GEOECOLOGICAL RESEARCH INTO THE CATASTROPHIC FLOODS OF NOVEMBER 1, 1990, IN THE SAVINJA RIVER BASIN AND ITS ROLE IN THE MITIGATION OF FUTURE DISASTERS

GEOEKOLOŠKE RAZISKAVE POSLEDIC KATASTROFALNIH POPLAV 1. NOVEMBRA 1990 V POREČJU SAVINJE IN NJIHOV DELEŽ PRI PREPREČEVANJU PRIHODNJIH KATASTROF

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Abstract UDC 556.166 (497.12-115)

Geoecological research into the catastrophic floods of November 1, 1990, in the Savinja River basin and its role in the mitigation of future disasters

The paper summarizes the main results of geoecological research into the consequences of catastrophic floods on November 1, 1990 in the drainage basin of the Savinja River. This is the basis for the evaluation of sanation measures performed up to the present with the emphasis on the new approach to the flood-protection of Celje through the natural retention basin in the Lower Savinja Valley. The author is analysing the mistakes, done during regulation works along the Savinja River and its tributaries and utilisation of flood plains, what seems to contribute a great deal to the damage.

Izvleček UDK 556.166 (497.12-115)

Geoekološke raziskave posledic katastrofalnih poplav 1. novembra 1990 v porečju Savinje in njihov delež pri preprečevanju prihodnjih katastrof

V referatu so povzeti poglavitni rezultati dosedanjega geoekološkega proučevanja posledic katastrofalnih poplav 1. novembra 1990 v porečju Savinje. Na njihovi osnovi avtor vrednoti dosedanjo sanacijo posledic, še zlasti nov pristop k varovanju Celja pred poplavami s pomočjo naravnega retencijskega bazena v Spodnji Savinjski dolini. Hkrati s tem opozarja na napake, ki so bile storjene doslej pri brzdanju hudourniške Savinje in njenih pritokov ter rabi poplavnih ravnic, kar je po avtorjevem mnenju veliko prispevalo k nastali škodi.

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The tragic consequences of the catastrophic floods of November 1, 1990, were a revealing experience for all flood experts. This natural disaster has given us the unique opportunity to rid ourselves of a false sense of security and of superiority over natural forces. The following decades will demonstrate whether we were able to take advantage of this opportunity.

It is a matter of fact that the Savinja River flood of November 1, 1990, was a major surprise for the people living in the Savinja River basin, especially those living in Celje. There was general confidence in the flood protection measures taken in and around the city after the catastrophic floods of June 5, 1954. During the 1956-1960 period, major flood-protection projects had been carried out intended to finally protect the city from floods. The riverbed of the Savinja was deepened and enlarged, its Ložnica, Koprivnica, and Sušnica tributaries were joined in a single channel, the lower reaches of the Hudinja and the Voglajna rivers were regulated, and a dike was built along the left bank of the Savinja River. This dike, extended upstream along the Ložnica River, was intended to protect the city up to the Savinja's 300-year maximum flood level. The regulation of the Hudinja and Voglajna, together with the joint river channel for the Ložnica, Koprivnica, and Sušnica, were planned to protect the city against flood waters from these rivers which had devastated the city in 1954.

The consequences of the catastrophe on November 1, 1990, which in one day cost almost twenty per cent of the 1989 gross national product of Slovenia, were disastrous for the population directly affected and for the society as a whole. Although the damage exceeded two billion USD, from the geoecological point of view it was only a short episode in the continual process of reshaping the landscape of Slovenia. For scientists it was a good opportunity for direct observation of the extremely violent geomorphic processes which have been changing our landscape for millions of years.

During this catastrophe the greatest damage occurred in the drainage basins of the Savinja, Kamniška Bistrica, and Sora rivers. This fact can be indirectly seen from Table 1 which shows the maximum water discharges of the major Slovene rivers.

Table 2 shows the maximum water discharges of the Savinja River and its tributaries. It is quite obvious that only the Savinja and some tributaries in the upper part of the drainage basin reached a very high maximum water discharge, while the others, in particular the Hudinja and Voglajna rivers, did not flood at all.

Table 1: Maximum water discharge of the major Slovene rivers on November 1, 1990 (K o l b e z e n, 1991).
Tabela 1: Maksimalni pretoki večjih slovenskih rek 1. novembra 1990.

1	2	3	4	5
Mura - Gornja Radgona	1465	1938	819	4-5
Ledava - Polana	80	1972	43	2-5
Meža - Otiški Vrh	337	1966	350	Over 50
Dravinja - Videm	291	1964	189	5+10
Sava - Radovljica	887	1926	516	5
Sava - Šentjakob	1610	1926	1417	50
Sava - Radeče	2809	1933	2987	100
Sava - Čatež	3520	1933	3267	n. a.
Sora - Suha	649	1926	686	Over 100
Kamniška Bistrica - Kamnik	215	1933	282	Over 100
Ljubljanica - Moste	372	1933	296	2-5
Savinja - Nazarje	480	1926	630	Over 100
Savinja - Celje	946	1926	1208	Below 100
Savinja - Laško	1200	1933	1406	Over 100
Dreta - Kraše	208	1968	236	50-100
Krka - Podbočje	498	1933	276	1-2
Kolpa - Radenci	936	1966	597	2
Soča - Solkan	2141	1982	1991	25
Idrijca - Hotešček	874	1979	833	50
Vipava - Miren	353	1965	205	2

Legend: 1. River-gauging station; 2 Maximum discharge, prior to the flood of November 1, 1990 (cu. m/sec); 3. Year of the maximum; 4. Maximum discharge during the flood of November 1, 1990 (cu. m/sec); 5. Return period of discharge (year).

The floods of November 1, 1990, were studied by a number of scientists from various branches, among which the contribution of geographers cannot be ignored. Immediately after the floods, geographers were among the first to call public attention to the fact that man had contributed a great deal to the disaster (G a m s, 1990; N a t e k, 1990). The first findings were presented to the public at a symposium in Slovenj Gradec on January 17, 1991, and a more elaborated analysis of the flood was presented at a symposium in Poljče on April 22, 1992.

Detailed studies made by numerous experts from various fields confirmed the thesis that man had contributed greatly to the disaster. We optimistically offered these findings as a useful basis for the reconsideration of existing flood protection measures and land use planning. It should be mentioned that due to the absence of major floods in recent decades, flood plains have been exploited for residential housing, industrial facilities, and transportation links which are impossible to protect completely because of the torrential nature of floods in the Savinja River basin.

Table 2: Maximum water discharge of the Savinja River and its tributaries on November 1, 1990 (K o l b e z e n - Š k e r j a n c, 1991).
Tabela 2: Maksimalni pretoki Savinje in njenih pritokov 1. novembra 1990.

1	2	3	4	5	6
Savinja - Solčava	63.7	232	76.2	1196	
Savinja - Nazarje	457.3	467	630	1378	Over 100
Savinja - Letuš	534.4	510	715	1338	
Savinja - Celje	1189.2	722	1208	1016	
Savinja - Laško	1663.6	694	1406	845	Over 100
Lučnica - Luče	57.6	455	173	3003	
Dreta - Kraše	101.8	400	236	2318	50-100
Paka - Rečica	206.5	372	189	915	10-20
Bolska - Dolenja vas	175.1	400	182	1039	
Ložnica - Levec	64.9	320	82	1263	
Voglajna - Celje	202.2	312	67	330	
Hudinja - Škofja vas	156.5	317	85	541	

Legend: 1. River–gauging station; 2. Area of the drainage basin (sq. km); 3. Water level (cm); 4. Maximum discharge on November 1, 1990 (cu. m/sec); 5. Specific discharge (l/sq. km/sec); 6. Return period of this discharge (year).

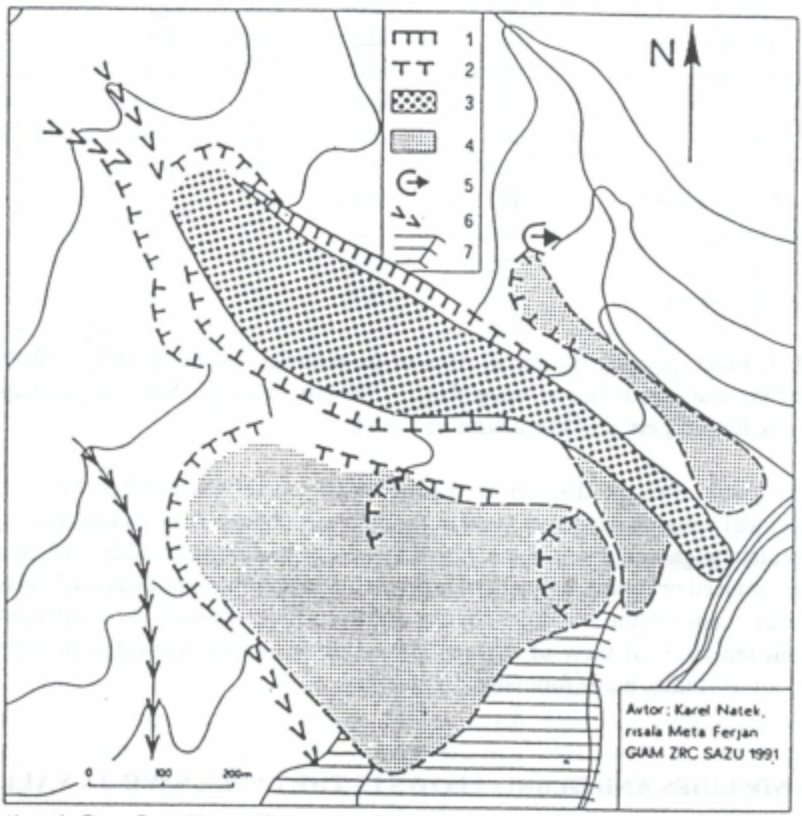
Three years after the disaster, it is time to ask ourselves whether the findings of geoecological research have been used in the reconstruction of the stricken area or, possibly, completely ignored. It is not the aim of this paper to discuss whether this catastrophe was man-induced or completely natural in origin but to present some effects of the flooding where man's contribution was quite obvious and to consider the state of current reconstruction from the point of view of the application of knowledge collected in the various geoecological studies made following the floods.

LANDSLIDES AND DEBRIS FLOWS IN THE UPPER SAVINJA VALLEY

In the Upper Savinja Valley, landslides and debris flows were the most common feature of the catastrophe and along with the flooding of the narrow flood plain along the Savinja River contributed a great deal to the damage (M e z e, 1991; N a t e k, 1991a, 1991b, 1992a, 1992b; K l a d n i k, 1991a, 1991b).

The occurrence of numerous smaller landslides on steep deforested slopes, mostly on impermeable Oligocene andesite tuff, was very closely linked to human activity on the slopes. They were triggered mostly on meadows and pastures, usually along roads and farm tracks cut into the labile slope material of mainly periglacial origin. A number of landslides appeared on the lower convex sections of valley slopes where they were linked to the natural process of considerable downward cutting by the Savinja's tributaries. Man alone cannot be blamed for triggering these landslides because it was very obvious that the small landslides were an inevitable part of natural processes of denudation, although the protective role of forest was evident.

The majority of these landslides were triggered during the worst downpours on the night of October 31, 1990 (M e z e, 1991). The larger landslides, however, were a big surprise, in particular the huge landslides at Raduha and Podveža. The latter even dammed the Lučnica River and created a short-lived lake.



Karta 1. Plaz v Raduhi in starejši plazovi v bližnji okolici.
Legenda: 1 — sedanja plazna razpoka, 2 — starejša plazna razpoka, 3 — sedanji plaz, 4 — starejši plaz, 5 — manjši sedanji plaz, 6 — grapa, 7 — rečna terasa.

Fig. 1: The Landslides at Raduha.
Slika 1: Plazovi v Raduhi.

Legend: 1. Scar of new landslide; 2. Scars of former landslides; 3. New landslide; 4. Previous landslides; 5. Smaller new landslide; 6. Ravine; 7. River terrace.

The Raduha landslide occurred on November 3 at 20:30, more than two days after the catastrophic flooding (N a t e k, 1991a). Detailed geomorphological analysis of the site showed that the Raduha landslide had been triggered at exactly the same place as a similar landslide which occurred a few centuries earlier. The accumulated debris of the first is still clearly visible south of the recent landslide, and the local name 'Pekel' (Hell) was given to the impassable terrain of this previous landslide (Fig. 1). The fieldwork revealed even more such fossil landslides in the upper reaches of ravines over the whole mountain region in the andesite tuff around Luče (a landslide more than 400 meters wide was found just south of the most recent slide).

On the contrary, the Podveža landslide (Fig. 2) appeared on a slope which had no previous landslide activity and was caused by the buoyant force of collected rainwater in the layers of the lower section of the slope (B r e z n i k, 1991).

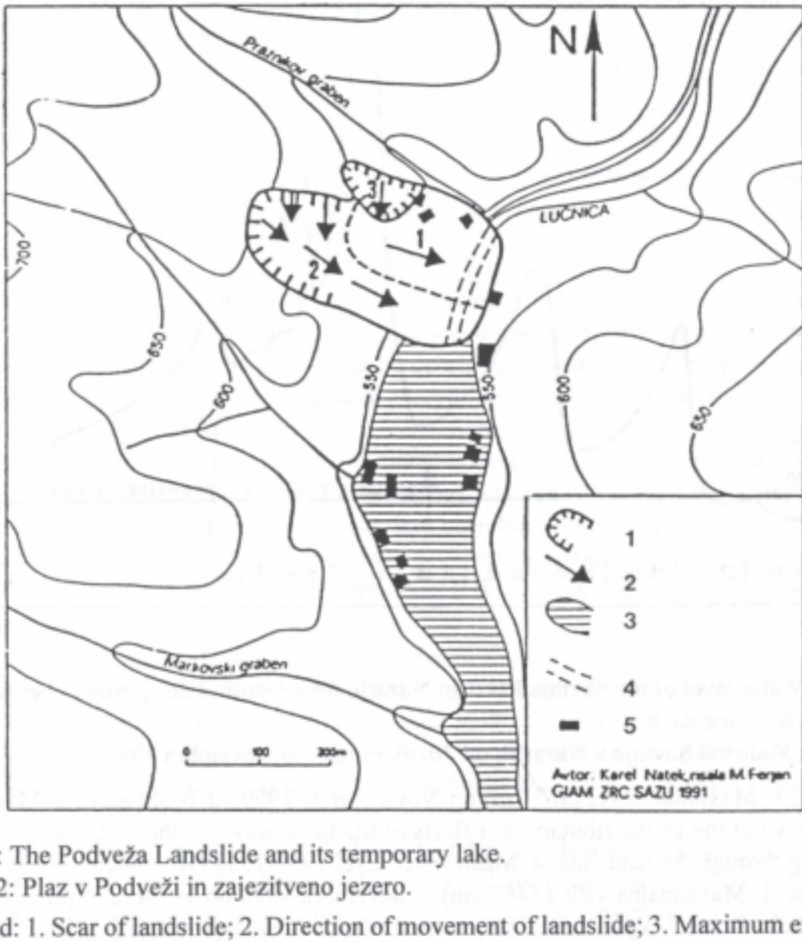


Fig. 2: The Podveža Landslide and its temporary lake.
Slika 2: Plaz v Podveži in zajezitveno jezero.

Legend: 1. Scar of landslide; 2. Direction of movement of landslide; 3. Maximum extent of lake; 4. New riverbed of Lučnica River through landslide; 5. House.

The Podveža landslide was triggered at 22:00 on November 1 and dammed the Lučnica River. Over the next few hours, a twenty meter deep and 1500 meter long lake was created containing about one million cubic meters of water. At 5:20 on November 2, the water broke the dam and poured down the valley, destroying everything in its path. A two meter high wave reached the village of Luče in a few minutes and devastated the lower section of the settlement along the river (N a t e k, 1991a; K l a d n i k, 1991a). The flood wave of this water was clearly evident in Nazarje, about twenty kilometers downstream (Fig. 3) and even as far as Laško.

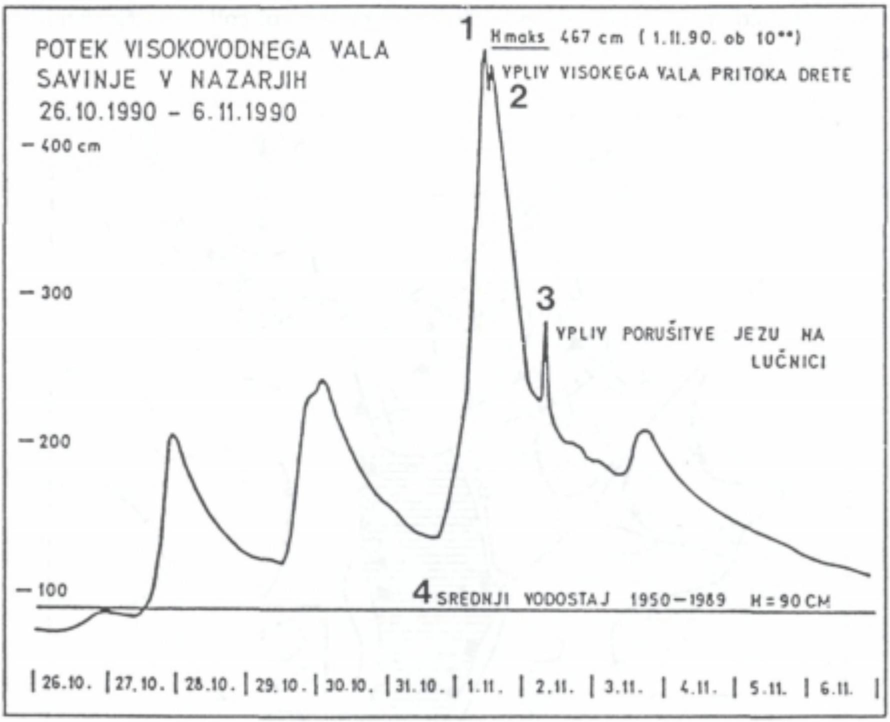


Fig. 3: Water level of the Savinja River in Nazarje from October 26 to November 6, 1990 (K o l b e z e n, 1991).

Slika 3: Vodostaj Savinje v Nazarjih od 26. oktobra do 6. novembra 1990.

Legend: 1. Maximum level (467 cm) on November 1, 1990, at 10.00 a.m.; 2. Maximum flood wave of the Dreta tributary; 3. Effects of the flood wave on the Lučnica River after breaking through the landslide; 4. Mean water level 1950-1989 (H = 90 cm).

Legenda: 1. Maksimalna višina (467 cm) 1. novembra 1990 ob 10.00; 2. Vpliv visokega vala pritoka Reke; 3. Vpliv posušitve jezu na Lučnici; 4. Srednji vodostaj 1950–1989 (H= 90 cm).

The larger landslides were not triggered by any kind of human activity in the mountainous upper section of the Savinja River basin. They were a constituent part of the slow movement of periglacial slope debris since the Würm glacial when the area was situated above the upper tree line and exposed to intensive periglacial processes. The growth of forest vegetation has slowed but not stopped the downward movement of this debris.

Older settlements (mountain farms on the slopes and villages at the valley bottom) successfully avoided the critical sites. Some were cut off for several days because of destroyed roads, but none was directly endangered due to their well considered locations. On the other hand, the landslides destroyed several newer buildings which had been built directly in their paths. It is very obvious that traditional 'geoecological knowledge' based on the experience of former generations of the rural population had been completely ignored.

It is also worth mentioning that a few decades ago the construction of a high valley dam for a hydroelectric power plant was planned in the Lučnica Valley only a few hundred meters upstream from the landslide at Podveža. This latest catastrophe has buried that project forever (N a t e k, 1992b).

In the rugged mountains around the Upper Savinja Valley, fans were considered the most favourable sites for settlement and agriculture. There is a significant difference between the fans of Pleistocene origin, which are composed of fluvio-periglacial material and rather large in size, and the Holocene fans, which are much smaller and still active. The older fans are dissected by twenty to fifty meter deep valleys and their gentle slopes are the most suitable sites for mountain farms, very well protected from floods and other natural hazards (M e z e, 1966).

However, the younger fans at the mouths of ravines were among the most affected sites during the floods of 1990. The simultaneous processes of fluvial erosion and accumulation were disastrous, especially on fans struck by debris flows which started with landslides in the upper reaches of ravines and destroyed everything in their paths. There was little damage in the ravines themselves as they remained uninhabited, but on fans where newcomers not privy to the oral transmission of traditional geoecological knowledge had built their homes directly in the paths of debris flows damage was considerable. It was quite obvious after the disaster that the older farmhouses had been built on the edges of fans out of the reach of recent erosional and accumulative processes. The fans proved to be unsuitable sites for settlement, and it should be an important task of geoecology to convince people to stay away from Holocene fans.

Civil engineers constructing roads in the rugged and steep terrain of the Upper Savinja Valley did not consider warnings that the small ravines on steep slopes are in fact very dangerous torrents and paths of debris flows. Due to this fact, which originated from a lack of geoecological education, and due partially to the inevitable lack of money, the ravines were not crossed by bridges with appropriate openings but drained instead by narrow culverts.

There are many examples of such culverts with half to one meter diameters even on the main road between Ljubno and Solčava. These proved insufficient to drain all the water and debris from the very steep and occasionally quite large catchment areas of the ravines, which in some cases exceeded one square kilometer. The debris blocked the culverts in a very short time, and the water was forced to flow across the pavement where huge fans were formed and, at the same time, the water cut deep ditches in the road. Because of this construction error, the Upper Savinja Valley above Ljubno was cut off from the rest of Slovenia for three days, although the consequences of the disaster were considerably mitigated by the ability of the local people to organize themselves (N a t e k, 1990).

Unfortunately, the findings of geoecological analysis have not been accepted by the civil engineers. During the repair work, culverts of similar diameter are being reinstalled at the same sites, an action which cannot be explained simply by lack of money.

THE FLOODS IN THE LOWER SAVINJA VALLEY

One of the most important findings of the very extensive and detailed investigations of flood plains in Slovenia undertaken by the Anton Melik Institute of Geography and published in many issues of 'Geografski zbornik' was the knowledge that the flood plains are simply the riverbeds of torrential flood waters and should remain available for them. These investigations have clearly shown that the construction of family houses, factories, warehouses, etc., on flood plains is extremely risky and should be completely avoided.

The process of accelerated urbanization of flood plains in recent decades could be explained by the low price of flat land of inferior agricultural quality and by the complete lack of geoecological knowledge of owners and governmental officials. The occasional warnings of the water authorities were ignored, and their activities were limited to passive flood protection works (R a j a r, 1991). Such practices were severely punished by the disastrous consequences of the 1990 floods for the society as a whole and for the individuals who lost their property (N a t e k, 1990).

In the Lower Savinja Valley there is another reason to blame man for the major portion of the damage. The Savinja River is a torrent carrying large amounts of gravel which was once deposited in the riverbed and on the flood plain on both sides of the river. The river previously meandered across the valley bottom, but during extensive regulation works between 1876 and 1893, it was enclosed by tight dikes on both sides along its whole path through the flatland.

Due to these dikes, the speed of the water increased considerably during flooding and the accumulation of debris was limited to the riverbed. As a consequence, the Savinja River cut its riverbed one to three meters deeper between Letuš and Dolenja vas, increasing the discharge capacity of the riverbed but destroying anti-erosion dams and undercutting bridges and dikes.

Furthermore, the deposition of gravel and other loads which occurred in the lower section between Dolenja vas and Celje decreased the discharge capacity of the riverbed at Celje, and the water itself, which had been accelerated by enclosure between the dikes, broke through the dike just above Celje and devastated the city.

After the floods of June 5, 1954, when the Hudinja River and some other tributaries of the Savinja River from the area north of Celje devastated the city, the bed of the Savinja River was dredged to a discharge capacity of about 1000 cubic meters per second. Further deepening of the riverbed is not possible due to the rock threshold at an altitude of 238 meters above sea level just below Celje, which is situated at the boundary between the neotectonically uplifting Sava Mountains and the Celje Basin.

As a result, a general feeling of 'absolute' safety developed, and no one expected a flood to strike the city again. This is a reasonable explanation for the enormous property damage since there is no other justification, for instance, for the installation of valuable medical equipment in the basement rooms of the Celje hospital.

During the floods of 1990, the discharge capacity of the riverbed at Celje was further decreased by waterborne trees and branches which clung to bridge piers and blocked the arches, increasing the water level by about one meter. The larger number of waterborne trees in comparison with previous floods could be evidence of the increased erosion of the Savinja riverbed in the Lower Savinja Valley (M a r i n č e k, 1992).

Due to the previously mentioned regulation of the Savinja River, its erosive force was substantially increased in the Lower Savinja Valley. Even before reaching its highest level, the river had carried away one after another all five wooden dams between Letuš and Dolenja vas which had prevented downward erosion and in the lower section of the valley had broken through the dike in two places (N a t e k, M., 1991).

The most significant was the destruction of three hundred meters of dike on the left bank below Kasaze where a secondary stream was created heading straight toward Celje. On its path toward the city, this stream containing from 10 to 15 per cent (about 200 cubic meters per second) of the Savinja's water destroyed the transverse protective dike above Celje. At the same time, the dike along the left bank of the Savinja prevented this stream of water from returning to its normal riverbed before reaching Celje (M a r i n č e k, 1991). Thus, almost the whole city of 42 000 residents, except for the old city core which lies two or three meters higher than its surroundings, was flooded to a depth of around one meter. These facts seem sufficient to confirm the introductory statement that man contributed a great deal to the disaster under discussion.

Comparing the floods of June 5, 1954, and November 1, 1990, has led to another significant speculation. The first flood was caused primarily by a major summer storm in the mountains north of Celje, and the greatest proportion of damage was done by the turbulent waters of the Hudinja River. The discharge of the Savinja River was not extremely high, but its waters dammed the flow of the Hudinja River which devastated the northern and eastern parts of Celje (M e l i k et al., 1954).

The second flood was the consequence of a heavy autumn storm which covered the Savinja Alps and the Upper Savinja Valley, but it was fortunate for the people of the Lower Savinja Valley and especially of Celje that the belt of maximum rainfall stretched westwards over the drainage basin of the Kamniška Bistrica River on the western side of the Savinja Alps (Fig. 4). Had this belt extended some twenty kilometers further east, it would have reached the rugged mountains of impermeable rock in the source areas of Paka and Hudinja rivers as well.

The coincidence of major flooding from both the Savinja and Hudinja rivers would be even more disastrous for the city of Celje. In my opinion, it is very dangerous to rely on the hope that during future floods the high waters of the Savinja and Hudinja Rivers will not

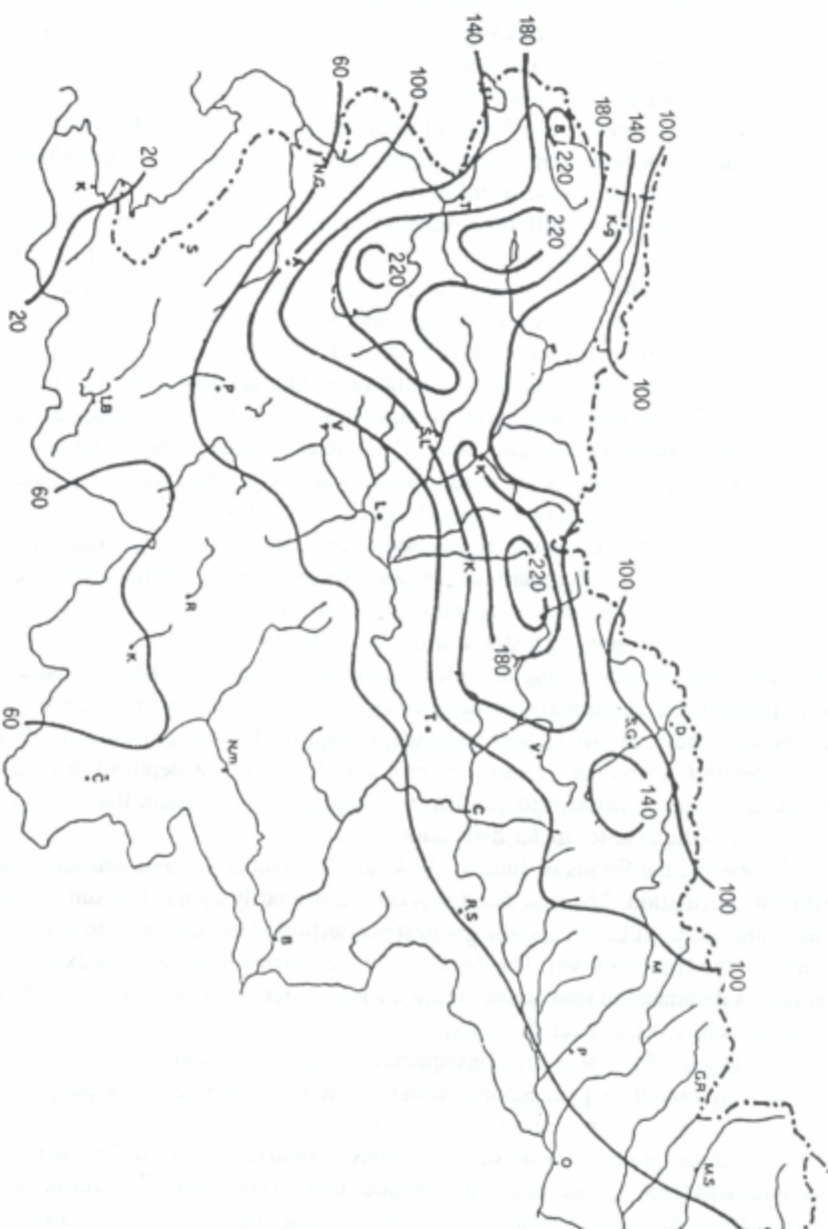


Fig. 4: Precipitation levels recorded at 7:00 a. m. on November 1 and 2, 1990 (P r i s t o v, 1991).
Slika 4: Množine padavin, zabeležene 1. in 2. novembra 1990 ob 7.00.

coincide, since we have no reliable geoecological justification for this belief (N a t e k, 1992a).

The floods of 1990 also led to further discussions on the function of flood plains as natural reservoirs. These studies of the flood plains of Slovenia again pointed out very clearly that flood plains have a very important function as natural reservoirs for flood waters of quite large capacity. In older times, man recognized their function of mitigating the effects of floods and adapted his own use of the land to this primary function.

Before the extensive regulation works on the Savinja River (1876–1893) and its tributaries (Ložnica 1953–1964, Trnavca 1959–1968, and Bolska 1964–1968), there were about forty square kilometers of flood plain in the Lower Savinja Valley. Along the Savinja River in particular, there were about twenty square kilometers of flood plain, mainly on the left bank between Šempeter and Celje. Some villages in this area (Zgornje Roje, Spodnje Roje, Vrbje) were exposed to periodic flooding, but most of the flood plain was left to meadows, pastures, and forest (N a t e k, M., 1979).

After the regulation works and especially in recent decades, urbanization and intensive agriculture encroached upon this flood plain, which seemed satisfactorily protected by the dike along the river bank. This contributed a great deal to the damage caused by the flood of 1990 and also limits the possibility of reestablishing a natural reservoir for flood waters which could protect Celje much more effectively than the classic multipurpose reservoirs in the source areas of the Savinja River and its tributaries (N a t e k, 1992a; V o d n o g o s p o d a r s k i inštitut, 1993).

According to the latest studies, about fifteen square kilometers of flood plain in the Lower Savinja Valley should be reserved for the retention of extremely high flood waters which exceed the discharge capacity of the Savinja riverbed at Celje. With the proper management of retention basins, it would be possible to reduce the 100-year peak of flood water discharge at Celje from 1318 to 1116 cubic meters per second, which seems sufficient to protect Celje from future disasters.

The difficult realization of this goal in the densely populated Lower Savinja Valley with its intensive production of hops and critical pressures on space due to projects of national importance such as the new motorway, irrigation, flood protection, etc., is beyond the scope of geoecological research.

CONCLUSION

In 1992, with the devastation of 1990 and the findings of geoecological investigations in mind, the Ministry of Environment and Planning started a new project of flood protection in the Lower Savinja Valley with emphasis on the city of Celje. This project can be considered the most important result of geoecological research, in which the contribution of geographers played a significant role. It could be the beginning of a new era of water management in accordance with and not counter to natural processes, but we must wait for its realization.

The mitigation of the consequences of the last disaster is still proceeding in the classic fashion with the construction of additional dams and other defensive measures only. In many cases, this is simple necessity for which we can not blame the water management authorities alone. It is simply the burden of a past when man made many serious mistakes in dealing with natural processes in the mistaken belief of his superiority and ability to dominate natural forces.

The major investigations following the floods of November 1, 1990, and the application of some of the conclusions of geoecological research could be considered a positive sign, but large-scale intervention in the practice of building on flood plains is still missing. This is partially due to lack of money but mostly due to the fact that the catastrophe of 1990 is already disappearing from the memory of a public which does not understand the nature of the disaster and has not been properly prepared to manage and mitigate floods and their damage (G a m s, 1991).

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GEOEKOLOŠKE RAZISKAVE POSLEDIC KATASTROFALNIH POPLAV 1. NOVEMBRA 1990 V POREČJU SAVINJE IN NJIHOV DELEŽ PRI PREPREČEVANJU PRIHODNJIH KATASTROF

Povzetek

Tragične posledice katastrofalnih poplav 1. novembra 1990 so bile kruta izkušnja za vse strokovnjake, ki se ukvarjajo s poplavami. Naravna katastrofa nam je dala izjemno priložnost, da se znebimo lažnih občutkov varnosti in superiornosti nad naravo. V prihodnjih desetletjih bomo lahko videli, če smo izkoristili to priložnost.

Dejstvo je, da so bile te poplave veliko presenečenje za ljudi, ki živijo v porečju Savinje, zlasti v Celju. Prevladalo je prepričanje, da bodo protipoplavni ukrepi, ki so jih izvedli po katastrofalnih poplavah 5. junija 1954, za vedno rešili Celje pred poplavami. Strugo Savinje so poglobili in razširili, njene pritoke (Ložnico, Sušnico in Koprivnico) združili v enotni kanal, regulirali Hudinjo in Voglajno ter zgradili nasip vzdolž levega brega Savinje. Ta nasip, ki so ga potegnili tudi ob Ložnici navzgor, naj bi varoval Celje pred 300-letnimi poplavami Savinje, regulacije Hudinje, Voglajne in skupni kanal pa naj bi zaščitili mesto pred podobnimi poplavami kot je bila 1954. leta. To je edina razlaga za popolno neupoštevanje možnosti ponovne poplave, kar je bistveno povečalo škodo v mestu (npr. namestitev dragocenih medicinskih naprav v kletnih prostorih celjske bolnišnice).

Katastrofalne posledice poplav 1. novembra 1990 so proučevali številni raziskovalci iz različnih strok, med katerimi so viden prispevek dali tudi geografi. Že takoj po katastrofi so nekateri geografi opozorili javnost, da je velik delež h katastrofi prispeval človek (G a m s, 1990; N a t e k, 1990). Podrobnejše raziskave so kasneje potrdile hipotezo o velikem deležu človeka pri teh poplavah. Ker v zadnjih nekaj desetletjih ni bilo večjih poplav, so se na poplavnih območjih gradila stanovanjska naselja, tovarne in prometnice, ki jih je nemogoče povsem zaščititi zaradi hudourniškega značaja poplav Savinje.

Tri leta po katastrofalnih poplavah je čas, da se vprašamo, ali so bili rezultati geoekološkega proučevanja koristno uporabljeni pri sanaciji posledic poplav ali ne.

V Gornji Savinjski dolini so bili plazovi in blatni tokovi glavna značilnost katastrofe, ki so poleg poplav vzdolž Savinje tudi povzročili največ škode. Pojav številnih majhnih zemeljskih plazov na strmih pobočjih, še posebej v neprepustnih andezitnih tufih, lahko neposredno povežemo s človekovimi posegi v labilno plast preperelíne na pobočjih.

Pravo presenečenje so bili veliki zemeljski plazovi, zlasti v naseljih Raduha (slika 1) in Podveži (slika 2). Prvi plaz se je pojavil na popolnoma istem mestu kot podoben plaz pred nekaj stoletji, terensko proučevanje pa je razkrilo še večji fosilni plaz v neposredni bližini. Nasprotno pa se je plaz v Podveži sprožil na pobočju, kjer ni bilo opaziti starejših zemeljskih plazov. Na pojav takšnih plazov človek ne more vplivati s svojim delovanjem, pač pa so se starejše naselbine (samotne kmetije na pobočjih in vasi v dolinah) izognila kritičnim mestom, medtem ko so plazovi uničili nekaj novih zgradb.

V goratem svetu Gornje Savinjske doline so vršaji veljali kot najprimernejša mesta za poselitev in obdelovalne površine. To drži za starejše pleistocenske vršaje, medtem ko so bili recentni vršaji močno prizadeti zaradi hudournikov in blatnih tokov, ki so pridrveli po grapah navzdol v glavno dolino. V neposeljenih grapah je bilo malo škode, na vršajih pa so si ljudje, odrezani od tradicionalnega geoekološkega znanja, ki se je posredovalo iz roda v rod prek ustnega izročila, zgradili domove točno na poti blatnih tokov.

Tudi gradbeniki niso pri sanaciji poškodb na cestah upoštevali opozoril, da so majhne grape na strmih pobočjih pravzaprav nevarni hudourniki in poti blatnih tokov. Posledica tega neupoštevanja je gradnja enako neprimernih prepustov, kot so jih gradili pred katastrofo.

V Spodnji Savinjski dolini se je ob poplavah novembra 1990 jasno pokazalo, da je gradnja družinskih hiš, tovarn, skladišč ipd. na poplavnem svetu zelo tvegana in bi se ji morali odpovedati. Nagla urbanizacija poplavnega sveta je po eni strani posledica nizke cene zemljišč, po drugi strani pa popolno pomanjkanje geoekološkega znanja pri lastnikih in uradnikih. Opozoril vodnega gospodarstva se ni upoštevalo, tako da je bilo vodno gospodarstvo omejeno na pasivno protipoplavno zaščito (R a j a r, 1991).

Velik delež škode v Spodnji Savinjski dolini lahko pripišemo tudi regulaciji Savinje (1876–1893), s katero so neukrotljiv hudournik, ki prenaša s seboj velike množine proda, obdali s tesnimi nasipi vzdolž obeh bregov. Zaradi teh nasipov se je ob poplavi močno povečala hitrost vodnega toka, akumulacija proda pa je bila omejena na rečno strugo. S tem si je Savinja med Letušem in Dolenjo vasjo poglobila strugo za 1 do 3 m, ob tem pa spodjedla protipoplavne jezove, mostove in nasipe.

V spodnjem toku, med Dolenjo vasjo in Celjem, se je akumulacija proda in drugega materiala povečala, kar je po eni strani zmanjšalo pretočno kapaciteto struge, po drugi strani pa se je hitreje tekoči vodi povečala erozijska moč, tako da je prebila nasipe tik nad Celjem in opustošila mesto. Kapaciteta struge v Celju se je še dodatno zmanjšala zaradi drevja in vejevja, ki se je nabralo na opornikih mostov in zamašilo pretoke, tako da se je gladina Savinje dvignila za okrog 1 m.

Primerjava med poplavo 5. junija 1954 in 1. novembra 1990 je pripeljala do še ene usodne špekulacije. Prva poplava je nastala prvenstveno zaradi obsežne poletne nevihte v hribovju severno od Celja, tako da je največ škode v Celju povzročila Hudinja. Druga poplava je bila posledica dolgotrajnejšega jesenskega deževja v Kamniško–Savinjskih Alpah. Če bi segal pas teh padavin kakšnih 20 km bolj proti vzhodu, bi zajel tudi hribovja v neprepustnih kamninah v povirju Pake in Hudinje. Sovpadanje poplav Savinje in Hudinje bi bilo za Celje še bolj usodno, zelo nevarno pa se je zanašati na verjetnost, da se ob prihodnji poplavi to ne bo zgodilo.

Poplave 1990 so sprožile tudi razpravo o funkciji poplavnih območij kot naravnih zadrževalnikov poplavne vode, kar je bila nekoč ena njihovih poglavitnih funkcij. Ponovna vzpostavitev naravnega zadrževalnika ob Savinji nad Celjem se je v novejših raziskavah izkazala učinkovitejša kot gradnja večnamenskih zadrževalnikov v povirnih delih Savinje in njenih pritokov. Po tem projektu bi za zadrževanje poplavne vode rezervirali okrog 15 km^2 poplavnega sveta v Spodnji Savinjski dolini. S pravilnim ravnanjem bi lahko zmanjšali 100-letno poplavno vodo z dosedanjih 1318 m^3/sek na 1116 m^3/sek, kar bi zadoščalo za preprečitev prihodnjih poplav v Celju.