in great extent influenced by lasting and annual variability of floods, but the agriculture is limited too by the altitude and lower temperatures connected to climatic inversion. Beside cattle-breeding on the poljes the woods are important on the poljes borders encouraging the woodworking industry.
- 1.5. Dry karst poljes in higher continental part of Dinaric karst in between the wood belt are suitable exclusively for grassland and cattle-breeding (Glamočko polje, Babno polje). The wood on littoral mediterranean side is extremely degraded or even completely extinguished because of exaggerated exploitation, as for example in Montenegro (Cetinje, Grahovo, Njeguši).

Beside the agricultural function the poljes are important because of their situation among higher karst ridges for their communication significance. Across them the old roads had been leading from the interior towards the coast and back, modern circulation communications, more roads than railway, are there too. At cross-roads on poljes smaller urban centres developed, being the industry centres and causing new problems regarding protection and management of karst.

On some poljes of tectonic origin with Neogene lacustrine sediments there are stocks of brown coal and lignite which are more and more important as energetic sources (Gacko polje). Superficial waters on dinaric poljes with common underground connections and possibilities for construction of greater accumulations on the different altitudes present the main energetic potential of Dinaric karst (Trebišnjica system, Cetina).

## 2. The purpose of intervention into the karst water regime

By social economic development and building industry progress as well as by research results the human interventions on karst poljes increased, specially regarding their water regime by drying them up, partly by irrigation and mostly by exploitation of available energetic potential. According to

exploitation the interventions into karst poljes can be divided to:

- 2.1. Arrangement of water conditions for the need of agriculture and cattle-breeding production by either drying up or irrigation with local use of water energy at springs and ponors.
- 2.2. Arrangement exclusively for energetic use by construction of accumulation basins and artificial outflow tunnels and energetic plants.
- 2.3. Arrangement for several purposes of water economy use, agricultural, energetic and touristic ones and by limited coordination of ecological and landscape problems.
- 2.4. Preservation and conservation of natural unchanged properties in a form of reserves, touristic curiosities or protected catchment areas of water sources.

## 3. Problems of karst poljes regulations

Forms, ways and problems of regulation and use of karst poljes are connected with:

- 3.1. knowledge degree of karst phenomena and karst processes investigation rate on the surface and in the underground of narrow and wider background,
- 3.2. technical mastery degree of karst phenomena and their progress and ecological lawfulness,
- 3.3. the expanse of interventions,
- 3.4. accordance and coordination of interventions to purpose,
- 3.5. expected and secondary effects,
- 3.6. cost of interventions and other fees,
- 3.7. valorization of natural properties in present and in future, not yet known, economic and social demands.

According to tasks and needs the research methods and technical interventions as well as the organisational management demands have been considerably ameliorated (Herak, 1972; Mikulec & Trumić, 1976; Milanović, 1978).

## 4. Improved research methods

On the research area the efforts were directed to:

- 4.1. Inventarisation and classification and cartographic documentation of the karst phenomena in the poljes region as well as in their wider background. From this point of view were important geological, geographical and speleological investigations beside the geodetic surveys.



- 4.2. Finding of water quantities, regime, precipitation budget, inflow and outflow - for all these tasks the improved hydrometeorological service has taken care.
- 4.3. Finding of underground water connections on outflow side by corresponding springs and definition of catchment area on inflow side. The water tracing methods were introduced and improved (different tracers were used), somewhere in big quantities. Water tracing methods were improved by international collaboration of different institutions (Ist - 5 th SUWT).
- 4.4. Study of cavernosity and permeability and distribution of different hydrogeological units, complete, partial and hanging barriers, influencing to distribution and direction of karst underground waters flow. From this point of view the geological investigations by detailed mapping and boring, geomechanical and geophysical measurements and analyses contributed the most.
- 4.5. At first bigger technical interventions the planners had not taken enough care for natural and ecological investigations. They followed later, when the problems of preservation of endemic subterranean animal specimens have emerged, when the changed microclimatic conditions and troubles of human adaptation to new conditions in life, empty settlements, interrupted roads, disturbed agrarian production and agricultural use and other different results and changes in karst ecosystem have occurred.

## 5. Ways and effects of technical interventions

While planning and realizing the regulation projects some new methods have been introduced just because of specific karst circumstances.

- 5.1. By previous cleaning and opening of ponors no essential ameliorations of poljes water regime have been achieved; on one side a man wanted to avoid the floods while on the other he surpasses the lack of water in dry summer months by difficulties (wells, rain-water, reservoirs). The majority of outflow tunnels, constructed on lower lying karst poljes (Jezero, Bokačjačko blato, Imotsko polje, etc.) were not conceived on the real water conditions, the planners did not consider enough the entire underground water system. Thus the drought was increased but the floods were not eliminated (Bonacci, 1985).

- 5.2. The attempts of simple water retention on poljes by closing up the swallow holes and by controlled water outflow into existent natural conduits did not give the expected results either. The floods increased, threatened the agricultural surface and settlements on the border, the drying up started a little later but has finished more quickly (Cerkniško jezero, Habič, 1974).
- 5.3. First serious attempts for permanent retention of water on the karst poljes have been furthermore conceived on superficial tightning and isolation of the known swallow-holes. In the alluvium inside the artificial accumulations have occurred new one (Nikšić).
- 5.4. The ill success forced the technicians to conceive new methods for deep tightning of water courses in karst. Practical realizations of deep injections in borders and under the superficial dams have been sometimes accompanied by surprises when big caverns have been hit by boreholes (Lika, Buško blato) but these problems have been promptly successfully solved. Supplementary investigations and tightnings have namely risen the costs of the objects, but with rare exceptions, the foreseen effects have been achieved (Mikulec & Trumić, 1976).

## 6. The meaning of karst landscape regulation

In the sphere of management and complex landscape arranging an important progress has been achieved. Exclusively energetic use of karst waters for which the only fertile and for life suitable surfaces in the middle of the karst have been sacrificed, soon proved to be too much biased (Mikulec & Trumić, 1976). Aggressive drainage of water through the shortest artificial way from the mountains to the sea, in spite of useful energetic objects, unabled the exploitation of precious karst waters for other purposes, water supply, irrigation, ecological balance, sport and tourist activities etc. The plans for several purposes use of karst waters and for available agricultural surfaces have been done, which had diminished the energetic profit in behalf of other users of water and space. On the other hand such way had increased the costs of building and indirectly the price of energy. Regarding the fees only big, connected systems are acceptable (for example Trebišnjica). At particular smaller poljes the costs of intervention were too high and the effects too small. It is important specially when considering unfavourable ecological consequences of unilateral and exaggerated intervention into na-

tural karst system. More reasonable natural conservation and preservation measures were proved, accelerating accordant agricultural, touristical, urban and other economic uses of karst poljes. Classical karst poljes of Notranjsko, as are Cerknica and Planina poljes should be, together with their environment and several caves, among them the world famous Postojnska jama, included into natural karst park.

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