I. del: PREGLED HIDROLOŠKIH RAZMER V LETU 2003

Part I: A REVIEW OF HYDROLOGICAL CONDITIONS IN THE YEAR 2003

A. POVRŠINSKE VODE

VODOSTAJI IN PRETOKI REK

Mojca Sušnik

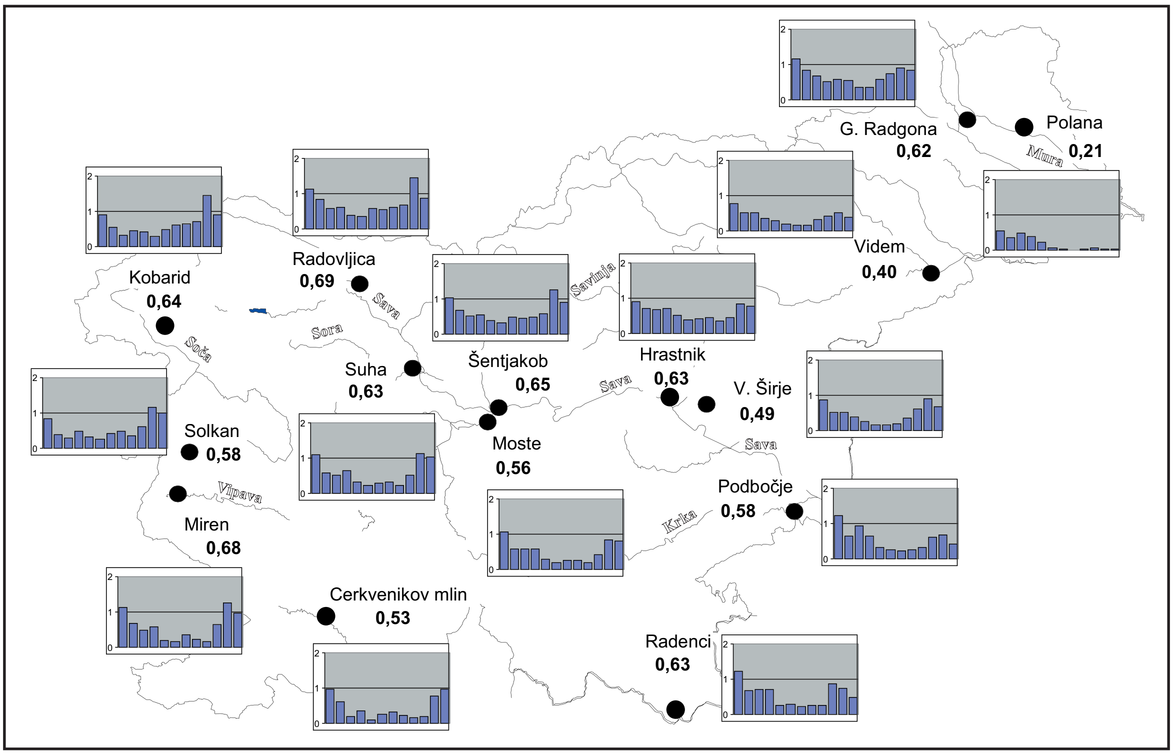
Leto 2003 je bilo zelo suho. V Sloveniji je preteklo malo nad petdeset odstotkov vode glede na povprečni pretok tridesetletnega primerjalnega obdobja 1971-2000. Bolj vodnata so bila porečja zahodne, osrednje in južne Slovenije. Večinoma je vodnatost rek upadala od začetka leta pa do konca junija, ponekod do konca avgusta, z manjšim povišanjem v aprilu. Na Krki in rekah skrajnega severovzhoda Slovenije so se pretoki nekoliko povečali že v marcu. Poletne nevihte, zlasti v Alpskem svetu, so prispevale k manjšemu dvigu rečnih gladin s povirjem v tem delu. Kljub temu so reke na zahodu ostale pod srednjimi pretoki do novembra, na vzhodu pa celo vse do konca leta. Sušne razmere so bile

A. SURFACE WATERS

WATER LEVELS AND DISCHARGES OF RIVERS

Mojca Sušnik

The year 2003 was a very dry year. Slightly over fifty percent of the water flowed through Slovenia in comparison with the mean discharge of the thirty-year reference period of 1971-2000. The western, central and south Slovenian river basins were most abundant in terms of water discharges. In most cases, the water quantities in rivers were diminishing from the beginning of the year until the end of June and in some places until the end of August with a slight increase in April. Discharges on the Krka River and the rivers in the remote north-eastern part of Slovenia increased somewhat already in March. Summer storms, particularly in the Alpine world, contributed to a slight water level rise in rivers that

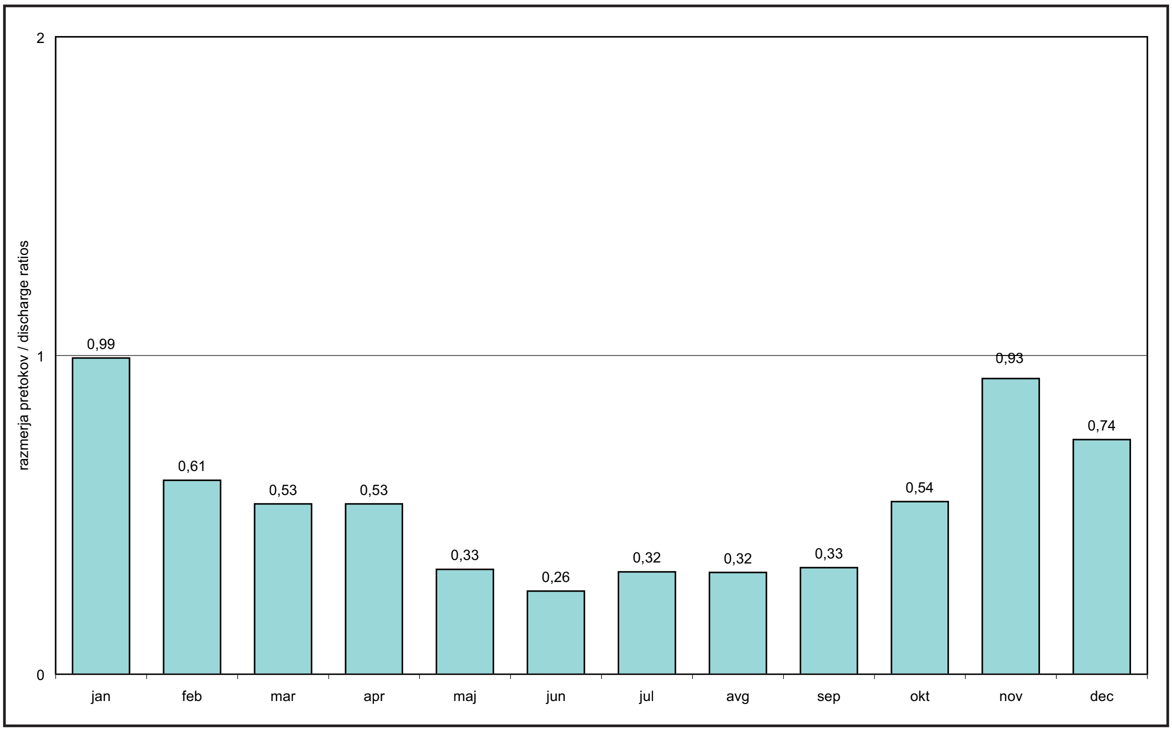


Karta 1: Razmerja med srednjimi letnimi pretoki leta 2003 in obdobja 1971-2000 ter grafični prikazi razmerij med srednjimi mesečnimi pretoki leta 2003 in obdobja 1971-2000. Vrednost razmerja 1 pomeni enak pretok leta 2003 kot v povprečju dolgoletnega obdobja.
Map 1: Ratios between mean annual discharges in 2003 and the 1971-2000 period, and graphic representations of ratios between mean monthly discharges in 2003 and the 1971-2000 period. The ratio value of 1 means that the discharge in 2003 was the same as the multi-annual mean.

najbolj izrazite v severovzhodni Sloveniji (z izjemo Mure), kjer so reke dosegle le okoli dvajset odstotkov povprečnega letnega pretoka (karta 1).

V povprečju so bili mesečni pretoki vse leto manjši kot v tridesetletnem obdobju. Od maja do septembra so imeli izbrani vodotoki glede na dolgoletno povprečje v posameznih mesecih le okoli 30

have headwaters in this region. Nevertheless, rivers in the west remained under the mean discharges until November and, in the east even until the end of the year. Drought conditions were most prominent in north-eastern Slovenia (with the exception of the Mura River) where rivers reached only twenty percent of the mean annual discharge. (see Map 1).



Graf 5: Razmerja med srednjimi mesečnimi pretoki v letu 2003 in obdobnimi srednjimi mesečnimi pretoki. Razmerja so izračunana kot povprečja razmerij na izbranih postajah (karta 1).
Graph 5: Ratios between the mean monthly discharges in 2003 and the multi-annual mean monthly discharges. Ratios are calculated as average values of ratios at selected stations (see Map 1).

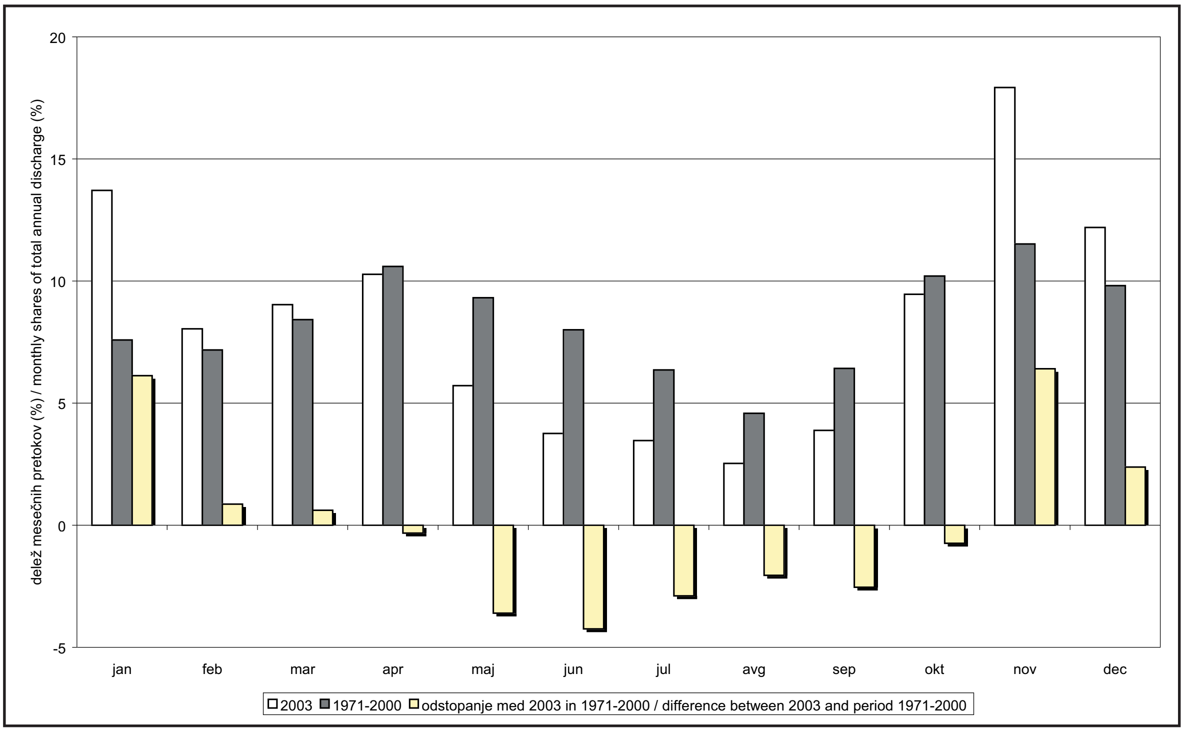
odstotni pretok. V juniju, ko so bili najnižji, so imeli le okoli četrtine običajne vrednosti (graf 5).

Deleži mesečnih pretokov, glede na celoletno količino pretokov, so bili v januarju ter novembru precej večji kot v obdobju 1971-2000, le malo večji so bili tudi februarja, marca in še nekoliko bolj decembra. Od aprila do oktobra so bili deleži pretokov manjši od običajnih značilnih za obdobje 1971-2000. Najmanjši delež, v primerjavi z obdobjem, je bil zabeležen v juniju (graf 6).

Deleži mesečnih pretokov so bili izrazito večji od običajnih januarja in novembra, izrazito manjši pa od maja do oktobra. November, običajno najbolj vodnat mesec, je bil tak tudi v letu 2003, ko je bil delež mesečnega pretoka kar za 6,4 odstotkov večji od običajnega. Odstopanje od ustaljenih reži-

On average, the monthly discharges throughout the year were lower than the multi-annual means of the thirty-year reference period. From May until September, selected watercourses only had around 30 percent of discharges compared with the multi-annual means for individual months. In June when discharges were the lowest, they only contained approximately one quarter of their mean values (see Graph 5).

The percentage shares of monthly discharges in comparison with the annual discharges were considerably higher in January and November than in the 1971-2000 period and only slightly higher in February and March, and in December even slightly higher than that. From April to October, the shares of discharges were lower than those characteristic of the 1971-2000 period. The lowest percentage share



Graf 6: Delež mesečnih pretokov v odstotkih glede na celotno količino pretokov v letu 2003 in obdobju 1971-2000 za izbrane postaje. Na grafu je podano tudi odstopanje deležev mesečnih pretokov v letu 2003 od deležev v obdobju 1971-2000 za izbrane postaje (karta 1).
Graph 6: The share of monthly discharges in percentages with respect to the total quantity of discharges in 2003 and in the 1971-2000 period for selected stations. The graph also shows the deviation of shares of monthly discharges in 2003 from the shares in the 1971-2000 period for the selected stations (see Map 1).

mov se kaže tudi v izredno nizkem deležu pretokov v juniju, ko je znašal komaj polovico običajnega.

Odstopanja od ustaljenih režimov rek so bila v zahodnem delu države velika novembra, v severovzhodnem delu Slovenije pa v marcu. Pretočni režim v letu 2003 je najmanj odstopal od ustaljenega (obdobje 1971-2000) na Muri, na Savi v Hrastniku ter Kolpi v Radencih (karta 2).

Visokovodne konice, ob katerih so reke le redko poplavljale, so bile večinoma novembra. Največje hudourniške poplave so bile v letu 2003 konec avgusta v Kranjski Gori in Ratečah zaradi česar je Sava Dolinka na Jesenicah dosegla 20- letno povratno dobo pretoka.

Leto 2003 je bilo četrto leto zapored, ko so bile sušne razmere bolj izrazite kot navadno. Najmanjši pretoki so bili zabeleženi v avgustu. Na več merilnih mestih mreže vodomernih postaj so bili tedaj zabeleženi najmanjši pretoki v opazovalnem obdobju. Pretoki rek v južni in ponekod v osrednji Sloveniji so dosegli 10-letno povratno dobo malih pretokov, Ščavnica, Pesnica, Savinja, Sotla in Sava v spodnjem delu pa so dosegle 20- do 50-letno povratno dobo. Podrobneje so visokovodne in sušne razmere v letu 2003 opisane v drugih poglavjih.

in comparison with the reference period was recorded in June (see Graph 6).

The percentage shares of monthly discharges were considerably higher than the normal percentage shares in January and November and considerably lower than those from May to October. November, normally having the highest discharges, remained as such also in 2003 when the percentage share of monthly discharges was by as much as 6.4 percent higher than usual. Deviations from the normal river regimes are also reflected in the considerably low share of discharges in June when the share barely reached one half of the normal quantity.

Deviations from the normal river regimes were high in the western part of the country in November and in the north-eastern part in March. The discharge regime in 2003 deviated the least from the normal regime (1971-2000 period) on the Mura River, the Sava River in Hrastnik and the Kolpa River in Radenci (Map 2).

High water peaks, during which the rivers rarely flooded, occurred mainly in November. The largest torrential floods occurred in 2003 at the end of August in Kranjska Gora and Rateče, due to which the Sava Dolinka River in Jesenice achieved a 20-year discharge return period.

Časovni pregled hidroloških razmer na rekah v posameznih mesecih leta

V začetku januarja so se na slovenskih rekah še poznali nekoliko nadpovprečni pretoki iz decembra 2002, predvsem zaradi njihovega povišanja konec meseca. Januarja so se pretoki do 22. oz. 23. zmanjševali, potem pa naglo narasli, tako da je večina rek dosegla največje pretoke v mesecu. Nato so do konca januarja reke ponovno upadale, večina pod srednje januarske pretoke. Izjeme so bile Mura, Drava in Krka v spodnjem toku, ki so imele konec januarja pretoke še vedno večje od srednjih mesečnih pretokov obdobja 1971-2000.

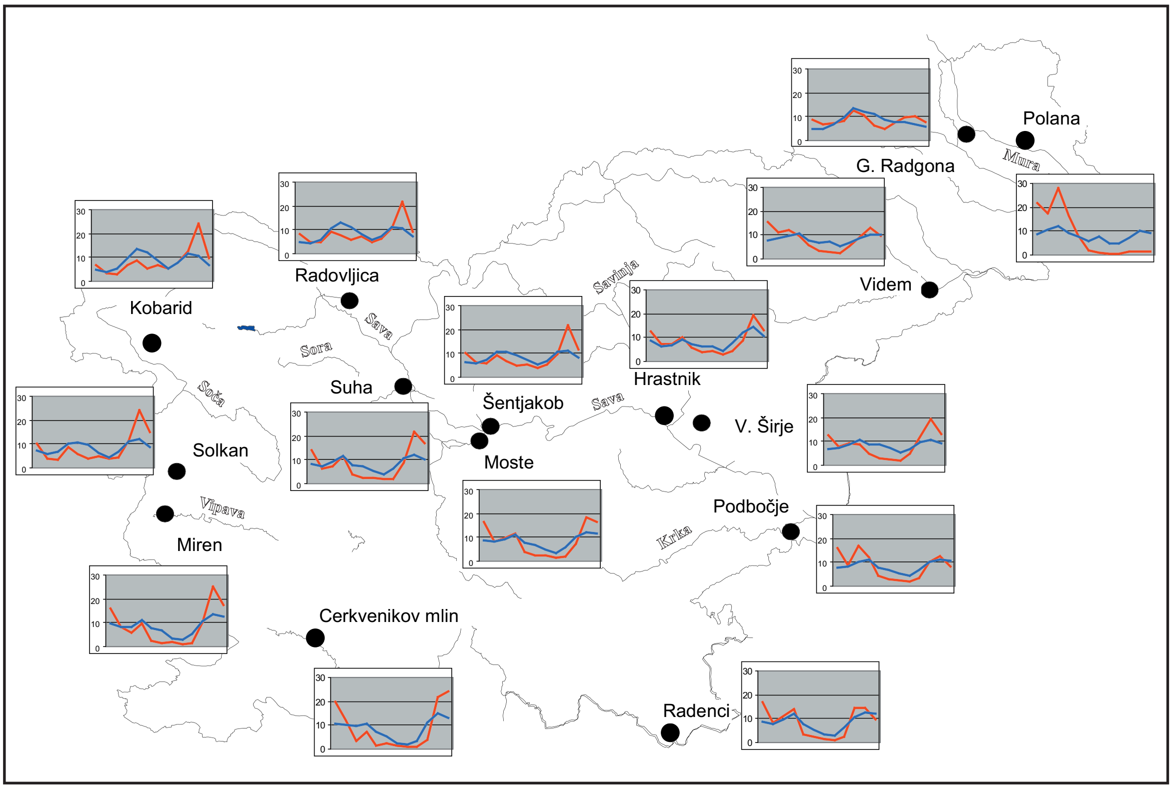
Februarja so reke v južni in jugozahodni Sloveniji, med 4. in 6. februarjem, Krka pa 8. februarja, narasle preko srednjih februarskih pretokov. Porasti pretokov rek drugod po Sloveniji so bili manjši. Pretoki so v povprečju dosegali 61 odstotkov običajnih pretokov v tem mesecu.

Marec se je začel s porastom rek, izjeme so bile Soča in Sava v zgornjem toku, Drava in Reka. Poleg rek južne in severovzhodne Slovenije sta le še Drava in Dravinja v tem mesecu za kratko presegli srednji pretok.

2003 was the fourth consecutive year, in which drought conditions were more prominent than usual. The lowest discharges were recorded in August. At the majority of the water gauging stations in the hydrological station network, the all time low discharges in the observation period have been recorded at that time. River discharges in the south and in some places in central Slovenia reached a 10-year return period of small discharges whereas the rivers Ščavnica, Pesnica, Savinja, Sotla and Sava in their downstream sections reached from 20- to 50-year return periods. High water and drought conditions in 2003 are described in more detail in other chapters.

Timeline of hydrological conditions on rivers in individual months of the year

In the beginning of January, Slovenian rivers still exhibited slightly above-average discharges from December 2002, primarily due to their increase at the end of the month. In January, discharges decreased until the 22nd or 23rd and then rapidly increased when the majority of the rivers reached maximum discharges for the month. Afterwards, the river discharges were again decreasing until the end of January, most of them to below the mean January discharges. Exceptions were the rivers Mura, Drava and Krka in their downstream sections. At the end of



Karta 2: Delež mesečnih pretokov v letu 2003 (rdeče linije) in v obdobju 1971-2000 (modra linija) kot ponazoritev odstopanj od ustaljenih režimov pretokov rek v letu 2003.
Map 2: The share of monthly discharges in 2003 (red lines) and in the 1971-2000 period (blue line) as an illustration of deviations from normal regimes of river discharges in 2003.

Hidrometrična meritev na vodomerni postaji Škocjan na Radulji ob nizkem vodostaju.
(foto: Marko Burger, 28. april 2003)
Current meter measurement of the low Radulja stream at Škocjan.
(photo: Marko Burger, 28 April, 2003)

V aprilu so reke dvakrat do trikrat narasle do srednjih in ponekod do velikih pretokov, vendar pa so bili pretoki večji del meseca mali. V aprilu so bili pretoki v povprečju pol manjši od običajnih.

Maja se je hidrološka suša stopnjevala. Po koritih slovenskih rek je pretekla le tretjina običajne majske količine voda. Povprečni mesečni pretoki rek so bili v večini primerov manjši od najmanjših vrednosti v dolgoletnem primerjalnem obdobju.

Junijski pretoki rek so dosegli le tretjino običajnih (karta 3). Pretoki rek so se večji del meseca zmanjševali, ob koncu meseca pa prehodno povečali. Razen Drave in Soče srednji dnevni pretoki rek niso presegli povprečnih malih pretokov iz obdobja 1971-2000.

Tako julija kot tudi avgusta se je nadaljevalo obdobje hidrološke suše. Ob poletnih nevihtah so se pretoki za kratek čas le občasno povečali (graf 7). Srednji mesečni pretoki so bili manjši od tridesetletnega povprečja, srednji dnevni pretoki so bili večino časa manjši tudi od srednjih malih pretokov. V povprečju so pretoki dosegali le tretjino običajnih pretokov meseca julija in avgusta. Mnoge reke, zlasti v severovzhodni in jugovzhodni Sloveniji, so dosegle ali pa se zelo približale najnižjim zabeleženim pretokom.

Večmesečna hidrološka suša se je nadaljevala še v septembru. Srednji mesečni pretoki so bili septembra v povprečju še vedno le tretjino običajnih. Še bolj poglobljeno hidrološko sušo so omilile

January, their discharges were still higher than the mean monthly discharges of the 1971-2000 period.

In February, the rivers in the southern and south-western Slovenia rose above the mean February discharges between 4 and 6 February and the Krka River on 8 February. Discharge increases of rivers elsewhere in Slovenia were lower. The discharges have on average reached 61 percent of the ordinary discharges for the month.

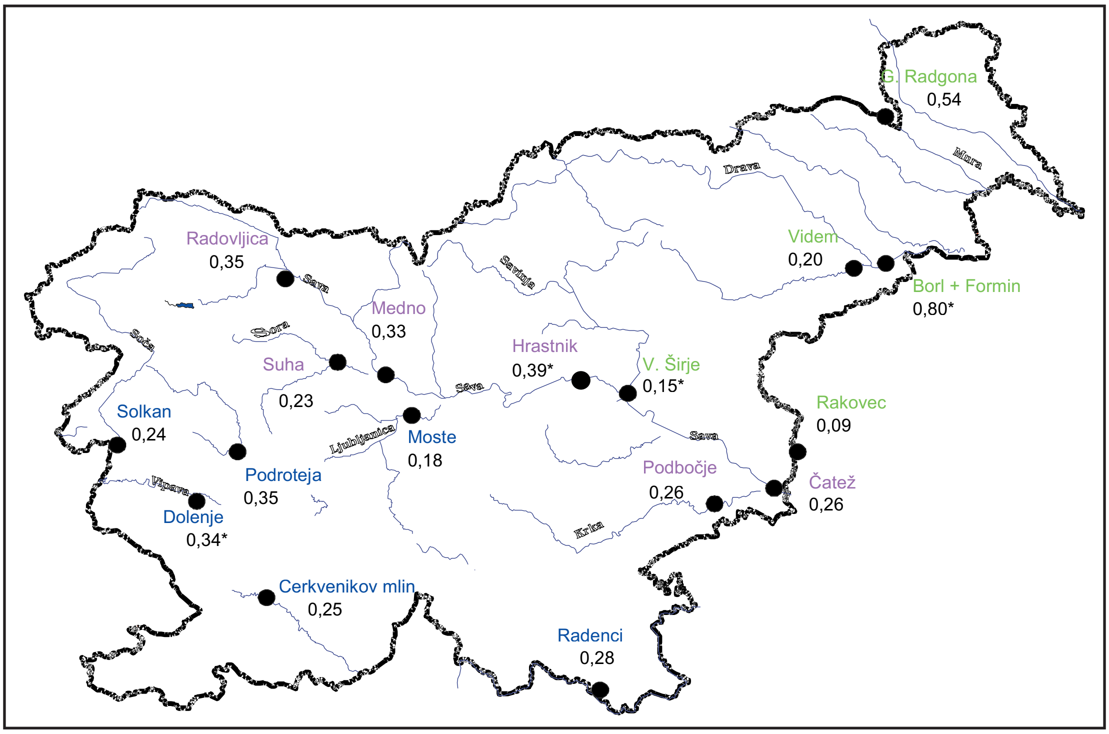
March began with an increase in river discharges, exceptions to this were the rivers Soča and Sava – in their upstream parts, and the Drava and Reka. In addition to the rivers in the southern and south-eastern parts of Slovenia, only the rivers Drava and Dravinja in that month exceeded for a short while the mean March discharge of the 1971-2000 period.

In April, the rivers rose on two or three occasions to the mean and somewhere to the high water discharges, however, discharges were low for the greater part of the month. In April, discharges were on average by a half lower than usual.

In May, the hydrological drought intensified. The total discharge of Slovenian rivers reached only a third of the ordinary water quantity for the month of May. The average monthly river discharges were in the majority of cases lower than the lowest values in the multi-annual reference period.

The river discharges in June reached only a third of the ordinary discharges (Map 3). The river discharges were decreasing for the greater part of the month and increased transitionally at the end of the month. Except for the rivers Drava and Soča, the mean daily river discharges did not exceed the mean low discharges of the reference period.

In July as well as August, hydrological drought continued. During summer storms, discharges only occasionally increased for a brief period (see Graph 7). The mean monthly discharges were lower than the multi-annual mean, the mean daily discharges were lower than the mean low discharges for the majority of the time. On average, discharges reached only a third of the ordinary discharges for the months of July and August. Many rivers, especially in the north-eastern and south-eastern parts of Slovenia, reached or considerably drew closer to the lowest recorded discharges.



Karta 3: Razmerja med srednjimi pretoki junija 2003 in povprečnimi srednjimi junijskimi pretoki v obdobju 1971-2000 (*krajše obdobje) na slovenskih rekah.
Map 3: The ratios between mean discharges in January 2003 and the average mean discharges on Slovenian rivers in June in the 1971-2000 period (*shorter period).

manjše padavine v začetku, sredi in ob koncu septembra.

Večmesečna suša se je nadaljevala tudi še v oktobru, ki pa je bil že nekoliko bolj vodnat. Pretoki rek so v povprečju dosegli 54 odstotkov običajnih pretokov v tem mesecu. Po padavinah v začetku oktobra je večina rek dosegla mesečne največje pretoke, kar so bili srednji oz. veliki pretoki glede na tridesetletno obdobje 1971-2000.

Novembra so bili pretoki rek v povprečju običajni za ta letni čas. Nekoliko manjši so bili pretoki rek v severovzhodni Sloveniji in nekoliko večji v severozahodni Sloveniji. V novembru sta bili dve visokovodni konici, prva v začetku in druga konec meseca, kot kaže primer na vodomerni postaji Hrastnik (graf 8). To so bile v večini primerov letne konice.

Tudi december je bil hidrološko suh mesec. V povprečju je bilo 26 odstotkov manj vode kot navadno v tem mesecu. December se je začel z dokaj velikimi pretoki rek, ki pa so se zmanjševali do konca druge dekade meseca. Sledila sta dva porasta pretokov, od katerih je bil drugi večji.

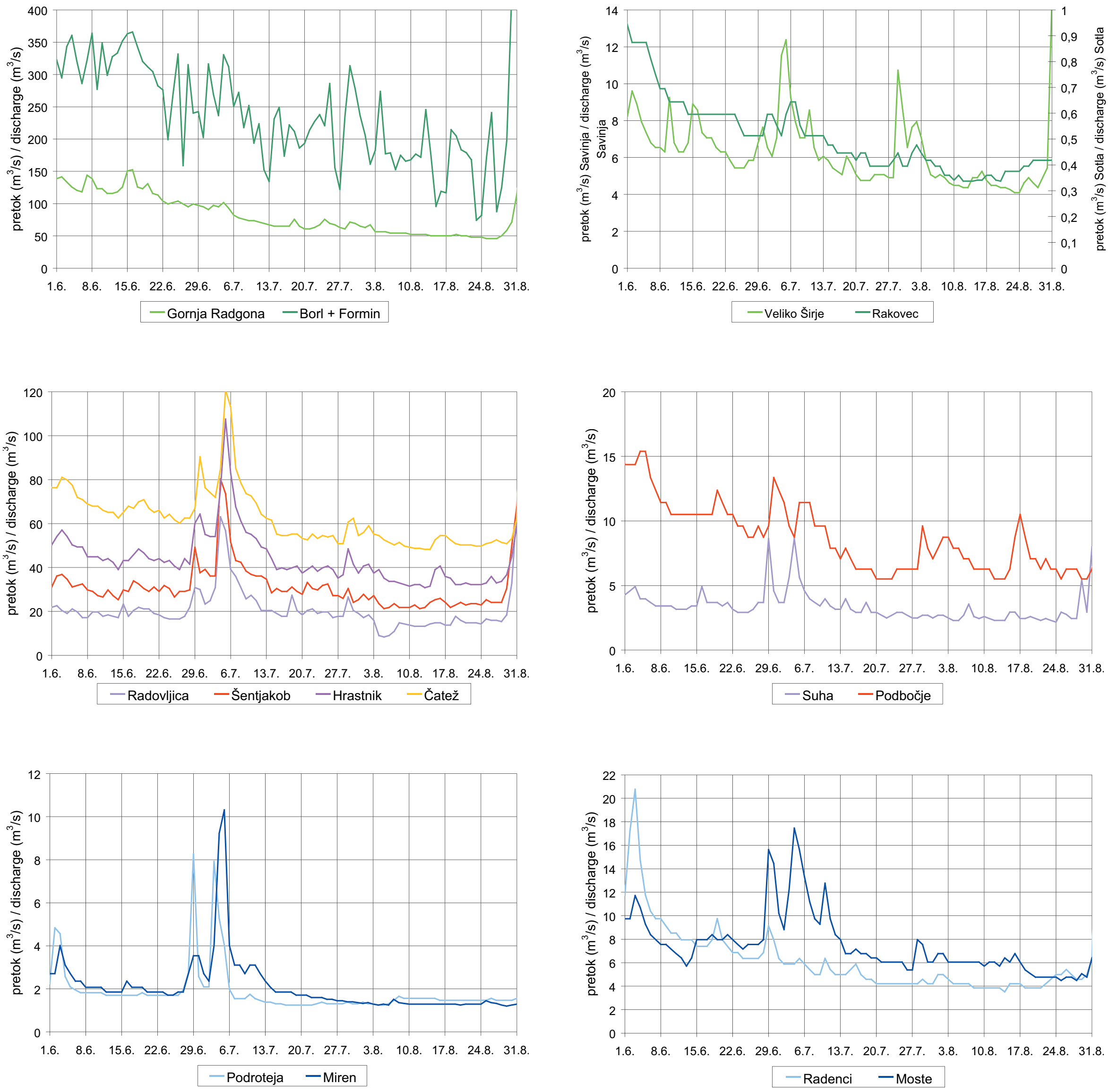
Podrobneje so hidrološke razmere na rekah v letu 2003 opisane v Mesečnih biltenih Agencije Republike Slovenije za okolje.

The hydrological drought of several months continued in September. The mean monthly discharges in September on average still represented only a third of the ordinary discharges. An even more pronounced hydrological drought was mitigated by low amounts of precipitation in the beginning, middle and end of September.

A drought lasting several months also continued in October, which however had slightly more water. River discharges have on average reached 54 percent of the ordinary discharges for the month. Following the precipitation in the beginning of October, the majority of the rivers reached the highest discharges of the month being in the range between the mean and high discharges of the 1971-2000 reference period.

In November, river discharges were on average usual for the season. River discharges were slightly lower in north-eastern Slovenia and slightly higher in north-western Slovenia. In November, there were two high water peaks – the first at the beginning and the second at the end of the month as is shown for example at the Hrastnik water gauging station (Graph 8). In the majority of the cases, these represented maximums for the year 2003.

December was also a hydrologically dry month. On average, discharges were by 26 percent



Graf 7: Pretoki rek v juniju, juliju in avgustu 2003 so le redko narasli.
Graph 7: River discharges in June, July and August 2003 only rarely increased.

Primerjava značilnih pretokov v letu 2003 z značilnimi pretoki v primerjalnem obdobju 1971-2000

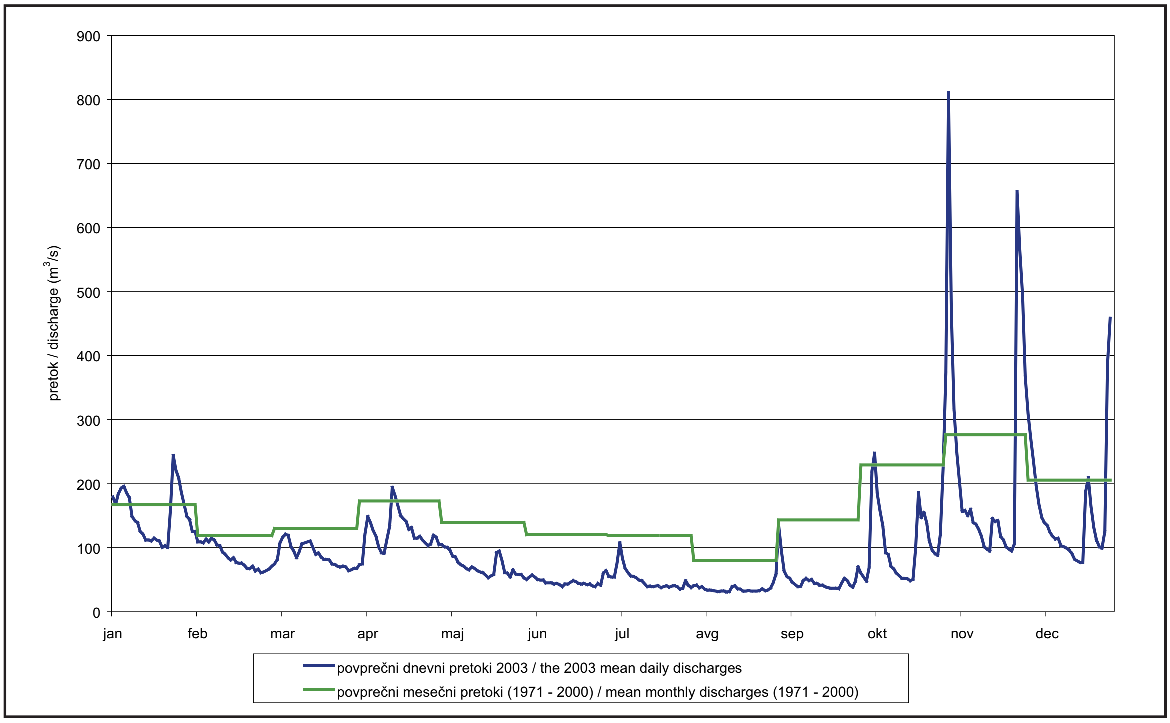
Najmanjši pretoki v letu 2003 so bili v povprečju približno štirideset odstotkov manjši kot v primerjalnem dolgoletnem obdobju. Pretoki rek so bili v glavnem najmanjši v avgustu. Krka v Podbočju je imela najmanjši pretok v juliju, Soča v Kobaridu pa že marca (preglednica 1). Najmanjši pretoki so bili v severovzhodni Sloveniji, kjer so bili pod dvajsetimi odstotki srednjih najmanjših pretokov iz obdobja 1971-2000. Pretok Ledave v Polani je dosegel le en odstotek povprečnega malega pretoka iz tridesetletnega obdobja. Mnogo vodotokov v Prekmurju je tudi presahnilo. V jugovzhodni Sloveniji

lower than usual in this month. December began with rather high river discharges, which however decreased by the end of the second third of the month. This was followed by two increases in discharges, of which the second was higher.

Hydrological conditions on rivers in 2003 are described in more detail in the Monthly Bulletins of the Environmental Agency of the Republic of Slovenia.

Comparison of characteristic discharges in 2003 and the characteristic discharges in the 1971-2000 reference period

The **lowest discharges** in 2003 were on average around forty percent lower than in the ref-



Graf 8: Srednji dnevni pretoki v letu 2003 in srednji mesečni pretoki v dolgoletnem obdobju 1971-2000 na reki Savi v Hrastniku.
Graph 8: Mean daily discharges in 2003 and mean monthly discharges in the 1971-2000 reference period on the Sava River at Hrastnik.

so mali pretoki rek dosegli okoli štirideset odstotkov običajnih malih pretokov. Nekoliko boljše so bile razmere le na Savi v Radovljici, kjer se pretok ni zmanjšal pod povprečni mali pretok.

Srednji letni pretoki rek so bili v povprečju okoli štirideset odstotkov manjši kot v dolgoletnem primerjalnem obdobju. Pretoki v severovzhodni Sloveniji so bili med najmanjšimi v primerjalnem obdobju. Srednji letni pretok Ledave v Polani je znašal le 21 odstotkov srednjega letnega pretoka dolgoletnega primerjalnega obdobja.

Nizek vodostaj na vodomerni postaji Podbočje na Krki.
(foto: Marko Burger, 28.april 2003)
Low water level at gauging station Podbočje on the Krka River.
(photo: Marko Burger, 28 April 2003)

erence multi-annual period. River discharges were in general the lowest in August. The Krka River in Podbočje exhibited the lowest discharge in July whereas the Soča River in Kobarid already reached its low discharge in March (Table 1). The discharges were lowest in north-eastern Slovenia with discharges below twenty percent of the mean low discharges for the 1971-2000 period. The discharge of the Ledava River in Polana only reached one percent of the mean low discharge of the reference period. Numerous watercourses in Prekmurje even dried up. In the south-eastern part of Slovenia, low river discharges reached around forty percent of the ordinary low discharges. The conditions were somewhat better only on the Sava River in Radovljica where the discharge did not fall below the mean low discharge.

Mean annual discharges were on average around forty percent lower than in the reference period. Discharges in north-eastern Slovenia were among the lowest in the reference period. The mean annual discharge of the Ledava River in Polana amounted to merely 21 percent of the mean annual discharge of the reference period.

Maximum discharges were also approximately thirty percent lower than in the reference period. Somewhat higher than usual were only the high-water peaks on the Drava River, on the Sava River in its upper- and midstream parts, on the Reka River at Cerkvenikov mlin and on the Soča River in Kobarid. All the other instances of annual maximum

Tudi **največji pretoki** so bili okoli tridest odstotkov manjši kot v dolgoletnem obdobju. Nekoliko večje kot navadno so bile le visokovodne konice na Dravi, na Savi v zgornjem in srednjem toku, na Reki pri Cerkvenikovem mlinu in na Soči v Kobaridu. Vsi ostali največji pretoki v letu so bili manjši od dolgoletnega povprečja največjih letnih pretokov. Pretoki so bili v veliki večini največji v zadnjih treh mesecih leta. Le reke v severovzhodni Sloveniji so imele največje pretoke že v aprilu. (preglednica 1).

discharges were lower than the multi-annual mean of maximum discharges. Discharges were for the most part the highest in the last three months of the year. Only the rivers in north-eastern Slovenia exhibited maximum discharges already in April (Table 1).

Preglednica 1: Značilni pretoki v letu 2003 in obdobju 1971-2000.
Table 1: Characteristic discharges in 2003 and in the 1971-2000 reference period.

Vodotok Stream	Vodomerna postaja Gauging station	Qnp 2003		nQnp	sQnp	vQnp
				1971-2000		
		m³/s	dan	m³/s	m³/s	m³/s
MURA	G. RADGONA	46.0	25.8.	45.3	62.1	81.7
DRAVINJA	VIDEM	0.48	30.8.	0.6	2.1	4.3
LEDAVA	POLANA	0.002	11.8.	0.004	0.1	0.5
SAVA	RADOVLJICA	8.4	5.8.	5.0	8.4	13.3
SAVA	ŠENTJAKOB	21.3	5.8.	19.1	27.1	35.3
SAVA	HRASTNIK	30.8	13.8.	32.8	45.6	62.2
SORA	SUHA	2.2	24.8.	2.14	3.8	5.3
LJUBLJANICA	MOSTE	4.5	25.8.	4.1	7.7	15.6
SAVINJA	V. ŠIRJE	4.1	23.8.	4.7	9.5	15.2
KRKA	PODBOČJE	5.5	20.7.	6.2	10.4	17.7
KOLPA	RADENCI	3.5	14.8.	3.5	5.8	9.1
REKA	CERKVENIKOV MLIN	0.25	1.8.	0.2	0.6	1.2
SOČA	KOBARID	6.4	11.3.	4.6	7.6	10.9
SOČA	SOLKAN	15.6	19.8.	9.6	19.6	29.3
VIPAVA	MIREN	1.2	29.8.	1.2	2	3.2

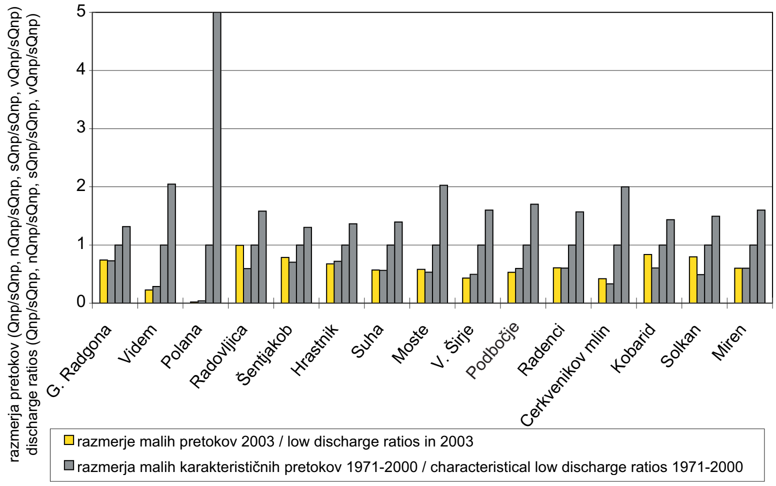
Vodotok Stream	Vodomerna postaja Gauging Station	Qs 2003	nQs	sQs	vQs
			1971-2000		
		m³/s	m³/s	m³/s	m³/s
MURA	G. RADGONA	95.5	103	153	221
DRAVINJA	VIDEM	4.46	5.9	11.2	20.7
LEDAVA	POLANA	0.25	0.47	1.2	2.1
SAVA	RADOVLJICA	29.8	30.4	43.1	53.8
SAVA	ŠENTJAKOB	55.1	61.2	85.1	104
SAVA	HRASTNIK	99.7	132	158	188
SORA	SUHA	12.2	13.5	19.3	24.4
LJUBLJANICA	MOSTE	31.3	35.7	55.6	72.5
SAVINJA	V. ŠIRJE	21.6	29.2	44	62.5
KRKA	PODBOČJE	30.3	31.7	51.9	78.6
KOLPA	RADENCI	31.9	35.1	50.7	65.6
REKA	CERKVENIKOV MLIN	4.1	4.3	7.8	12.1
SOČA	KOBARID	21.1	21.9	33.1	44.4
SOČA	SOLKAN	51.8	60.9	89.8	116
VIPAVA	MIREN	11.8	10.7	17.3	22.2

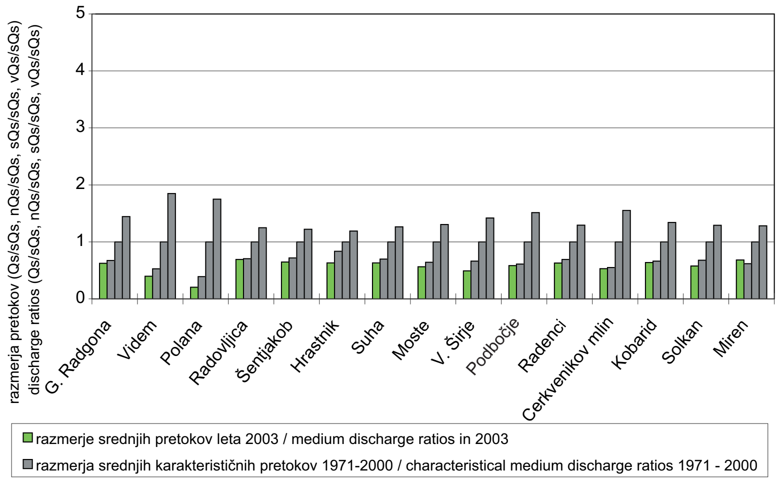
Vodotok Stream	Vodomerna postaja Gauging Station	Qvk 2003		nQvk	sQvk	vQvk
				1971-2000		
		m3/s	dan	m3/s	m3/s	m3/s
MURA	G. RADGONA	287	3.11.	273	735	1205
DRAVINJA	VIDEM	37.8	5.10.	71.1	151	291
LEDAVA	POLANA	2.3	11.4.	8	32.8	80.5
SAVA	RADOVLJICA	451	1.11.	208	411	687
SAVA	ŠENTJAKOB	951	2.11.	442	861	1422
SAVA	HRASTNIK	998	2.11.	786	1202	1668
SORA	SUHA	252	1.11.	147	329	687
LJUBLJANICA	MOSTE	243	27.11.	206	282	405
SAVINJA	V. ŠIRJE	262	5.10.	278	717	1490
KRKA	PODBOČJE	145	28.11.	217	289	356
KOLPA	RADENCI	371	30.10.	355	669	949
REKA	CERKVENIKOV MLIN	192	30.12.	83.3	182.6	305
SOČA	KOBARID	540	1.11.	237	438	664
SOČA	SOLKAN	721	1.11.	747	1391	2066
VIPAVA	MIREN	200	30.12.	143	240	319

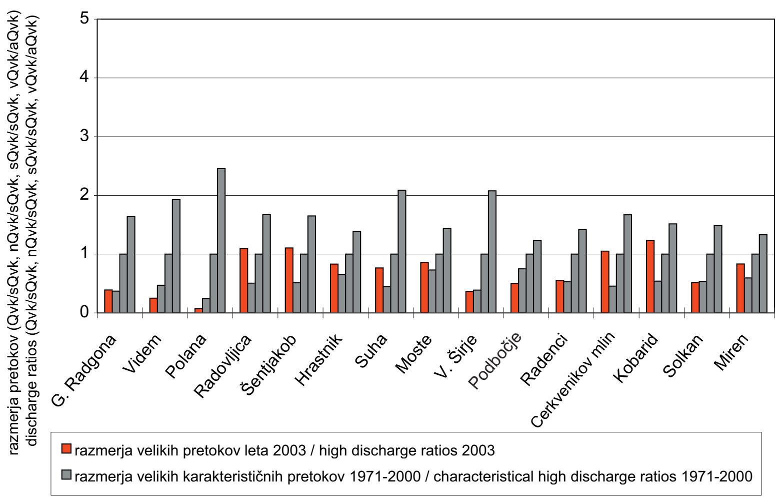
Qnp **najmanjši pretok v letu - dnevno povp.**
sQs srednji pretok v obdobju
nQnp najmanjši mali pretok v obdobju
vQs največji srednji pretok v obdobju
sQnp srednji mali pretok v obdobju
Qvk **največji pretok v letu - konica**
vQnp največji mali pretok v obdobju
nQvk najmanjši veliki pretok v obdobju
Qs **srednji pretok v letu - dnevno povprečje**
sQvk srednje veliki pretok v obdobju
nQs najmanjši srednji pretok v obdobju
vQvk največji veliki pretok v obdobju

Qnp **the minimum discharge in the year – daily average**
sQs the mean discharge in the period
nQnp the minimum low discharge in the period
vQs the maximum mean discharge in the period
sQnp the mean low discharge in the period
Qvk **the maximum discharge in the year – peak**
vQnp the maximum low discharge in the period
nQvk the minimum high discharge in the period
Qs **the mean discharge in the year – daily average**
sQvk the mean high discharge in the period
nQs the minimum mean discharge in the period
vQvk the maximum high discharge in the period

Odpravljanje posledic avgustovskih visokih voda na vodomerni postaji Blejski most na Savi Dolinki.
(foto: Marko Burger, 2.september 2003)
Repairing consequences of high water situation in August at gauging station Blejski most on the Sava Dolinka River.
(photo: Marko Burger, 2 September 2003)







Graf 9: Razmerja malih, srednjih in velikih pretokov v letu 2003 ter razmerja karakterističnih pretokov obdobja 1971-2000. Vrednosti so podane relativno glede na srednje vrednosti malih, srednjih in velikih obdobnih pretokov.
Graph 9: The ratios of low, mean and high discharges in 2003, as well as the ratios of characteristic discharges in the 1971-2000 reference period. The values are relative according to the mean values of low, medium and high discharges of the reference period.

TEMPERATURE REK IN JEZER

Barbara Vodenik

Temperatura vode je ena izmed osnovnih hidroloških značilnosti. Merjenje temperatur površinskih voda je pomembno za ocenjevanje izhlapevanja jezer, določanje dnevne in sezonske akumulacije energije, napovedovanje nastajanja ledu na vodotoku, ocenjevanje ekološke stabilnosti razmer v jezerih in rekah, napovedovanje koncentracije kemičnih snovi v vodi in nadzorovanje toplotnega onesnaženja rek in jezer.

Termodinamika rek in jezer je odvisna predvsem od vremenskih razmer, od hidrodinamičnih značilnosti vode in od temperatur pritokov. Na izviru je temperatura vode odvisna od hidrogeoloških in hidrodinamičnih značilnosti, vzdolž toka pa postaja vse bolj odvisna od lokalnih vremenskih razmer in jo lahko dokaj dobro opišemo s temperaturo zraka, sončnim obsevanjem in padavinami.

Leta 2003 je bila povprečna temperatura (povprečje je izračunano iz srednjih letnih temperatur na postajah) Mure, Ledave, Dravinje, Save, Kamniške Bistrice, Ljubljanice, Savinje, Krke, Vipave in Soče 11,6 °C, kar je za 1,3 °C več kot v večletnem primerjalnem obdobju, povprečna temperatura Blejskega in Bohinjskega jezera pa je znašala 12,6 °C, kar je za 1,4 °C več kot v primerjalnem obdobju. Odstopanje od večletnega povprečja je bilo posebej izrazito v juniju, ko je povprečna temperatura rek za 5,6 °C, povprečna temperatura jezer pa za 5,1 °C presegla dolgoletno povprečje. Za izračun povprečja so na petih postajah upoštevani podatki za obdobje 1954-2002, le za Muro, Ledavo, Dravinjo, Savinjo in Vipavo so nizi podatkov krajši.

Mreža vodomernih postaj, na katerih poteka spremljanje temperatur, je prikazana na karti A v III. delu publikacije.

Časovno spreminjanje temperatur rek

Temperature rek so bile z izjemo Ledave v začetku januarja med 4,8 °C in 8,8 °C. Sredi meseca je večina rek dosegla najnižje letne vrednosti in sicer med 0 °C in 4,0 °C. Temperature rek so narasle ob koncu januarja, v februarju pa se niso bistveno spreminjale. V marcu se je temperatura vode postopoma zviševala, konec prve tretjine aprila pa se je voda ohladila. Padec temperature je najbolj izrazit pri Ledavi v Polani, kjer se je temperatura znižala na 0,8 °C. Razlog za tako izrazit padec temperature je oblika profila reke, zaradi katerega se temperatura vode hitro odziva na vremenske razmere. Reke so

TEMPERATURES OF RIVERS AND LAKES

Barbara Vodenik

Water temperature represents one of the basic hydrological factors. The measurement of surface water temperatures is an important factor in evaluating the evaporation of lakes, determining daily and seasonal accumulation of energy, forecasting the formation of ice on watercourses, assessing ecological stability of conditions in lakes and rivers, forecasting the concentrations of chemical substances in water and inspecting thermal pollution of rivers and lakes.

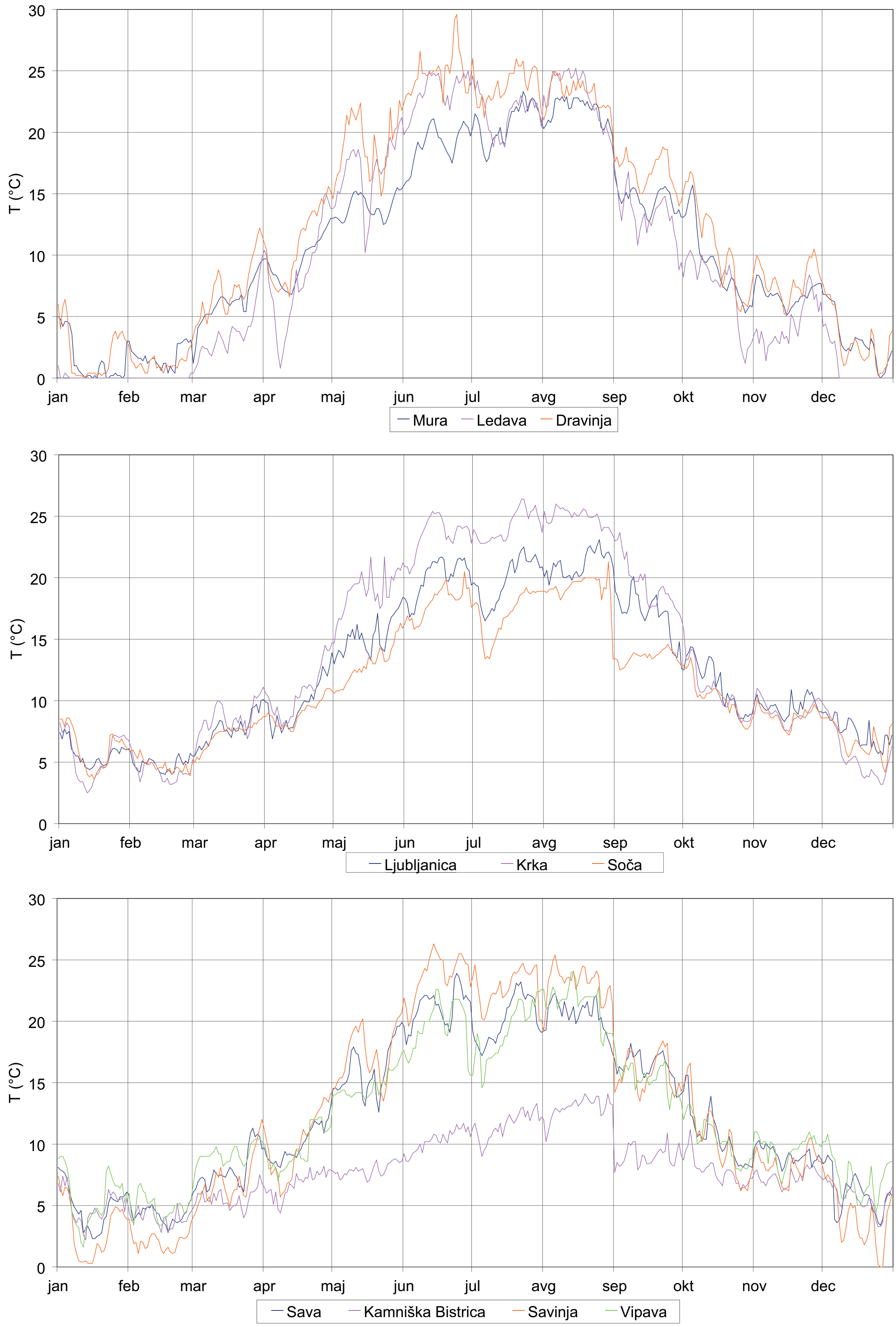
The thermal dynamics of rivers and lakes are predominantly dependent on weather conditions, hydrodynamic properties of water and on temperatures of tributaries. At their source, the temperature of surface water is dependent on the hydrogeological and hydrodynamic factors and down the river they become increasingly more dependent on local weather conditions thus being determined by air temperature, solar radiation and precipitation.

The average temperature in 2003 (the average calculated from the mean annual temperatures recorded at the gauging stations) for the rivers Mura, Ledava, Dravinja, Sava, Kaminška Bistrica, Ljubljanica, Savinja, Krka, Vipava and Soča was 11.6 °C which was by 1.3 °C higher than the average of the comparative period while the average temperature of Lakes Bled and Bohinj amounted to 12.6 °C which was by 1.4 °C higher than in the comparative period. Deviations from the multi-annual average were especially prominent in June when the average temperature of rivers exceeded the multi-annual average by 5.6 °C and lakes by 5.1 °C. Data from five stations for the 1954-2002 period were included in the calculation of the average temperature, while on the rivers Mura, Ledava, Dravinja, Savinja and Vipava, time series are shorter.

Gauging stations with temperature monitoring are indicated on map A in Part III.

Timeline of river temperature changes

River temperatures, with the exception of the Ledava River, fluctuated between 4.8 °C and 8.8 °C at the beginning of January. The majority of rivers reached the lowest annual values in the middle of the month, namely between 0 °C and 4 °C. River temperatures rose at the end of January, not changing much in February. In March, water temperatures gradually increased with water cooling in the first third of April. The temperature fall was most promi-

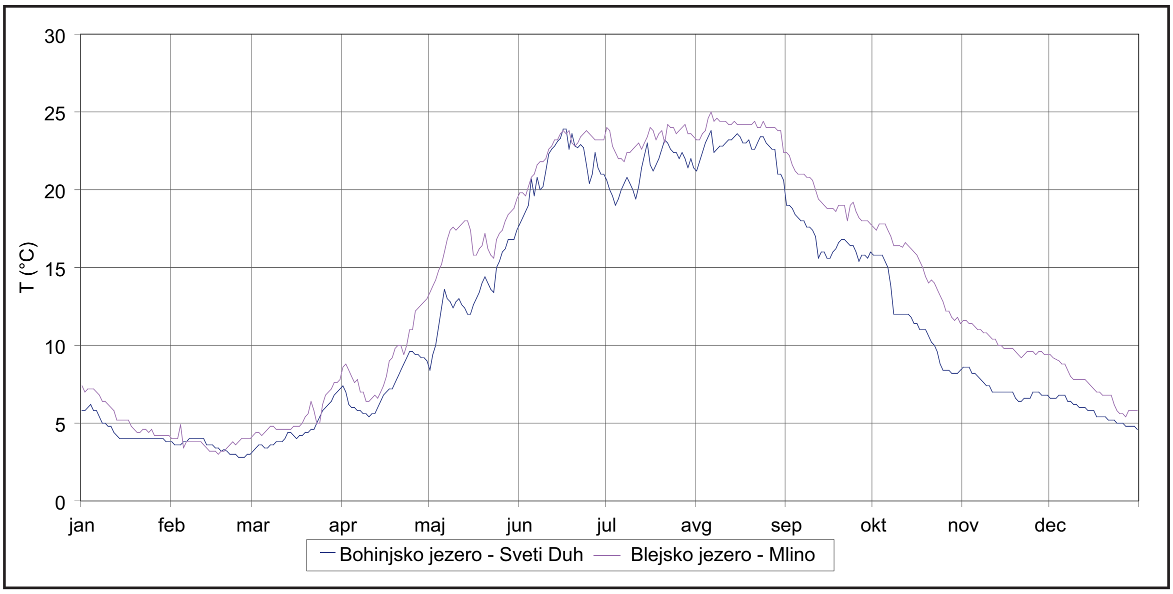


Graf 10: Temperature vode slovenskih rek leta 2003: Mure v Gornji Radgoni, Ledave v Polani, Dravinje v Vidmu, Ljubljanice v Mostah, Krke v Podbočju, Soče v Solkanu, Save v Litiji, Kamniške Bistrice v Kamniku, Savinje v Velikem Širju in Vipave v Dornberku.
Graph 10: Water temperatures of Slovenian rivers in 2003: the Mura River in Gornja Radgona, the Ledava River in Polana, the Dravinja River in Videm, the Ljubljanica River in Moste, the Krka River in Podbočje, the Soča River in Solkan, the Sava River in Litija, the Kamniška Bistrica in Kamnik, the Savinja River in Veliko Širje and the Vipava River in Dornberk.

Vodomerna postaja na Blejskem jezeru.
(foto: Marko Burger, april 2003)
Gauging station on Bled lake.
(photo: Marko Burger, April 2003)

se opazno segrele šele v maju in temperatura vode je na Dravinji, Savinji in Krki že sredi meseca dosegla 20 °C. Junij je bil izjemno vroč in zaradi pomanjkanja padavin so bili pretoki slovenskih rek močno pod dolgoletnim povprečjem. To je vplivalo na temperature rek. Dravinja, Sava in Savinja so že v juniju dosegle najvišje letne vrednosti (preglednica 2). V začetku julija je hitremu padcu sledil ponoven porast temperature vode. V drugi polovici julija in avgusta ni bilo večjih temperaturnih nihanj. V tem času so bile zabeležene najvišje letne vrednosti temperatur vode na Muri, Ledavi, Kamniški Bistrici, Ljubljanici, Krki, Vipavi in Soči. Znatna ohladitev je sledila prvi dan septembra, ko so se temperature vode znižale za 4,8 °C na Soči, 7,2 °C na Savinji in 5,5 °C na Kamniški Bistrici. Temperature voda so se nato z večjimi ali manjšimi nihanji zniževale vse do konca leta.

nent on the Ledava River in Polana where temperatures fell to 0.8 °C. The reason for such a pronounced fall in temperature was the cross-section of the river with shallow water in a wide river channel whereby water temperatures responded quickly to weather conditions. Rivers warmed up notably only as late as in May with water temperatures on the rivers Dravinja, Savinja and Krka reaching 20 °C already in the middle of the month. June was a markedly hot month and due to the lack of precipitation, discharges of Slovenian rivers remained significantly below the multi-annual mean, affecting temperatures of rivers. The rivers Dravinja, Sava and Savinja had already reached their highest annual temperatures in June (Table 2). At the beginning of July, the rapid fall of temperature was followed by a renewed increase in water temperatures. No larger temperature fluctuations were recorded in the second half of the months of July and August. During these periods, the highest annual values of water temperatures were recorded on the rivers Mura, Ledava, Kamniška Bistrica, Ljubljanica, Krka, Vipava and Soča. A pronounced cooling was seen on the first day of September when water temperatures decreased to 4.8 °C on the Soča River, 7.2 °C on the Savinja River and 5.5 °C on the Kamniška Bistrica River. Water temperatures then decreased up until the end of the year in larger or smaller fluctuations.



Graf 11: Temperature vode Blejskega in Bohinjskega jezera leta 2003.
Graph 11: Water temperatures of Lakes Bled and Bohinj in 2003.

Časovno spreminjanje temperatur jezer

Letni potek temperature vode Blejskega in Bohinjskega jezera je zelo podoben tistim na rekah, le da so nihanja manj izrazita. Bohinjsko jezero je bilo vse leto hladnejše od Blejskega in sicer v celoletnem povprečju za 1,8 °C .

Primerjava značilnih temperatur rek in jezer z večletnim obdobjem

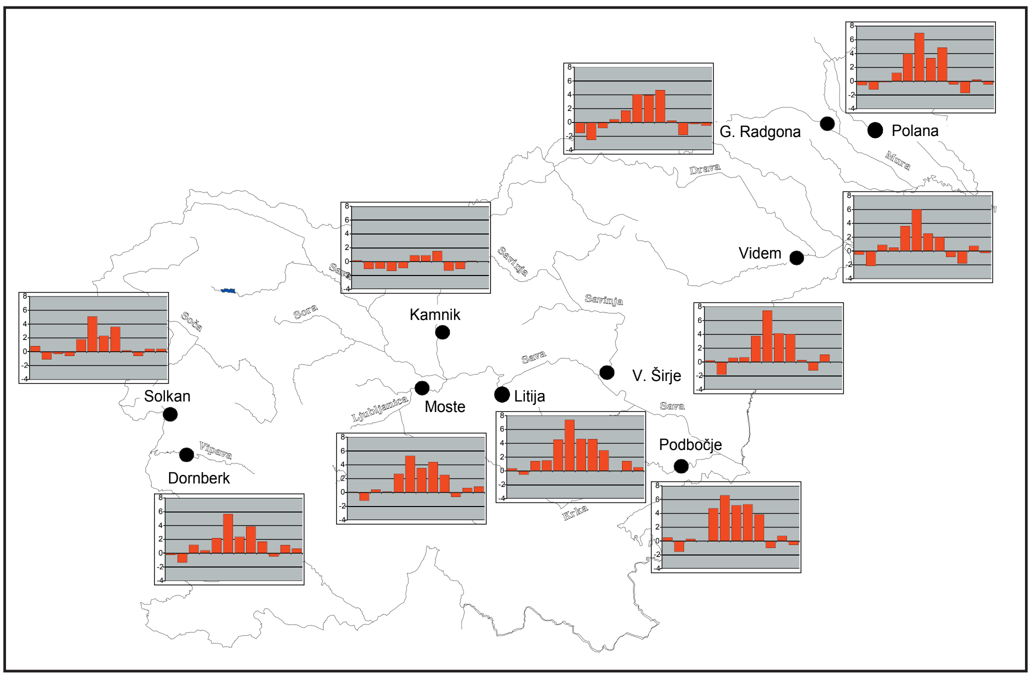
Januarja 2003 se povprečne temperature rek niso razlikovale od dolgoletnega povprečja. Povprečna temperatura 3,9 °C je bila za 0,1 °C nižja kot v primerjalnem obdobju. Februarja je bila povprečna temperatura rek 3,1 °C, kar je 1,4 °C manj kot v večletnem primerjalnem obdobju. Marca in aprila je povprečna temperatura rek znašala 7,0 °C oz. 9,4 °C. Tako so bile reke 0,3 °C toplejše kot v večletnem primerjalnem obdobju. Tudi v maju so bile povprečne temperature višje kot navadno. Največje odstopanje od dolgoletnega povprečja je bilo v juniju, povprečne mesečne temperature so bile kar za 5,6 °C višje kot v primerjalnem obdobju. Pri posameznih rekah je najvišja odstopanja od dolgoletnega povprečja v juniju opaziti na Savinji (7,4 °C), Savi (7,4 °C), Ledavi (7,0 °C), Krki (6,6 °C), Dravinji (6,0 °C) in Vipavi (5,7 °C) (karta 4). Povprečna temperatura rek v juliju je znašala 20,1 °C, kar je za 3,3 °C več kot v primerjalnem obdobju. Tudi avgusta so bile temperature visoko nad dolgoletnim povprečjem in sicer so ga presegle za 3,9 °C. Povprečna temperatura je znašala 21,1 °C. Septembra so bile temperature vode

Timeline of lake temperature changes

The annual course of water temperature for Lakes Bled and Bohinj is very similar to that of the rivers with fluctuations being less pronounced. Lake Bohinj remained cooler than Lake Bled throughout the year with the the annual mean being lower by 1.8 °C.

Comparison of characteristic temperatures of rivers and lakes with the multi-annual period

In January 2003, the average river temperatures did not deviate from the multi-annual average. The average temperature of 3.9 °C was 0.1 °C lower than in the comparative period. The average river temperature in February was 3.1 °C, which was 1.4 °C lower than that of the multi-annual reference period. In March and April, the average temperatures of rivers amounted to 7.0 °C and 9.4 °C respectively. As a result, rivers were 0.3 °C warmer than in the multi-annual reference period with temperatures in May also being higher than usual. The largest deviations from the multi-annual average occurred in June with the average monthly temperatures being higher by as much as 5.6 °C than in the comparative period. Among individual rivers, the largest deviations from the multi-annual mean in June were observed on the rivers Savinja (7.4 °C), Sava (7.4 °C), Ledava (7.0 °C), Krka (6.6 °C), Dravinja (6.0 °C) and Vipava (5.7 °C) (Map 1). The average river temperature in July amounted to 20.1 °C which was 3.3 °C higher than in the comparative period. Temperatures



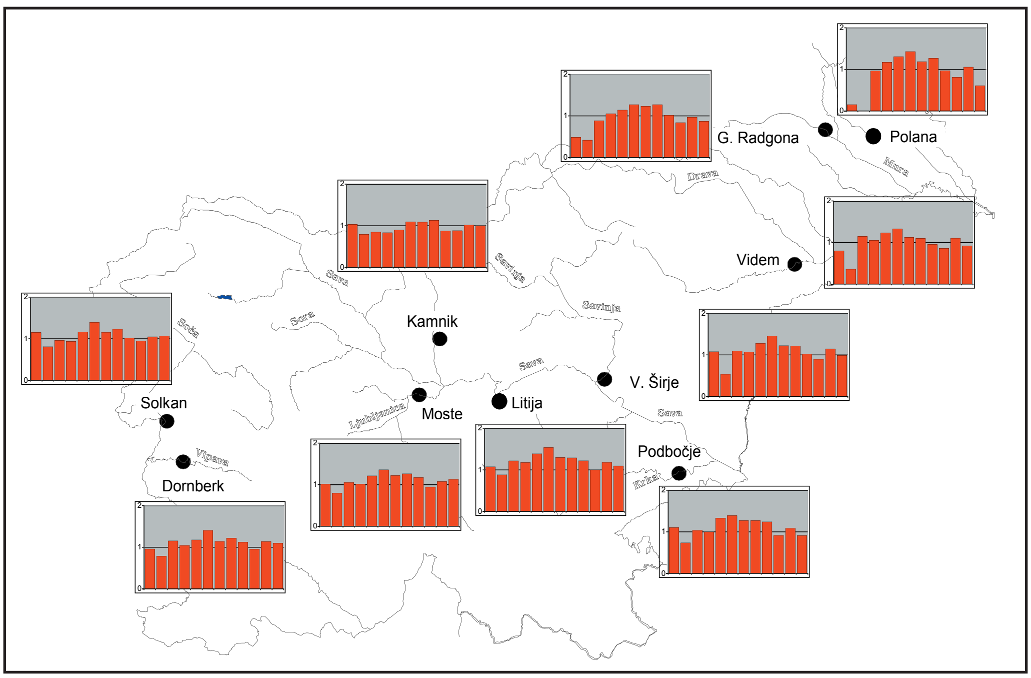
Karta 4: Odstopanja srednjih mesečnih temperatur v letu 2003 od srednjih mesečnih temperatur obdobja (ºC).
Map 4: Temperature deviations of average monthly temperatures in 2003 from average monthly temperatures of the comparative period (ºC).

višje od obdobnega povprečja za 0,9 °C, oktobra pa so se temperature v povprečju znižale za 1,0 °C pod obdobno povprečje. Novembra in decembra so bile temperature podobne obdobnim, saj so obdobno povprečje presegle za 0,6 ºC oz. 0,1 °C (graf 12).

Januarja 2003 so bile temperature obeh največjih slovenskih jezer višje kot navadno. Povprečna temperatura je bila 5,0 °C, kar je za 1,5 °C več kot v primerjalnem obdobju. Februarja in marca je bila povprečna temperatura jezer 3,6 °C oz. 5,0 °C in sta bili jezeri v povprečju 0,8 °C oz 0,6 °C toplejši kot v večletnem primerjalnem obdobju. Aprila je bila temperatura enaka obdobni vrednosti. Tudi v maju so bile temperature višje kot navadno in so presegale dolgoletno povprečje za 1,8 °C. V neobičajno vročem juniju so bile temperature jezer nadpovprečno visoke. Povprečna temperatura Blejskega jezera je bila 22,5 °C, Bohinjskega pa 21,5 °C, kar je za 2,8 °C oziroma 7,5 °C več kot znaša dolgoletno povprečje. Tudi temperature v juliju in avgustu so bile nadpovprečno visoke in so za 2,7 °C oz. 3,0 °C presegle obdobne vrednosti. Septembra je bila povprečna temperatura za 0,9 °C višja kot navadno. Oktober in november pa sta bila temperaturno enaka obdobnemu povprečju. Decembra je bila povprečna temperatura za 0,8 °C višja kot v primerjalnem obdobju.

remained above the multi-annual average in August and surpassed it by 3.9 °C. The average temperature was 21.1 °C. Water temperatures were 0.9 °C higher than the comparative period average while in September water temperatures dropped to 1.0 °C below the comparative average. November and December observed water temperatures similar to those of the comparative period only surpassing the multi-annual average by 0.6 °C and 0.1 °C (Graph 12).

In January 2003, temperatures of the two largest Slovenian lakes were higher than usual. The average temperature was 5 °C, which is 1.5 °C higher than in the comparative period. Mean lake temperatures in February and March were 3.6 °C and 5 °C respectively whereby the lakes were on average 0.8 °C and 0.6 °C warmer than in the multi-annual comparative period. The temperature in April was equal to the values of the comparative period. In May, temperatures were once again higher than usual surpassing the multi-annual mean by 1.8 °C. In the unusually warm June, lake temperatures were above-average. The mean temperature of Lake Bled was 22.5 °C and that of Lake Bohinj 21.5 °C, which is 2.8 °C and 7.5 °C higher than the multi-annual mean. Mean monthly temperatures in July and August were again above-average surpassing the mean temperatures of the comparative period by 2.7 °C and 3.0 °C respectively. In September, the mean temperature was 0.9 °C higher than normal. Temperatures in October and November were close to to the comparative mean.



Karta 5: Grafični prikaz razmerij med srednjimi mesečnimi temperaturami leta 2003 in obdobja. Vrednost razmerja 1 pomeni enako temperaturo leta 2003 kot v povprečju dolgoletnega obdobja.
Map 5: Graphic representation of the relationship of average monthly temperatures in 2003 and the comparative period. The ratio of 1 means an identical temperature in 2003 as in the average of the multi-annual period.

Najnižje temperature rečnih voda v letu 2003 so bile večinoma nekoliko višje kot v primerjalnem obdobju. Najnižji temperaturi obeh jezer, Blejskega 3,0 °C in Bohinjskega 2,8 °C v februarju, pa sta bili v povprečju 0,1 °C višji od dolgoletnega povprečja za februar.

Srednje temperature izbranih rek so bile za 1,3 °C, srednje temperature obeh jezer pa za 1,4 °C višje od povprečja. Srednja letna temperatura rek na izbranih postajah je bila 11,6 °C, jezer pa 12,6 °C. Srednje mesečne temperature rek so bile glede na primerjalno obdobje višje maja, junija, julija, avgusta in septembra, nižje pa februarja in oktobra (graf 12). Srednje mesečne temperature jezer so bile glede na primerjalno obdobje višje v vseh mesecih razen oktobra in novembra (graf 13).

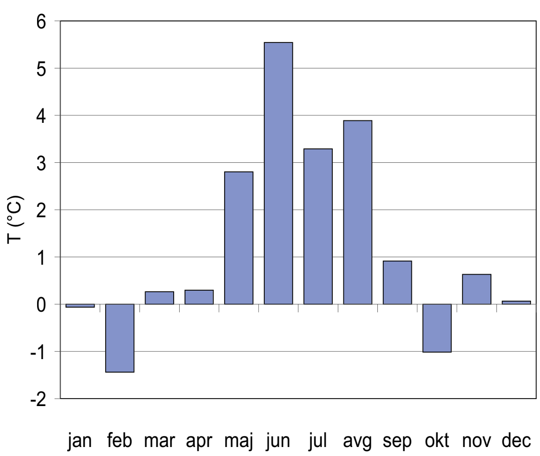
Najvišje temperature rek in obeh jezer so bile v splošnem rekordno visoke. Povprečna temperatura voda je bila najvišja avgusta, vendar so bile pri nekaterih rekah temperaturne konice v juniju in juliju. Petindvajsetega junija je izstopala temperatura Dravinje v Vidmu s 26,8 °C, sledila ji je Krka v Podbočju s 26,4 °C in Savinja v Velikem Širju s 26,3 °C. Visoki sta bili tudi letni visoki konici temperature Blejskega jezera s 25 °C in Bohinjskega jezera v Svetem Duhu s 24,6 °C.

The average temperature in December was 0.8 °C higher than in the comparative period.

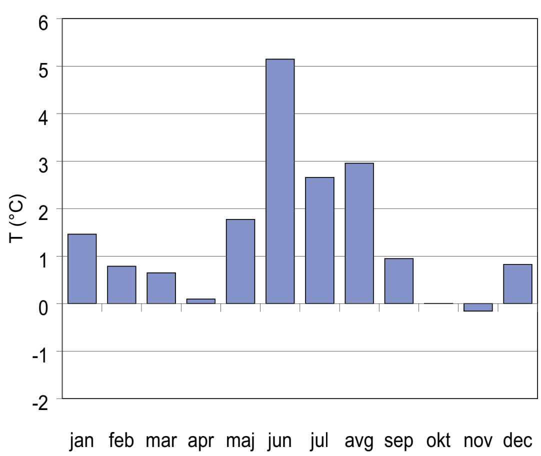
The minimum river temperatures in 2003 were for the most part somewhat higher than in the comparative period. The lowest temperatures of both Lake Bled with 3.0 °C and Lake Bohinj with 2.8 °C in February were on average 0.1 °C higher than the multi-annual monthly means for February.

The average temperatures of selected rivers were 1.3 °C higher than average and the average temperatures of both lakes 1.4 °C higher than average. The average annual river temperature at selected stations was 11.6 °C and that for the two lakes 12.6°C. The average monthly river temperatures were, when compared to the comparative period, higher in May, June, July, August and September and lower in February and October (Graph 12). Average monthly lake temperatures were, when compared to the comparative period, higher throughout the entire year except for in October and November (Graph 13).

The maximum temperatures of rivers and both lakes showed in general record highs. The mean water temperature was the highest in August; however, certain river temperatures displayed peaks in June and July. On 25 June, temperatures peaked on the Dravinja River in Videm at 26.8 °C, followed by the Krka River in Podbočje with 26.4 °C and the Savinja River in Veliko Širje with 26.3 °C. Annual high temperature peaks were also high for Lake Bled reaching 25 °C and Lake Bohinj in Sveti Duh with 24.6 °C.



Graf 12: Odstopanja srednjih mesečnih temperatur v letu 2003 od srednjih mesečnih temperatur primerjalnega obdobja na izbranih rekah. Odstopanja so izračunana kot povprečja odstopanj na desetih rečnih merilnih postajah.
Graph 12: Temperature deviations of mean monthly temperatures in 2003 from mean monthly temperatures of the comparative period on selected rivers. The deviations are calculated as mean values of deviations at ten river gauging stations.



Graf 13: Odstopanja srednjih mesečnih temperatur v letu 2003 od srednjih mesečnih temperatur primerjalnega obdobja na Bohinjskem in Blejskem jezeru.
Graph 13: Temperature deviations of mean monthly temperatures in 2003 from mean monthly temperatures of the comparative period on Lake Bohinj and Lake Bled.

Preglednica 2: Najvišje in najnižje temperature izbranih rek in jezer v letu 2003.
Table 2: The high and low temperatures of selected rivers and lakes in 2003.

Vodotok Stream	Vodomerna postaja Gauging Station	Tnk	Datum Date	Tvk	Datum Date
MURA	GORNJA RADGONA	0	13.01.	23.3	23.07.
LEDAVA	POLANA	0	02.01.	25.2	12.08.
DRAVINJA	VIDEM	0.1	12.01.	26.8	25.06.
SAVA	LITIJA	2.3	16.01.	23.9	24.06.
KAMN. BISTRICA	KAMNIK	2.2	13.01.	14.1	19.08.
LJUBLJANICA	MOSTE	4.0	16.02.	23.1	25.08.
SAVINJA	VELIKO ŠIRJE	0	26.12.	26.3	14.06.
KRKA	PODBOČJE	2.5	13.01.	26.4	22.07.
VIPAVA	DORNBERK	1.6	12.01.	24	13.08.
SOČA	SOLKAN	3.6	16.01.	21.3	29.08.
BLEJSKO JEZERO	MLINO	3.0	17.02.	25	06.08.
BOHINJSKO JEZERO	SVETI DUH	2.8	24.02.	24.6	16.06.

Preglednica 3: Srednje mesečne in letne temperature izbranih rek ter njihovo povprečje (Tpovp) v letu 2003.
Table 3: The mean monthly and annual temperatures of selected rivers and their monthly means (Tpovp) in 2003.

Vodotok Stream	jan Jan	feb Feb	mar Mar	apr Apr	maj May	jun Jun	jul Jul	avg Aug	sep Sep	okt Oct	nov Nov	dec Dec	Letna Ts 2003 Annual Ts
MURA	1.4	1.8	6.1	9.5	13.9	19.0	20.8	21.8	14.5	9.3	6.8	3.1	10.7
LEDAVA	0.1	0.0	3.5	8.2	16.9	23.2	21.6	23.0	13.3	7.3	4.4	0.7	10.2
DRAVINJA	2.0	1.2	7.2	10.9	19.0	24.4	23.8	23.1	16.8	10.8	8.0	3.0	12.6
SAVA	4.9	4.3	7.9	10.0	16.0	21.1	20.1	20.5	16.3	10.6	9.1	6.0	13.0
KAMN. BISTRICA	5.0	4.0	5.5	6.7	7.9	10.3	11.6	13.0	9.0	7.8	7.3	5.6	7.8
LJUBLJANICA	5.7	4.8	7.7	9.7	15.3	20.0	19.8	21.1	17.0	11.3	9.6	7.4	12.5
SAVINJA	3.1	2.1	6.9	10.0	17.3	23.8	22.8	23.1	15.8	10.3	8.3	4.0	12.3
KRKA	5.5	4.3	8.6	10.7	18.9	23.5	24.2	24.9	19.5	10.7	9.2	5.6	13.8
VIPAVA	5.6	4.9	9.1	9.6	14.4	19.6	19.2	21.5	15.4	10.3	9.6	7.3	12.3
SOČA	6.1	4.8	7.3	9.0	13.0	18.0	17.1	19.3	13.6	10.2	8.8	6.8	11.2
Povprečje Average	3.9	3.1	7.0	9.4	15.3	20.3	20.1	21.1	15.1	9.9	8.1	5.0	11.6

Preglednica 4: Srednje mesečne in letne temperature izbranih rek ter njihovo povprečje (Tpovp) v letu za večletno obdobje.
Table 4: The mean monthly and annual temperatures of selected rivers and their average (Tpovp) for the multi-annual period.

Vodotok Stream	jan Jan	feb Feb	mar Mar	apr Apr	maj May	jun Jun	jul Jul	avg Aug	sep Sep	okt Oct	nov Nov	dec Dec	Letna Ts obdobja Annual Ts in period
MURA	2.9	4.3	6.9	9.1	12.2	14.9	16.9	17.1	14.3	11.1	7.0	3.6	10.0
LEDAVA	0.7	1.2	3.6	7.0	12.9	16.2	18.3	18.1	13.7	9.0	4.2	1.2	8.8
DRAVINJA	2.5	3.3	6.3	10.4	15.4	18.4	21.3	21.1	17.7	12.6	7.2	3.3	11.6
SAVA	4.5	4.8	6.5	8.5	11.5	13.7	15.5	15.9	13.3	10.6	7.7	5.5	9.8
KAMN. BISTRICA	4.8	5.0	6.5	8.0	8.8	9.4	10.7	11.5	10.3	8.8	7.2	5.6	8.1
LJUBLJANICA	5.6	6.0	7.3	9.6	12.6	14.7	16.3	16.7	14.5	11.9	9.0	6.6	10.9
SAVINJA	2.9	3.9	6.3	9.3	13.5	16.4	18.6	19.1	15.5	11.5	7.2	4.0	10.7
KRKA	5.0	5.8	8.3	10.7	14.2	16.9	19.0	19.6	15.7	11.7	8.5	6.1	11.8
VIPAVA	5.8	6.2	7.9	9.2	12.2	13.9	16.8	17.6	13.7	10.8	8.4	6.6	10.8
SOČA	5.3	5.9	7.6	9.6	11.2	12.9	14.8	15.7	13.4	10.8	8.4	6.4	10.2
Povprečje Average	4.0	4.7	6.7	9.1	12.5	14.7	16.8	17.2	14.2	10.9	7.5	4.9	10.3

Preglednica 5: Srednje mesečne in letne temperature obeh jezer ter njihovo povprečje (Tpovp) v letu v letu 2003.
Table 5: The mean monthly and annual temperatures of both lakes and their monthly averages (Tpovp) in 2003.

Jezero Lake	jan Jan	feb Feb	mar Mar	apr Apr	maj May	jun Jun	jul Jul	avg Aug	sep Sep	okt Oct	nov Nov	dec Dec	Letna Ts 2003 Annual Ts
BLEJSKO J.	5.4	3.7	5.4	9	16.7	22.5	23.3	24.1	19.6	15.1	10.2	7.3	13.5
BOHINJSKO J.	4.5	3.5	4.6	7.3	13.4	21.5	21.3	22.7	16.8	11.4	7.2	5.7	11.7
Povprečje Average	5.0	3.6	5.0	8.2	15.1	22.0	22.3	23.4	18.2	13.3	8.7	6.5	12.6

Preglednica 6: Srednje mesečne in letne temperature obeh jezer ter njihovo povprečje (Tpovp) v letu za večletno obdobje.
Table 6: The mean monthly and yearly temperatures of both lakes and the monthly averages for the multi-annual period.

Jezero Lake	jan Jan	feb Feb	mar Mar	apr Apr	maj May	jun Jun	jul Jul	avg Aug	sep Sep	okt Oct	nov Nov	dec Dec	Letna Ts obdobja Annual Ts in period
BLEJSKO J.	4.2	4.1	5.7	9.5	16.0	19.7	22.3	22.9	19.5	15.7	10.5	6.5	13.0
BOHINJSKO J.	2.7	1.6	3.0	6.6	10.6	14.0	17.0	18.0	15.0	10.8	7.2	4.9	9.3
Povprečje Average	3.5	2.8	4.4	8.1	13.3	16.9	19.6	20.4	17.3	13.2	8.9	5.7	11.2

Reka Soča
(foto: Niko Trišić)
The Soča River
(photo: Niko Trišić)

VSEBNOST IN TRANSPORT SUSPENDIRANEGA MATERIALA V REKAH

Florjana Ulaga

Ves material premeščen pod vplivom turbulence rek imenujemo rečni nanos. Glede na velikost delcev in hitrost prenosa ga delimo na lebdeče plavine v suspendirani obliki in na prod, ki se premika po rečnem dnu s kotaljenjem. Cilj monitoringa je izračun skupne količine materiala, ki se premesti skozi izbrani prečni prerez vodotoka v določeni časovni enoti. Dinamiki gibanja plavin v vodi sledimo z merjenjem vsebnosti suspendiranega materiala, iz katere pri izmerjenem pretoku izračunamo količino transportiranega materiala. Večina materiala se transportira ob visokih vodah, zaradi česar je potrebno pogosto vzorčenje prav v času visokih valov.

Redna merjenja vsebnosti suspendiranega materiala izvajamo na petih vodomernih postajah: v Gornji Radgoni na Muri, v Hrastniku na Savi, v Velikem Širju na Savinji, v Mirnu na Vipavi in v Suhi na Sori. Na teh merilnih mestih se enkrat dnevno odvzame vzorec vode s prostornino enega litra, ki ga analiziramo v laboratoriju po klasični filtracijski metodi. Rezultati analiz so izmerjene vsebnosti suspendiranega materiala (c), izražene v g/m^3 vode. Na postajah primarne mreže poteka odvzem vzorcev ročno. Izjema je postaja Suha na Sori, kjer smo v letu 2002 pričeli z odvzemom vzorcev z avtomatskim vzorčevalnikom. Zanjo podatki niso na voljo za celo leto. Nekajkrat letno se na vseh vodomernih postajah monitoringa suspendiranega materiala opravljajo profilne meritve suspendiranega materiala: vzorci se odvzamejo v večih točkah prečnega prereza. Na podlagi vsebnosti snovi v odvzetih vzorcih izračunamo srednjo vsebnost v prerezu, s pomočjo izmerjenega pretoka pa trenutni transport suspendirane snovi. Rezultati so objavljeni v drugem delu publikacije.

Avtomatski vzorčevalnik na vodomerni postaji Suha na Sori.
(foto: Florjana Ulaga)
Automatic water sampler at gauging station
Suha on the Sora River.
(photo: Florjana Ulaga)

CONCENTRATION AND TRANSPORT OF SUSPENDED MATERIAL IN RIVERS

Florjana Ulaga

Sediment transported by the effects of river flow is called suspended material and bed load. Depending on the size of particles and transfer velocity, they are divided into flows of suspended material and bed load rocks rolling along the river bottom. The aim of monitoring is the calculation of total sediment quantities of materials which are transported through selected cross-sections of watercourses within defined time units. The dynamics of the suspended material transport in the rivers is monitored through the measurement of the concentration of suspended material from which the quantity of transported material can be calculated through the measured river discharge. The majority of material is transported during high waters whereby samples must be taken frequently during periods of high waves.

Regular sampling of the concentrations of suspended material are carried out at five water gauging stations: in Gornja Radgona on the Mura River, in Hrastnik on the Sava River, in Veliko Širje on the Savinja River, in Miren on the Vipava River and in Suha on the Sora River (Map 1). Water samples of 1 litre are taken at these gauging stations once daily and analyzed at the laboratory by classic filtration methods. The results of the analyses are the measured concentrations of suspended material (c) in g/m^3 of water. At most of the aforementioned stations, collection of samples is carried out manually. The exception to the rule is the gauging station Suha on the Sora River, in which automatic sampling was introduced in 2002 with an automatic sampler. Data from this station are not available for the entire year of 2003 due to malfunctions, etc. Several times annually at all water gauging stations of suspended material monitoring, cross-section measurements of suspended material are performed: samples are taken at a number of points along a transverse cross-section. On the basis of material concentrations of taken samples, the mean cross-section concentration is calculated and multiplied by river discharge thus obtaining the suspended material transport value for a given measurement.

Ročni odvzem vzorca vode s pomočjo droga.
(foto: Andrej Vidmar)
Manual water sampling.
(photo: Andrej Vidmar)

Poleg rednega odvzema in analiziranja vzorcev poteka tudi odvzem vzorcev ob izrednih hidroloških razmerah na petih dopolnilnih vodomernih postajah. S pomočjo analiz vzorcev dopolnilne mreže lažje in pravilneje vrednotimo podatke rednih meritev, hkrati pa rezultati predstavljajo pregled stanja ob visokovodnih razmerah po vsej Sloveniji. Izredni odvzemi vzorcev so bili leta 2003 na Dravinji v Vidmu, na Soči v Kobaridu, na Idrijci v Hotešku, na Bači v Bači pri Modreju in na Reki pri Cerkvenikovem mlinu.

Mreža vodomernih postaj, na katerih poteka odvzem vzorcev, je prikazana na karti A v III. delu publikacije.

Rezultati meritev vsebnosti suspendiranega materiala v letu 2003

Glede na izmerjene vsebnosti suspendiranega materiala na postajah z dnevnim odvzemom vzorcev ugotavljamo, da so bile za leto 2003 značilne majhne vsebnosti drobnih delcev v rekah. Leto je bilo sušno z malo padavinami predvsem v vzhodni Sloveniji. To se odraža pri hidroloških značilnostih rek, med katere sodi tudi vsebnost suspendiranega materiala. Izredno majhne vsebnosti suspendiranega materiala so bile v Muri, kjer je dosegla srednja letna vsebnost le 1/5 srednje obdobne vsebnosti. Največja vsebnost na Muri je bila v letu 2003 izmerjena januarja. Glade na visoke konice dolgoletnega obdobja je največja izmerjena vrednost leta 2003 najnižja v obdobju (cvk 143 g/m^3).

Vsebnosti suspendiranega materiala v Savinji prav tako niso bile velike, saj je srednja letna vsebnost dosegla le 1/3 srednje obdobne vrednosti. Največja letna vsebnost je bila majhna (927 g/m^3), izmerjena v novembru. V Savi v Hrastniku so bile vsebnosti suspendiranega materiala povprečne, največja vsebnost pa je bila prav tako izmerjena novembra. Tudi v Sori so bile vsebnosti majhne, največja pa je bila izmerjena oktobra in je znašala 679 g/m^3.

In addition to regular sampling and analysis of samples at the primary network, samples are also taken during extreme hydrological conditions at five supplemental water gauging stations. Through the analyses of samples taken at the supplementary network, the data of regular measurements are more easily and accurately evaluated while the results give an overview at high-water conditions throughout Slovenia. Additional sampling during extreme conditions in 2003 was performed on the Dravinja River in Videm, Soča River in Kobarid, Idrijca River in Hoteško, Bača River in Bača near Modrej and on the Reka River at Cerkvenikov mlin.

Gauging stations with water sampling are indicated on map A in Part III.

Results of suspended material concentration measurements in 2003

Based on the measured concentrations of suspended material at stations through daily sampling, it was determined that 2003 was characterized by small quantities of suspended material in rivers. The year was a dry one with low precipitation, especially in eastern Slovenia. This results in hydrological conditions of rivers which also includes concentrations of suspended material. An extraordinarily small concentration of suspended material was observed in the Mura River, where the mean annual concentration only reached 1/5 of the multi-annual mean concentration in the comparative period. The largest concentration for the Mura River was recorded in January 2003. Considering the high peaks of the multi-annual period, the largest measured value in 2003 was the lowest value for the multi-annual period (143 g/m^3).

The concentrations of suspended material in the Savinja River were similarly low as the mean annual concentration reached only 1/3 of the mean value of the comparative period. The largest annual concentration was low (927 g/m^3) and was measured in November. Concentrations of suspended materi-

Za razliko od ostalih merilnih mest so bile vsebnosti suspendiranega materiala v Vipavi velike. Srednja letna vsebnost je presegla srednjo obdobno kar 3-krat. Največjo vsebnost smo izmerili v začetku januarja (986 g/m^3), ki je celo tretja največja vsebnost izmerjena v Vipavi do sedaj.

Na postajah dopolnilne mreže so bili vzorci z veliko vsebnostjo suspendiranega materiala odvzeti v Soči. V Kobaridu je bila vsebnost 5. oktobra celo 3200 g/m^3, kar je največja vsebnost izmerjena v Soči, če izvzamemo stanje novembra 2000, ko je zaradi plazu v Logu pod Mangartom vsebnost suspendiranega materiala presegla 8000 g/m^3.

als in the Sava River in Hrastnik were average, with the highest concentration also being measured in November. Concentrations in the Sora River were also low, with the highest concentration in October amounting to 679 g/m^3.

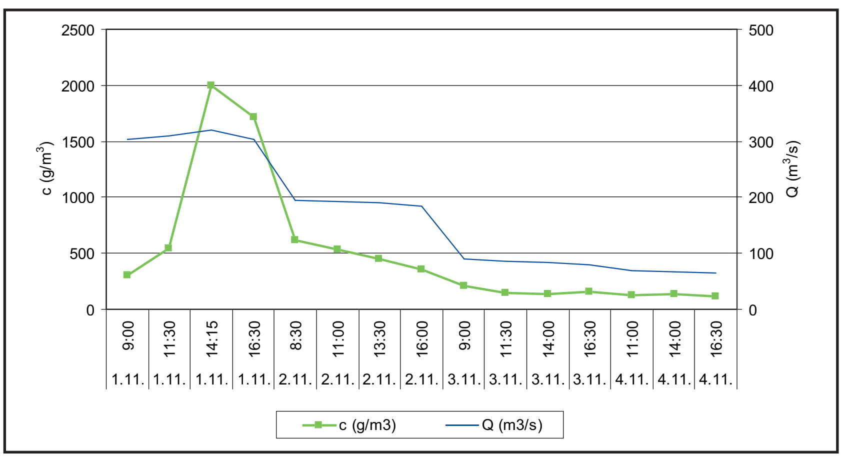
As opposed to the above mentioned gauging stations, the concentrations of suspended material in the Vipava River were high. The mean annual concentration exceeded the mean multi-annual value by three times. The highest concentration was measured at the beginning of January (986 g/m^3) which is also the third highest concentration measured for the Vipava River to date.

Preglednica 7: Največje vsebnosti suspendiranega materiala vzorcev izbranih postaj z enkrat dnevnim odvzemom v letu 2003 in v obdobju 1985-2002.
Table 7: Maximum concentration of suspended material in samples of selected stations with daily samplings in 2003 and in the 1985-2002 period.

Vodomerna postaja Gauging station	2003		1985 - 2002		
	Vsebnost c (g/m^3) Concentration	Datum odvzema vzorca Date of sampling	Največja obdobna vsebnost c (g/m^3) The highest concentration in the period	Datum največje obdobne vsebnosti Date of the highest concentration in the period	Srednja obdobna vsebnost Mean concentration in the period
MURA – G. RADGONA	143	14.1.	2364	16.5.1996	48,9
SAVINJA – VELIKO ŠIRJE	927	2.11.	6026	7.11.2000	54,9
VIPAVA – MIREN	986	3.1.	1066	14.9.1997	16,7

V novembru je bilo v času visokovodnega stanja v štirih dneh odvzetih 15 vzorcev (graf 14). S pomočjo tako pogostega vzorčenja ugotavljamo odvisnost dinamike vsebnosti suspendiranega materiala v vodi od količine padavin v zaledju.

At the supplementary network, samples with high concentrations of suspended material were taken from the Soča River. In Kobarid, the concentration on 5 October was as much as 3200 g/m^3, which is the largest concentration ever measured for the Soča River if we exclude the condition in November



Graf 14: Pretok in vsebnosti suspendiranega materiala v Soči na vodomerni postaji Kobarid, med 1. in 4. 11. 2003.
Graph 14: The discharge and concentrations of suspended material in the Soča River at the watergauging station Kobarid between 1 and 4 November 2003.

Na ostalih postajah dopolnilne mreže pa v letu 2003, razen 4. oktobra v Bači (1223 g/m^3), ni bilo velikih vsebnosti suspendiranega materiala.

Transport suspendiranega materiala

Količini transporta plavin v vodi sledimo z merjenjem vsebnosti suspendiranega materiala, iz katere pri izmerjenem pretoku izračunamo prenos suspendiranega materiala S (kg/s). Iz dnevnih vrednosti izračunamo mesečne in letne vrednosti transportiranega materiala (preglednica 9).

2000 when due to the landslide in Log pod Mangart, the concentration of suspended material exceeded 8000 g/m^3. In November during high water conditions, 15 samples were taken in four days (Graph 14). Through such frequent sampling, we determine the dependence of dynamics of concentration of suspended material in water on precipitation quantities in the catchment area.

No high concentrations of suspended material were recorded at other stations in the supplementary network in 2003 except at Bača on 4 October (1223 g/m^3).

Preglednica 8: Največje vsebnosti suspendiranega materiala vzorcev odvzetih ob izrednih hidroloških razmerah (max c1- največja obdobna vsebnost, max c2- druga največja obdobna vsebnost).
Table 8: The maximum suspended material concentrations in the samples taken during exceptional hydrological conditions (max c1 – maximum periodical concentration, max c2 – second highest periodical concentration).

Vodomerna postaja Gauging station	Vodotok Stream	2003		1990 - 2002			
		Vsebnost c (g/m3)	Datum odvzema vzorca	Največja obdobna vsebnost The highest concentration in the period			
		Concentration	Date of sampling	max c1	datum/date	max c2	datum/date
VIDEM	DRAVINJA	102	27.5.	4832	22.5.1999	4627	26.1.2001
KOBARID	SOČA	3200	5.10.	8112	17.11.2000	1656	7.1.2001
HOTEŠK	IDRIJCA	170	31.8.	3743	9.10.1993	2988	1.11.1990
BAČA PRI MODREJU	BAČA	1223	4.10.	1959	27.10.1990	1088	7.11.1997
CERKVENIKOV MLIN	REKA	31	11.4.	280	12.11.2001	131	16.4.2001

Preglednica 9: Mesečni in letni transport suspendiranega materiala v letu 2003.
Table 9: Monthly and annual transport of suspended material in 2003.

2003	MURA – G. RADGONA		SAVA – HRASTNIK		SAVINJA – V. ŠIRJE		VIPAVA – MIREN	
Mesec/month	ton	%	ton	%	ton	%	ton	%
jan / Jan	2778	8.92	2030	1.76	1646	3.47	14030	32.49
feb / Feb	630	2.02	293	0.25	192	0.40	1657	3.84
mar / Mar	1062	3.41	3349	2.91	674	1.42	295	0.68
apr / Apr	2969	9.54	3163	2.75	471	0.99	2193	5.08
maj / May	5040	16.19	1717	1.49	200	0.42	513	1.19
jun / Jun	3814	12.25	2105	1.83	88	0.18	343	0.79
jul / Jul	1736	5.58	3767	3.27	222	0.47	268	0.62
avg / Aug	1960	6.29	1339	1.16	81	0.17	241	0.56
sep / Sep	2180	7.00	6931	6.02	3119	6.57	121	0.28
okt / Oct	2994	9.61	10635	9.24	9384	19.76	2521	5.84
nov / Nov	5045	16.20	72493	62.98	25894	54.53	7670	17.76
dec / Dec	928	2.98	7291	6.33	5517	11.62	13322	30.86
Letni transport Yearly transport	31136	100	115111	100	47488	100	43176	100

Ker je bilo leto 2003 suho, je bila tudi količina transportiranega materiala v rekah majhna. Srednje vrednosti izkazujejo podpovprečen transport na Muri, Savinji, Savi in Sori, saj so bile vsebnosti suspendiranega materiala nizke, precej podpovprečen pa je bil tudi pretok. Največ, preko 115 tisoč ton materiala, je v enem letu prenesla Sava v Hrastniku, od tega skoraj dve tretjini v novembru. Tudi Savinja in Sora sta največ materiala transportirali novembra, Vipava pa januarja in decembra. V Vipavi je bil letni transport suspendiranega materiala nadpovprečen.

Zanimivi so tudi podatki o vsotah letnih vrednosti prenešenega materiala za zadnjih 10 let (preglednica 10), ki so nedvomno velike, ob upoštevanju dejstva, da gre le za suspendiran material rečnega transporta. Skupna količina transportiranega materiala je v 10 letih v Vipavi dosegla 277 tisoč ton, v Muri pa nekaj manj kot 3 milijone ton. Savinja je v istem obdobju transportirala skozi profil v Velikem Širju 3,4 milijone ton, čeprav je zaledje postaje mnogo manjše kot v primeru Mure v Gornji Radgoni. Vzrok za intenzivno premeščanje suspendiranega materiala lahko iščemo v izrazito hudourniškem režimu Savinje, v veliki reliefni energiji porečja ter v geološki sestavi pobočij, s katerih se material spira v Savinjo.

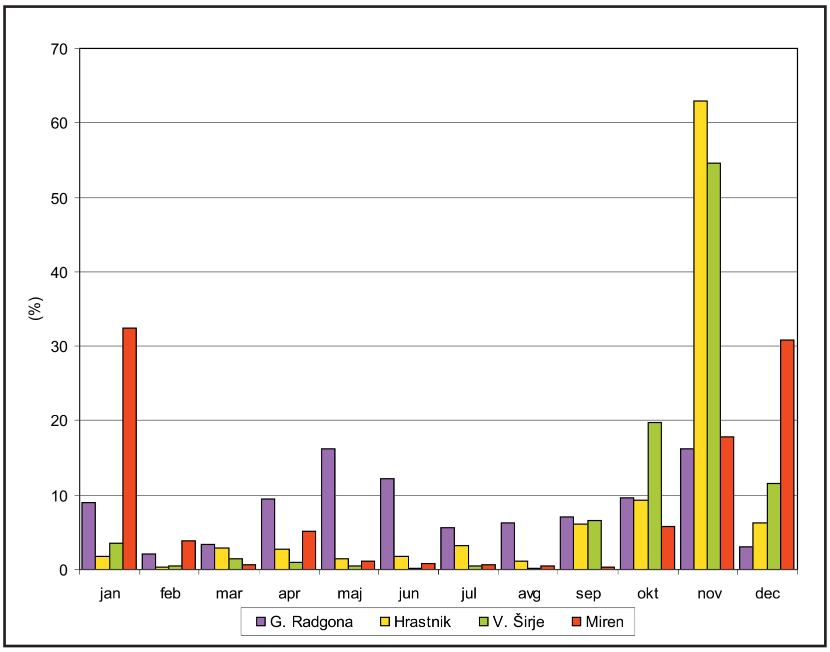
Razlike v količini transportiranega materiala med porečji, ki imajo izpolnjen deset letni niz so precejšnje (graf 16). V letu 2003 je Mura prenesla le 1 odstotek desetletnega transporta, Savinja pa 3 odstotke. Na Vipavi je bil transport precej nadpovprečen, saj je letni transport predstavljal 16 odstotkov

Transport of suspended material

The quantity of suspended material transport in water is monitored through the measurement of concentration of suspended material, from which, through the measurement of discharges, the transport of suspended material S (kg/s) is calculated. The monthly and annual concentrations of transported material are then calculated from daily concentrations (Table 9).

Since 2003 was a dry year, the quantity of transported material in rivers was small. The mean concentrations show below-average transport on the rivers Mura, Savinja, Sava and Sora as concentrations of suspended material were low with discharges considerably below the average. The highest annual transport exceeding 115 thousand tons of material was carried by the Sava River in Hrastnik, with almost two thirds of it in November. The largest quantities transported by the rivers Savinja and Sora also occurred in November; and in January and December by the Vipava River. The annual transport of suspended material by the Vipava River was above-average.

Worth noting are also the data on the total material transport for the last 10 years (Table 10), which is undoubtedly high when one considers that they only refer to the transport of suspended material by rivers. The total quantity of material transported in ten years by the Vipava River exceeded 277 thousand tons and material transported by the Mura River is slightly less than 3 million tons. The Savinja during the same period transported 3.4 million tons



Graf 15: Delež transportiranega materiala po mesecih v letu 2003.
Graph 15: Share of transported material by month in 2003.

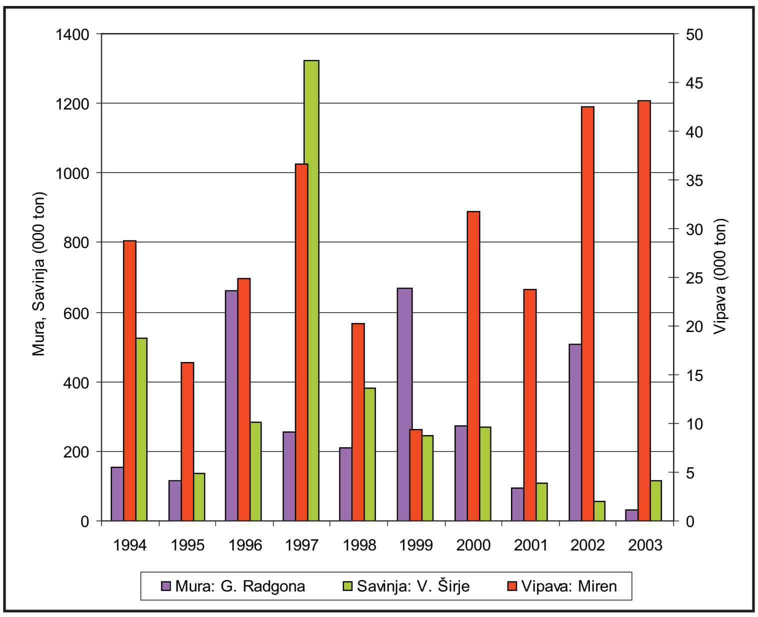
desetletnega transporta, kar je največji delež v obdobju. Savinja je največ materiala v zadnjih desetih letih transportirala leta 1997, kar 38 odstotkov, Mura pa 1996 in 1999 po 23 odstotkov.

through Veliko Širje although the catchment area at this station is considerably smaller than in the case of the Mura River in Gornja Radgona. The reason for the intensive transport of suspended material can also be found in the pronounced torrential regime of the Savinja River, the large hydraulic gradient energy of the river basin and in the geology of slopes, from which material is eroded into the Savinja River.

The differences in the quantities of transported material among river basins with 10-year data time series are considerable (Graph 16). In 2003, the Mura River transported only 1 percent of the ten-year transport amount and the Savinja River only three percent. The transport was considerably above-average on the Vipava River as the annual transport of material represented 16 percent of the 10-year transport total, which is the largest share for the period analyzed. The Savinja River transported the largest amount of material in the last 10 years in 1997, while in the years 1996 and 1999 the Mura River transported 23 percent respectively.

Preglednica 10: Letne vrednosti prenešenega suspendiranega materiala za obdobje 1994-2003 (tisoč ton).
Table 10: Annual values of transported suspended material for the 1994-2003 period (thousand tons).

Vodomerna postaja Gauging station	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Vsota Total
MURA – G. RADGONA	154	116	661	255	211	670	275	96	508	31	2977
SAVINJA - VELIKO ŠIRJE	525	136	283	1322	381	244	269	109	57	115	3441
VIPAVA - MIREN	29	16	25	37	20	9	32	24	43	43	277



Graf 16: Količina transportiranega suspendiranega materiala v desetletnem obdobju (tisoč ton).
Graph 16: The amount of transported suspended material in a ten-year period (thousand tons).

VISOKE VODE REK IN POPLAVE

Janez Polajnar

V letu 2003 je bilo občutno manj visokih voda kot prejšnja leta. Razen silovite hudourniške poplave v Zgornjesavski dolini v tem letu ni bilo velikih povodnji.

Največ visokih voda je bilo v jesenskem času, novembra in decembra, ko so večje reke poplavljale na območjih vsakoletnih poplav. Največ škode so povzročile hudourniške poplave konec avgusta na območju Rateč in Kranjske Gore. Nastopile so v času, ko so v večjem delu države prevladovale sušne razmere. Novembra so bile hudourniške poplave tudi v okolici Tržiča.

Leta 2003 je bilo zabeleženih 24 visokovodnih primerov, ko so reke na vodomernih postajah in gladina morja ob slovenski obali presegle pogojne vodostaje (graf 17). Leta 2003 je bilo za več kot polovico manj visokovodnih primerov kot prejšnja leta. Največ visokih voda je bilo novembra (10), oktobra (5) in decembra (3). Julija in avgusta so poplavljali hudourniki v severozahodni Sloveniji, jeseni pa so bile visoke vode po vsej državi.

Reke so poplavljale povečini na območjih vsakoletnih poplav, potoki in hudourniki na območju Kranjske Gore, Rateč in Tržiča so se razlili in nanašali plavine na območja, kjer poplave niso pogoste (preglednica 11). Hudourniške poplave so povzroči-

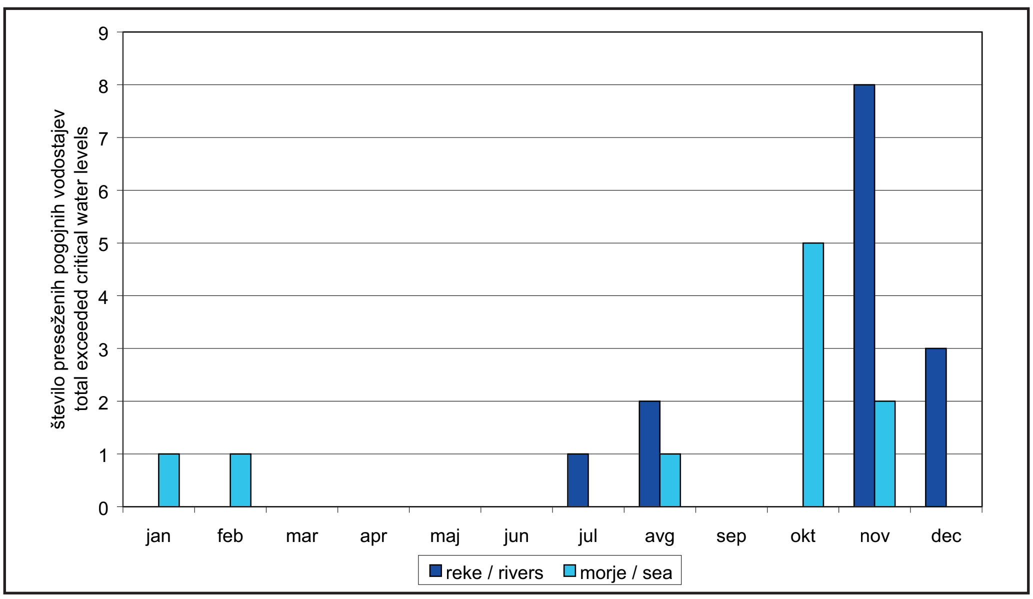
HIGH WATERS OF RIVERS AND FLOODS

Janez Polajnar

There were considerably fewer instances of high water in 2003 than in previous years. Except for extreme torrential flooding in the valley of Zgornjesavska dolina, no great inundation was noted in this year.

The most instances of high waters were observed in the autumn and in November and December when larger rivers flooded in their annual flood plains. The greatest damage was caused by torrential flooding at the end of August in the Rateče and Kranjska Gora areas arising during a period when the majority of the country experienced drought. Torrential flooding was also seen in the vicinity of Tržič in November.

In 2003, 24 cases of high waters were observed when rivers at water gauging stations and the sea level on the Slovenian coast exceeded critical water levels at which warnings are issued to the public (Graph 17). In 2003, there were half as many cases of high waters as compared to the previous years. The most instances of high waters occurred in November (10 instances), October (5 instances) and in December (3 instances). July and August saw torrential flooding in north-western Slovenia with high waters prevailing throughout the country in autumn.



Graf 17: Število preseženih pogojnih vodostajev slovenskih rek na opazovanih vodomernih postajah in gladine morja ob slovenski obali leta 2003.
Graph 17: The total exceeded critical water levels of Slovenian rivers at water gauging stations and the sea levels along the Slovenian coast in 2003.

Preglednica 11: Visoke vode in njihovo razlitje leta 2003 (ARSO, CORS, razlitja manjših hudournikov niso upoštevana).
Table 11: High waters and their flooding in 2003 (Environmental Agency of the Republic of Slovenia – ARSO, Republic of Slovenia Notification Centre – CORS, overflowing small torrents are not included).

Vodotok Stream	jan Jan	feb Feb	mar Mar	apr Apr	maj May	jun Jun	jul Jul	avg Aug	sep Sep	okt Oct	nov Nov	dec Dec
DRAVA											1	
VIPAVA											1	
REKA												1
LJUBLJANICA												1
POLJANSKA SORA											1	
SAVA DOLINKA								1				
GRADAŠČICA											1	
TRŽIŠKA BISTRICA											1	
TREBIŽA								1				
BELI POTOK								1				
KROTNIK								1				
SUHELJ								1				
PIŠNICA								1				
NADIŽA (TAMAR)								1				
Morje ob slovenski obali The sea on the Slovenian coast	1	1						1		5	2	

le gmotno škodo na stanovanjskih in gospodarskih objektih, prometnicah in kmetijskih površinah.

Visoke vode avgusta leta 2003

V petek 29. in nedeljo 31. avgusta 2003 je predvsem v severozahodni Sloveniji padla izjemno velika količin padavin. Po podatkih avtomatske postaje je 29. avgusta v Ratečah padlo 145 mm padavin. Glavnina je bila pozno popoldan, največ med 19:00 in 20:30 uro. V močnem nalivu je v uri in pol padlo okoli 59 mm dežja, za eno in pol urne padavine pomeni to 130-letno povratno dobo (graf 18). V soboto 30. avgusta 2003 je padlo manj kot 5 mm dežja.

V nedeljo 31. avgusta 2003 so bile v severozahodni Sloveniji ponovno obilne padavine. Avtomatska postaja v Ratečah je izmerila 127 mm dežja. Izdatnost padavin je bila manjša kot v petek, povratna doba nalivov je bila manj od 5 let (graf 19).

Zaradi obilnih padavin so na območju Rateč in Kranjske Gore 29. avgusta 2003 poplavljali potoki in hudourniki: Trebiža, Beli Potok, Nadiža, Krotnik, Suhelj, Tofov graben, Pišnica in Hladnik. Narasli hudourniki so v kratkem času napolnili strugo Save Dolinke. Na območju, kjer so bile hudourniške poplave, je bil izmerjen največji pretok Save Dolinke na vodomerni postaji Kranjska Gora 29. avgusta 2003 ob 20:30 uri, in sicer 35,6 m^3/s. Po statističnih analizah je tak pretok ovrednoten s 50-letno povratno dobo. V spodnjem delu Zgornjesavske doline je bil na vodomerni postaji na Jesenicah izmerjen največji

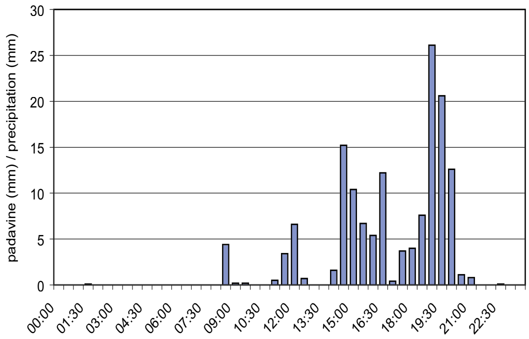
Rivers flooded predominantly in areas that experience annual flooding; streams and torrents spilled over in the areas of Kranjska Gora, Rateče and Tržič carrying suspended sediment to areas where flooding is not frequent (Table 11). Torrential flooding caused pecuniary damage to residential and commercial buildings, traffic infrastructure and farmland.

High waters in August 2003

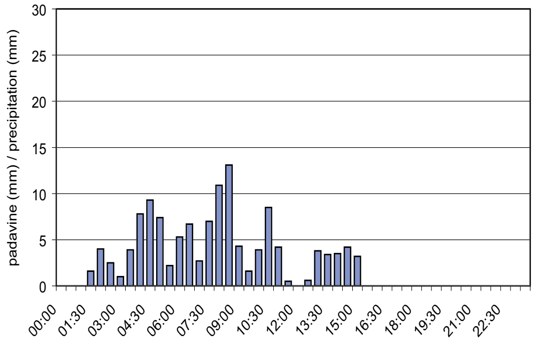
There was an extraordinarily large amount of precipitation on Friday the 29th and Sunday the 31st of August, particularly in north-western Slovenia. According to data from the automatic gauging station, there were 145 mm of precipitation in Rateče on 29 August with the majority occurring in the late afternoon and the greatest amount recorded between 7 p.m. and 8.30 p.m. The heavy downpour resulted in 59 mm of rain falling within an hour and a half, meaning a 130-year return period in one hour and a half (Graph 18). Less than 5 mm of rain fell on Saturday, 30 August 2003.

There was heavy precipitation once again in the north-western part of Slovenia on Sunday, August 31, 2003. The automatic water gauging station in Rateče recorded 127 mm of rain, a smaller quantity than on the Friday before with a return period of the downpours of less than 5 years (Graph 19).

The heavy precipitation led to the flooding of the following streams and torrents in Rateče and Kranjska Gora on 29 August 2003: Trebiž, Beli



Graf 18: Količina 30 minutnih padavin v mm, izmerjena 29. avgusta 2003 na avtomatski postaji Rateče.
Graph 18: The amount of the 30 minute precipitation in mm recorded on 29 August 2003 at the automatic rain gauge in Rateče.



Graf 19: Količina 30 minutnih padavin v mm, izmerjena 31. avgusta 2003 na avtomatski postaji Rateče.
Graph 19: The amount of the 30 minute precipitation in mm recorded on 31 August 2003 at the automatic rain gauge in Rateče.

pretok Save Dolinke 112 m^3/s, kar ustreza 10-letni povratni dobi velikih pretokov. Na prej omenjenih hudourniških potokih ni merilnih mest in podatkov, na osnovi katerih bi lahko ovrednotili odtok.

Potok, Nadiža, Krotnik, Suhelj, Tofov graben, Pišnica and Hladnik. The rising torrents filled the river channel of the Sava Dolinka within a short period of time. In the area experiencing torrential flooding, the highest discharge of the Sava Dolinka was measured at the water gauging station Kranjska Gora on 29 August 2003 at 8.30 p.m., namely 35.6

Podivjani potok Hladnik (foto: Tanja Cegnar, avgust 2003).
Torrent Hladnik (photo: Tanja Cegnar, August 2003).

Visoke vode novembra leta 2003

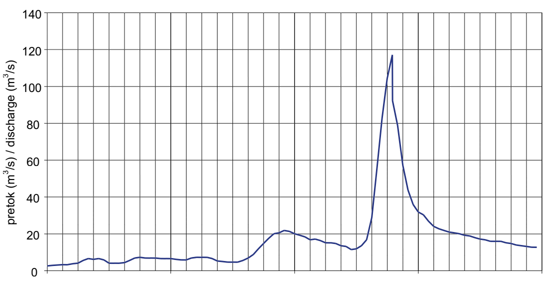
V četrtek 30. oktobra 2003 je predvsem v jugozahodni Sloveniji in v Julijskih Alpah padlo med 25 in 47 mm padavin. Namočenost tal se je povsod po državi povečala. 31. oktobra 2003 je povsod po državi deževalo, količina padavin ni bila velika. V soboto 1. novembra 2003 in v noči na nedeljo je deževalo povsod po državi. Največ padavin, preko 100 mm, je padlo v Julijskih Alpah, v predalpskem hribovju in v Karavankah (24 urna količina padavin: Vogel 114 mm, Vojsko 121 mm, Rateče 82 mm). Vmes so bile tudi krajevne nevihte. V noči na soboto 1. novembra 2003 so reke na zahodu države pričele naraščati, predvsem Soča, Sava Bohinjka in Sava Dolinka. Pretoki rek so bili veliki: Soča v Solkanu 740 m^3/s, Sava v Radovljici 383 m^3/s. V soboto dopoldne sta pričeli naraščati še Savinja in Drava. V soboto čez dan so se pretoki rek prehodno ustalili. Zvečer so ob ponovnih padavinah z nevihtami pričele naraščati reke v zahodni Sloveniji, Sava v srednjem toku ter Drava v spodnjem toku. Od pritokov reke Save je najbolj narasla Tržiška Bistrica, katere hudourniški pritoki so v dobrih dveh urah napolnili strugo. Največji pretok je dosegla 1. novembra ob 19. uri, ko je na vodomerni postaji v Preski znašal 117 m^3/s, kar je več kot 50-letna povratna doba velikih pretokov (graf 20).

Največja vodnatost večine rek je bila v noči na nedeljo 2. novembra 2003. Sava je v srednjem toku dosegla 2- do 5-letno povratno dobo velikih pretokov (graf 21), Sava Bohinjka 5- do 10-letno povratno dobo velikih pretokov. V drugem delu noči in v nedeljo 2. novembra 2003 so reke v svojem zgornjem toku že pričele upadati. Naraščale so še Drava, Sava v srednjem in spodnjem toku, Ljubljanica in Krka. V spodnjem toku je Drava ob 8. uri dosegla največji pretok okoli 1650 m^3/s, Sava je na meji s Hrvaško dosegla največji pretok okrog 1300 m^3/s, kar je v obeh primerih vsakoletna visoka voda.

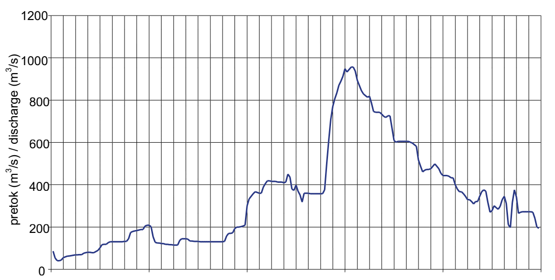
m^3/s. According to the statistical analyses, such a discharge was assessed as a 50-year return period. At the downstream section of the valley of Zgornjesavska dolina (Upper Sava River Valley), the largest discharge of the Sava Dolinka with 112 m^3/s was measured at the water gauging station in Jesenice with a 10-year return period. There are no gauging stations or data available on the aforementioned torrential streams, on the basis of which runoff could be evaluated.

High waters in November 2003

There was between 25 and 47 mm of precipitation on Thursday, 30 October 2003, predominantly in the south-eastern part of Slovenia and Julian Alps. Moisture content in the unsaturated zone increased throughout the country. There was precipitation throughout the country on 31 October 2003 without any marked precipitation amounts. On Saturday, November 1, 2003, and during the night until Sunday, there was precipitation throughout the country. The most precipitation, over 100 mm, was recorded in the Julian Alps, the pre-alpine hills and the Karavanke Mountains (precipitation in the 24 hour period: Vogel 114 mm, Vojsko 121 mm, Rateče 82 mm) with local storms occurring in between. During the night from Friday to Saturday, 1 November 2003, rivers in the western part of the country swelled, especially the rivers Soča, Sava Bohinjka and Sava Dolinka with river discharges being quite high: the Soča River in Solkan – 740 m^3/s and the Sava River in Radovljica – 383 m^3/s. On Saturday morning, the rivers Savinja and Drava also began to swell. During daytime on Saturday, river discharges temporarily stabilized. In the evening with renewed precipitation, the rivers in western Slovenia once again began to swell because of storms and also the Sava River in midstream and the Drava River in the downstream section. Of all the tributaries of the Sava River, the Tržiška Bistrica, whose torrential tributaries filled its stream in slightly over two hours, has



Graf 20: Pretok Tržiške Bistrice v Preski med 30. oktobrom in 3. novembrom 2003.
Graph 20: Discharge of the Tržiška Bistrica River in Preska between 30 October and 3 November 2003.



Graf 21: Pretok Save v Mednem med 30. oktobrom in 4. novembrom 2003.
Graph 21: Discharge of the Sava River in Medno between 30 October and 4 November 2003.

V nedeljo 2. novembra 2003 so padavine od zahoda postopno ponehale, delno se je razjasnilo, vodnatost rek se je po vsej državi zmanjševala.

Konec meseca, v noči s 26. na 27. november 2003, je v zahodni in osrednji Sloveniji obilno deževalo. Padlo je od 50 do 114 mm padavin. Največ na območju Postojne (96 mm), Brnika (100 mm), Škofjeloškega in Polhograjskega hribovja (Katarina nad Ljubljano 107 mm). V drugem delu noči so pričele naraščati reke na zahodu države, predvsem: Soča, Vipava in Sava Bohinjka. V osrednji in južni Sloveniji so naraščale Ljubljanica, Gradaščica, Poljanska Sora, Sora, Sava v srednjem toku, Krka in Kolpa. Reke so dosegle povečini vsakoletne visoke vode. Najbolj je narasla Gradaščica, ki je 27. novembra ob 3:30 uri v Dvoru dosegla pretok 43 m^3/s, kar je 2-letna povratna doba velikih pretokov.

Visoke vode decembra leta 2003

V ponedeljek in v noči na torek 30. decembra 2003 je predvsem v zahodni in osrednji Sloveniji ter na Notranjskem padla znatna količin padavin, med 25 in 81 mm. Meja sneženja je bila na višini med 800 in 1100 m. Na delih porečij pod mejo sneženja je deževalo, talil se je sneg.

Tržiška Bistrica je v Preski odnesla cesto.
(foto: Marko Burger, 3. november 2003)
Road eroded by high water of the Tržiška Bistrica at Preska.
(photo: Marko Burger, 3 November 2003)

swelled the most. The largest discharge was reached on 1 November at 7 p.m. when the discharge at the water gauging station Preska amounted to 117 m^3/s, which is more than a 50-year return period of high discharges (Graph 20).

The highest discharges in rivers occurred in the night from Saturday to Sunday, 2 November 2003. The Sava River in the midstream section reached a 2- to 5-year return period for high discharges (Graph 21) while the Sava Bohinjka achieved a 5- to 10-year return period of high discharges. In the second half of the night from Saturday to Sunday and on Sunday, 2 November 2003, rivers in their upstream sections began falling. Only the rivers Drava, the Sava in the midstream and downstream sections, the Ljubljanica and Krka continued to rise. The Drava in the downstream section reached its highest discharge of around 1650 m^3/s at 8 a.m. and the Sava River at the cross-section on the border with Croatia around 1300 m^3/s which represents high water on an annual level in both cases.

On Sunday, 2 November 2003, precipitation gradually ceased from the western part of the country, the weather clearing up partially, with water quantities of rivers decreasing throughout the country.

At the end of the month during the night from the 26th to the 27th November 2003, there was abundant precipitation in the western and central parts of Slovenia. There was from 50 to 114 mm of precipitation during this period with the greatest amounts recorded in the areas of Postojna (96 mm), Brnik (100 mm), and Škofja Loka and the hills of Polhograjsko hribovje (Katarina above Ljubljana – 107 mm). In the second half of the night, rivers began rising in the western part of the country, particularly: the rivers Soča, Vipava and Sava Bohinjka. In the central and southern part of Slovenia, the rivers Ljubljanica, Gradaščica, Poljanska Sora, Sora, Sava in the midstream section, Krka and Kolpa also began rising. The rivers reached the annual high water. The Gradaščica River rose the most, reaching a discharge of 43 m^3/s at Dvor on 27 November at 3.30 a.m. resulting in a 2-year return period of high discharges.

High waters in December 2003

On Monday and during the night to Tuesday, 30 December 2003, there was a considerable amount of precipitation predominantly in western and central Slovenia and in the Notranjska region of between 25 and 81 mm. The snowfall altitude lay between 800 and 1100 m. In river basin areas beneath the snowfall altitude, it rained and the snow melted.

V torek 30. decembra 2003 je deževalo povsod po državi, meja sneženja je bila na višini med 800 in 1100 m. Padlo je med 10 in 35 mm padavin.

V jutranjih urah 30. decembra so narasle reke v zahodni in osrednji Sloveniji ter na Notranjskem. Pretoki Soče, Vipave, Idrijce, Ljubljanice, Reke, Sore, Gradaščice, Kamniška Bistrice ter Save v srednjem in spodnjem toku so dosegli velike letne pretoke. Najbolj je narasla Reka, ki je poplavljala na območju vsakoletnih poplav v dolini med Zabičami in Ilirsko Bistrico. S hidrometrično meritvijo je bil na Reki v Trnovem, pod Ilirsko Bistrico, ugotovljen pretok 125 m^3/s, kar je že 5-letna povratna doba velikih pretokov. V jutranjih urah je pričela poplavljati Ljubljanica (pretok v Mostah 183 m^3/s) na območju vsakoletnih poplav med Bevkami in Blatno Brezovico, Vipava pa je, ob pretoku 127 m^3/s v Dolenju, ostala v strugi. Sredi dneva so pretoki rek v zahodni Sloveniji pričeli upadati. Naraščale so le še Sava in Vipava v spodnjem toku ter Krka in Kolpa. Pretok Ljubljanice je ostal nespremenjen vse do 31. decembra.

On Tuesday, 30 December 2003, it rained throughout the country with the snowfall altitude being between 800 and 1100 m. There was between 10 and 35 mm of precipitation during the day.

In the morning hours of 30 December, rivers in western and central Slovenia and the Notranjska region swelled again. Discharge of the rivers Soča, Vipava, Idrijca, Ljubljanica, Reka, Sora, Gradaščica, Kamniška Bistrica and Sava in the downstream and in the midstream sections reached high annual discharges. The Reka River swelled the most and flooded the annual flood plain in the valley stretch of the river between Zabiče and Ilirska Bistrica. Using hydrometric measurements, a discharge of 125 m^3/s was determined on the Reka River in Trnovo downstream from Ilirska Bistrica representing a 5-year return period of high discharges. The Ljubljanica River (discharge in Moste – 183 m^3/s) began flooding in the morning hours in the annual flood plain between Bevke and Blatna Brezovica while the Vipava River remained in the river channel with a discharge of 127 m^3/s in Dolenje. At midday, river discharges in western Slovenia began to decrease with only the rivers Sava and Vipava in the downstream section and the rivers Krka and Kolpa still rising. The discharge of the Ljubljanica remained unchanged all the way up to 31 December.

NIZKE VODE REK IN HIDROLOŠKA SUŠA

Mira Kobold

Za obdobje od leta 2000 naprej so za slovenske vodotoke značilna dolga nizkovodna stanja, ki so posledica pomanjkanja padavin. Še zlasti to velja za leto 2003, ko so bili pretoki od februarja pa vse do septembra pod srednjimi malimi vrednostmi, avgusta pa so se približali ter ponekod tudi padli pod najmanjše izmerjene obdobne pretoke. Stanje površinskih voda v letu 2003 smo primerjali z letom 1993, ki je bilo hidrološko najbolj suho leto v obdobju zadnjih štirideset let (graf 22).

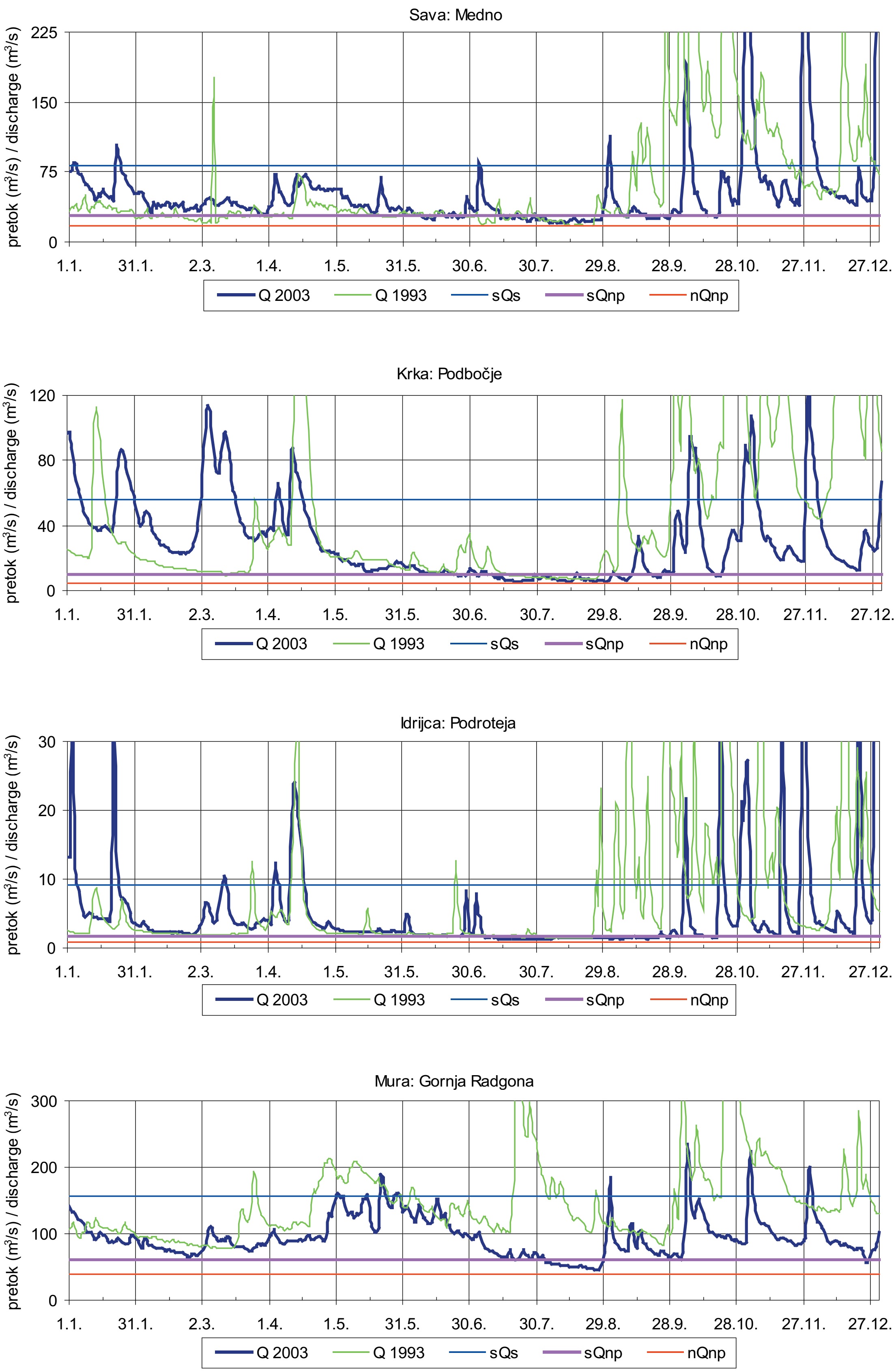
Januarja 2003 smo beležili pretoke, ki so bili v mejah srednjih obdobnih vrednosti. Že februarja so se pretoki močno zmanjšali in se približali srednjim malim obdobnim pretokom. Otoplitev konec februarja in v marcu je povzročila taljenje snega in s tem kratkotrajno povečano vodnatost rek, vendar so pretoki povečini ostali pod srednjimi obdobnimi pretoki. Padavine v aprilu, predvsem v prvi polovici meseca, so vplivale na povečanje pretokov do srednjih obdobnih vrednosti, ponekod tudi do velikih obdobnih vrednosti. Proti koncu meseca so se pretoki postopno zmanjševali in v maju smo zopet beležili srednje male pretoke, ki pa so ponekod v juniju že padli pod srednje male obdobne vrednosti. Proti koncu julija in v avgustu so se pretoki že približali najmanjšim izmerjenim obdobnim vrednostim. Padavine v poletnih mesecih, predvsem v obliki ploh in neviht, so le malokje vplivale na kratkotrajno povečanje pretokov. Hidrološka suša se je stopnjevala iz meseca v mesec. Najmanjše pretoke smo merili v avgustu. Na več merilnih mestih mreže vodomernih postaj (Ledava v Polani in Čentibi, Velika Krka v Hodošu, Dravinja v Makolah, Oplotnica v Draži vasi, Pesnica v Gočovi in Zamušanih, Savinja v Velikem Širju, Sotla v Rakovcu, Mestinjščica v Sodni vasi, Sava v Hrastniku, Sava v Čatežu) so bili zabeleženi najmanjši pretoki v opazovalnem obdobju. Primorske reke, Dragonja in Drnica ter Reka v spodnjem toku, so presahnile, kar je za te reke v poletnih mesecih skoraj običajen pojav. Presahnili so tudi vodotoki v severovzhodni Sloveniji (Kučnica, Martjanski in Kobiljski potok). Pretoki rek v južni in ponekod v osrednji Sloveniji so se zmanjšali na raven 10-letne povratne dobe malih pretokov. Ščavnica, Pesnica, Savinja, Sotla in Sava v spodnjem delu so imele 20- do 50-letno povratno dobo, drugod pa 2- do 5-letno povratno dobo malih pretokov. Na Muri, za katero so mali pretoki značilni za zimske mesece, smo beležili srednje male pretoke tudi v spomladanskih in poletnih mesecih, ko so ti običajno nad srednjimi vrednostmi. Zadnje dni v septembru in v

LOW FLOWS OF RIVERS AND HYDROLOGICAL DROUGHT

Mira Kobold

Long low water conditions characterized the period from 2000 to 2003 and were the result of the lack of precipitation in Slovenia. This especially holds true for the year 2003 when discharges from February up to September remained below the mean low values, nearing the mean in August and in places also falling under the all time lows. The condition of surface waters in 2003 was compared to that of 1993 which was the hydrologically driest year in the last forty years (Graph 22).

Discharges close to the mean values of the reference period were recorded in January 2003. Already in February, discharges strongly decreased nearing the mean low discharges of the reference period. The warming up at the end of February and March resulted in snow melting and with it a short-term increase in water quantities of rivers with discharges, however, predominantly remaining under the mean discharges for the reference period. Precipitation in April, especially in the first half of the month, led to increased discharges up to the mean discharge values of the reference period and in some places to high discharge values of the reference period. Towards the end of the month, discharges gradually decreased with the mean low discharges again recorded in May which had in some places in June already fallen under the mean discharge values of the 1971-2000 reference period. Towards the end of July and in August, discharges once again neared the minimum measured values of the reference period. Precipitation during the summer months predominantly in the form of showers and storms only affected the short-term increase of discharges in a few rivers. The hydrological drought intensified from month to month. The lowest discharges were measured in August. The lowest discharges for the entire observation period were recorded at a number of water gauging stations (the rivers Ledava in Polana and Čentiba, the Velika Krka in Hodoš, the Dravinja in Makole, the Oplotnica in Draža vas, the Pesnica in Gočova and Zamušani, the Savinja in Veliko Širje, the Sotla in Rakovec, the Mestinjščica in Sodna vas, the Sava in Hrastnik and the Sava in Čatež). Rivers in Primorska, the Dragonja, Drnica and Reka in the downstream section had dried up, which is quite usual for these rivers during the summer months. Watercourses in north-eastern Slovenia had also dried up (the Kučnica, Martjanski and the stream of Kobiljski potok). River discharges in the southern and some parts of central Slovenia had decreased to a 10-year return period of low discharges. The Ščavnica, Pesnica, Savinja, Sotla and Sava in its downstream section had between a 20- to 50-year return period while other places had a 2- to 5-year



Graf 22: Srednji dnevni pretoki na izbranih vodomernih postajah za leti 2003 in 1993 ter obdobne vrednosti pretokov: srednji obdobni (sQs), srednji mali (sQnp) in najmanjši mali (nQnp) obdobni pretok.
Graph 22: Mean daily discharges at selected water gauging stations for the years 2003 and 1993 and characteristic discharge values (sQs – mean characteristic discharge, sQnp – mean low discharge and nQnp – the lowest low characteristic discharge).

začetku oktobra so padavine v celi državi povzročile povečanje pretokov, marsikje tudi preko srednjih pretokov. Vendar smo ob suhem in lepem vremenu sredi oktobra zopet beležili srednje male pretoke, ki pa so v zadnji dekadi meseca ob močnejših padavinah presegli srednje vrednosti.

Potek hidrološke suše v letu 2003 smo ponazorili še s srednjimi in minimalnimi mesečnimi pretoki ter mesečno količino padavin (graf 23). Na izbranih vodomernih in padavinskih postajah je v prvih šestih mesecih leta 2003 v povprečju padlo le okrog 50 odstotkov običajne količine padavin, v zahodni in osrednji Sloveniji nekaj nad 50 odstotkov, na severovzhodu države pa pod 50 odstotkov. Do konca septembra 2003 se padavinske razmere niso dosti izboljšale. V prvih devetih mesecih je v povprečju padlo nekaj več kot 60 odstotkov padavin od devetmesečnega dolgoletnega povprečja. Izstopa izjemno suh marec, ko je padlo pod 10 odstotkov običajne količine padavin za ta mesec. Podpovprečna količina padavin se je odražala v majhni vodnatosti rek. Padavinski primanjkljaj vse od začetka leta je povzročil, da so bili mesečni pretoki v prvi tretjini leta v mejah srednjih malih obdobnih vrednosti, od maja do septembra pa pod srednjimi malimi pretoki. Pretoki rek so se približali najmanjšim obdobnim mesečnim vrednostim in se marsikje zmanjšali pod najmanjša obdobna mesečna povprečja. To še zlasti velja za Muro, ki ima snežni režim in je običajno najbolj vodnata v poletnih mesecih. Zaradi neugodnih padavinskih razmer se hidrološko stanje tudi v jesenskih mesecih ni bistveno izboljšalo.

Nizkovodno stanje smo podrobneje analizirali za 32 vodomernih postaj, pri čemer smo upoštevali dva kriterija: letni minimum in dolžino trajanja nizkovodnega obdobja. V analizo smo vključili leto 1993, ki je bilo eno najbolj sušnih let v opazovalnem obdobju (preglednica 12). Primerjava najmanjših izmerjenih pretokov leta 2003 z najmanjšimi obdobnimi vrednostmi in letom 1993 ter analiza trajanja malih pretokov s številom vseh dni v letu, ko je bil pretok pod srednjim malim pretokom sQnp, in številom dni neprekinjenega trajanja pretoka pod sQnp za leti 2003 in 1993, je potrdila, da je bilo leto 2003 bolj sušno. Izjemnost leta 2003 v primerjavi z letom 1993 je pregledno prikazana z osenčenjem polj: več nižjih Qnp na obravnavanih vodomernih postajah in dolgotrajnejše sušno obdobje tako po številu vseh dni, ko je bil srednji dnevni pretok pod vrednostjo sQnp, kot po dolžini neprekinjenega trajanja pretoka pod sQnp. Najdaljša nizkovodna obdobja so bila zlasti v severovzhodni Sloveniji in na Primorskem.

Regionalne značilnosti sušnih razmer v letu 2003 najbolje ponazarjajo specifični odtoki v mesecu avgustu, ko je bila suša najbolj izrazita (karta 6). Pomanjkanje vode je bilo najbolj izrazito v juž-

return period of low discharges. On the Mura River, for which low discharges are usual during the winter months, mean low discharges were also recorded in the spring and summer months when these values are usually above the mean value. In the last days of September and beginning of October, precipitation throughout the country led to the increase of discharges and on many rivers also over the mean discharge. With the dry and bright weather in the middle of October, mean low values were once again recorded followed by heavier precipitation in the last third of the month again leading to a surpassing of mean values.

The course of hydrological drought of 2003 is represented in graphs using mean and minimum monthly discharges and the monthly amount of precipitation (Graph 23). At selected water and precipitation gauging stations, there was an average of around 50 percent of the normal quantity of precipitation in the first six months of 2003 with the amount of precipitation above 50 percent in western and central Slovenia and the amount of somewhat below 50 percent in the north-eastern part of the country. Until the end of September 2003, the precipitation situation had not improved much. In the first nine months, an average of slightly over 60 percent of the precipitation nine-month multi-annual mean had fallen. March was an exceptionally dry month with precipitation of less than 10 percent of the normal quantity for this month. A below-average quantity of precipitation resulted in the low water discharges of rivers. The precipitation deficit since the beginning of the year had resulted in monthly discharges being within the values of mean low discharges in the first third of the year and below the mean low discharges from May to September. The river discharges neared the lowest monthly values of the period and in many places dropped below the lowest monthly means of the reference period. This was especially true for the Mura River, which has a nival regime and usually has the highest discharges during the summer months. Due to the unfavourable precipitation conditions, the hydrological status did not essentially improve in autumn.

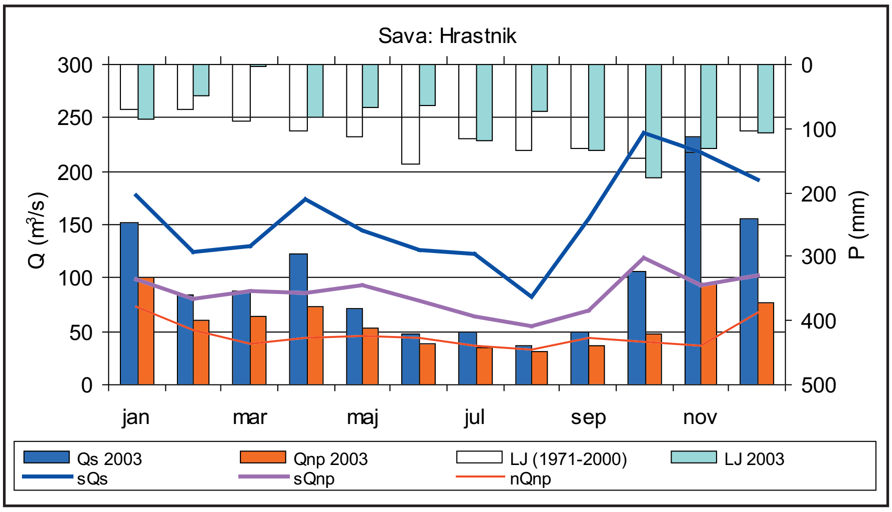
The low water level condition was analysed in detail at 32 water gauging stations whereby two criteria were considered: the annual minimum and the duration of the low water level period. Data from the year 1993 were included, which had been one of the driest years of the observed period (Table 12). A comparison made of the lowest measured discharges in 2003 with the lowest values of the reference period and the year 1993 and an analysis performed on the duration of low discharges against the number of days in the year when discharges remained below the mean low discharge sQnp and number of days with discharges continuously under sQnp for the years 2003 and 1993 confirmed that 2003 was drier. The exceptionality of 2003 compared to 1993 is displayed in the shadowed fields: more cases of low Qnp at considered water gauging stations and

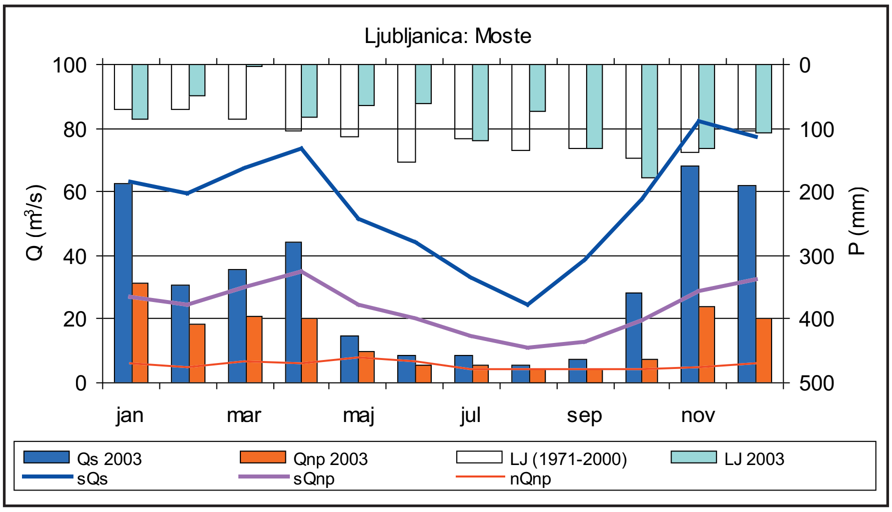
Preglednica 12: Najmanjši izmerjeni pretoki v letih 2003 in 1993 v primerjavi z obdobnima srednjim malim pretokom (sQnp) in najmanjšim pretokom (nQnp) iz obdobja delovanja postaje ter časovno trajanje malih pretokov.
Table 12: The lowest measured discharges in 2003 and 1993 in comparison with mean low discharge (sQnp) and the lowest discharge (nQnp) from the period of operation of the station and duration of low discharges.

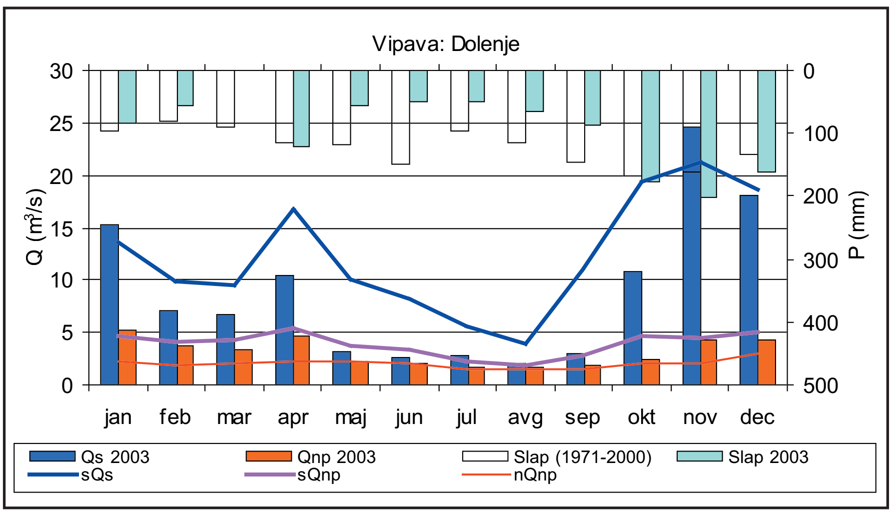
Vodomerna postaja Gauging station	Obdobne vrednosti Periodic discharges		2003			1993		
			Qnp	Q<sQnp		Qnp	Q<sQnp	
	sQnp	nQnp		št. vseh dni No. of days	neprekinjeno Continuous		št. vseh dni No. of days	neprekinjeno Continuous
MURA - GORNJA RADGONA	59.3	40	46	29	27	77.4	0	0
ŠČAVNICA – PRISTAVA	0.238	0.03	0.053	122	107	0.069	116	36
LEDAVA – POLANA	0.125	0.004	0.002	219	130	0.004	122	72
VELIKA KRKA – HODOŠ	0.037	0.003	0.003	222	138	0.003	167	142
MEŽA - OTIŠKI VRH	4.15	2.17	2.42	102	57	2.17	119	23
BISTRICA – MUTA	1.146	0.5	0.761	282	45	0.519	208	40
RADOLJNA – RUTA	0.618	0.325	0.285	135	40	0.446	28	11
DRAVINJA – LOČE	0.833	0.29	0.392	87	13	0.4	105	13
PESNICA – ZAMUŠANI	0.596	0.141	0.141	120	99	0.141	144	71
SAVA – RADOVLJICA	10.2	5	8.36	3	3	7.03	9	5
SAVA – ŠENTJAKOB	28.9	19.1	21.2	53	30	19.1	110	15
SAVA – ČATEŽ	77.6	50.8	48.3	114	54	50.8	96	28
TRŽIŠKA B. – PRESKA	2.36	1.64	1.61	84	57	1.64	37	6
SORA – SUHA	3.61	1.8	2.17	91	41	2.14	71	15
KAMNIŠKA B. – KAMNIK	2.1	1.14	1.16	63	28	1.14	95	36
SOTLA – RAKOVEC	0.893	0.4	0.337	128	101	0.604	25	13
KOLPA – RADENCI	6.29	3.36	3.52	72	51	4.25	43	34
LJUBLJANICA – MOSTE	7.92	4.04	4.48	87	57	6.02	43	27
GRADAŠČICA – DVOR	0.47	0.285	0.307	53	13	0.285	51	42
UNICA – HASBERG	2.27	0.94	1.49	92	85	1.6	25	13
SAVINJA – NAZARJE	3.47	1.44	1.98	74	28	2.63	46	16
SAVINJA – LAŠKO	7.89	3	3.74	100	31	4.55	66	13
BOLSKA - DOLENJA VAS	0.613	0.127	0.191	100	29	0.127	102	22
KRKA – PODBOČJE	9.89	4.4	5.5	82	40	7.05	41	40
RADULJA – ŠKOCJAN	0.273	0.09	0.085	72	29	0.25	20	12
SOČA - LOG ČEZSOŠKI	5.4	3.02	5.17	8	4	3.87	56	39
SOČA – SOLKAN	19.9	9.6	15.6	69	21	23.2	0	0
IDRIJCA – PODROTEJA	1.67	0.84	1.24	87	75	1.48	28	22
BAČA - BAČA PRI MODREJU	1.46	0.379	0.756	67	10	1.12	7	6
VIPAVA – DORNBERK	1.86	0.94	0.986	102	73	1.41	26	26
REKA - CERKVENIKOV MLIN	0.6	0.16	0.252	93	72	0.412	6	3
RIŽANA - KUBED	0.22	0.03	0.074	143	91	0.081	89	46

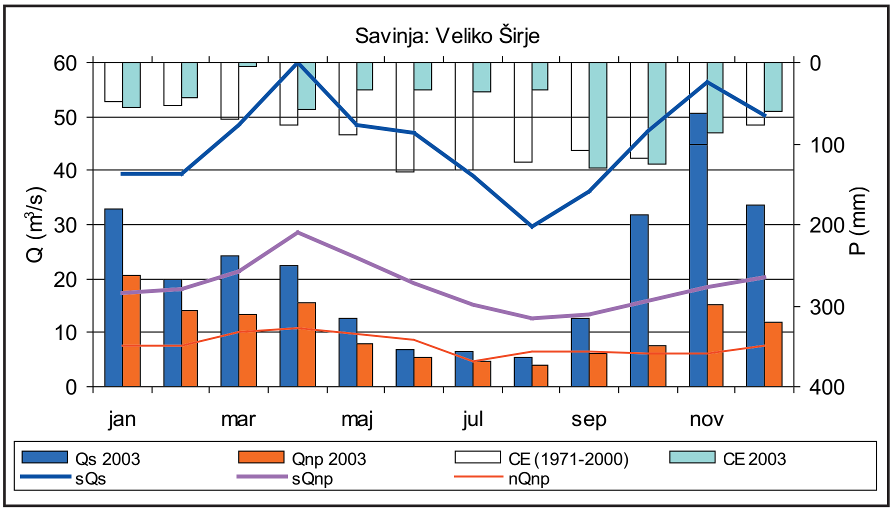
ni, vzhodni in severovzhodni Sloveniji, kjer so bili specifični odtoki najmanjši, med 0 in 2 l/s/km^2 (izjema je Mura). Primorske reke Dragonja in Drnica ter Reka v spodnjem toku so presahnile, prav tako potoki v severovzhodni Sloveniji. V osrednji Sloveniji so specifični odtoki znašali med 4 in 10 l/s/km^2. Največje specifične odtoke so v avgustu imele reke na severozahodu države, kjer so le ti znašali tudi do 20 l/s/km^2.

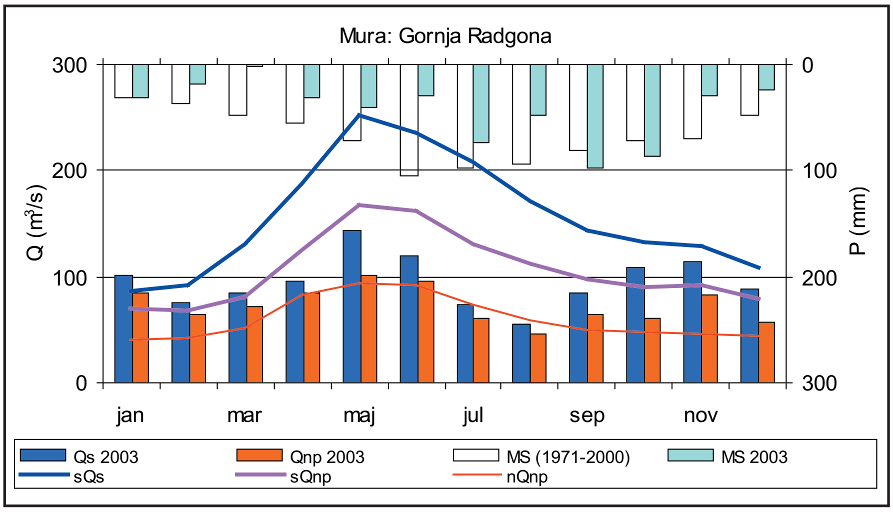
a longer drought period both according to all days in which the mean daily discharge remained below sQnp and according to the duration of discharges continuously under sQnp. The longest low water periods were primarily in north-eastern Slovenia and in Primorska.

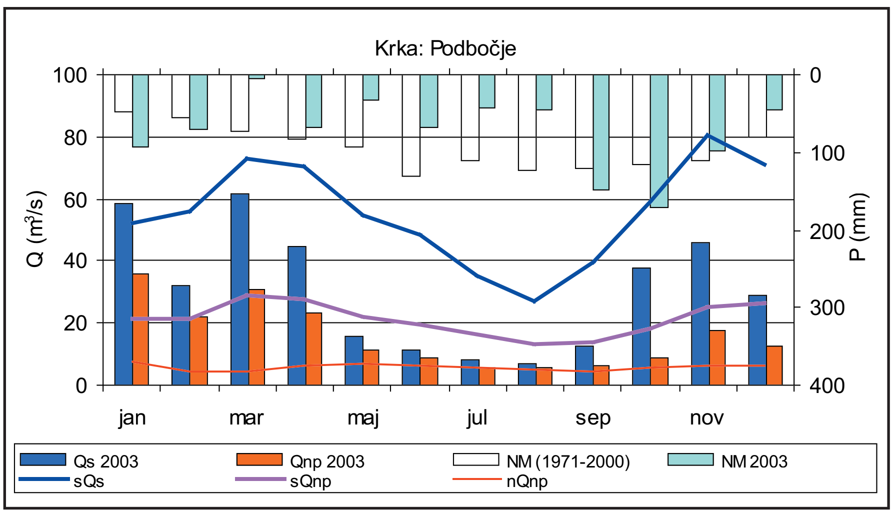

Sava: Hrastnik
300
250
200
150
100
50
0
Q (m³/s)
0
100
200
300
400
500
P (mm)
jan
mar
maj
jul
sep
nov
Qs 2003
Qnp 2003
LJ (1971-2000)
LJ 2003
sQs
sQnp
nQnp


Ljubljanica: Moste
100
80
60
40
20
0
Q (m³/s)
0
100
200
300
400
500
P (mm)
jan
mar
maj
jul
sep
nov
Qs 2003
Qnp 2003
LJ (1971-2000)
LJ 2003
sQs
sQnp
nQnp

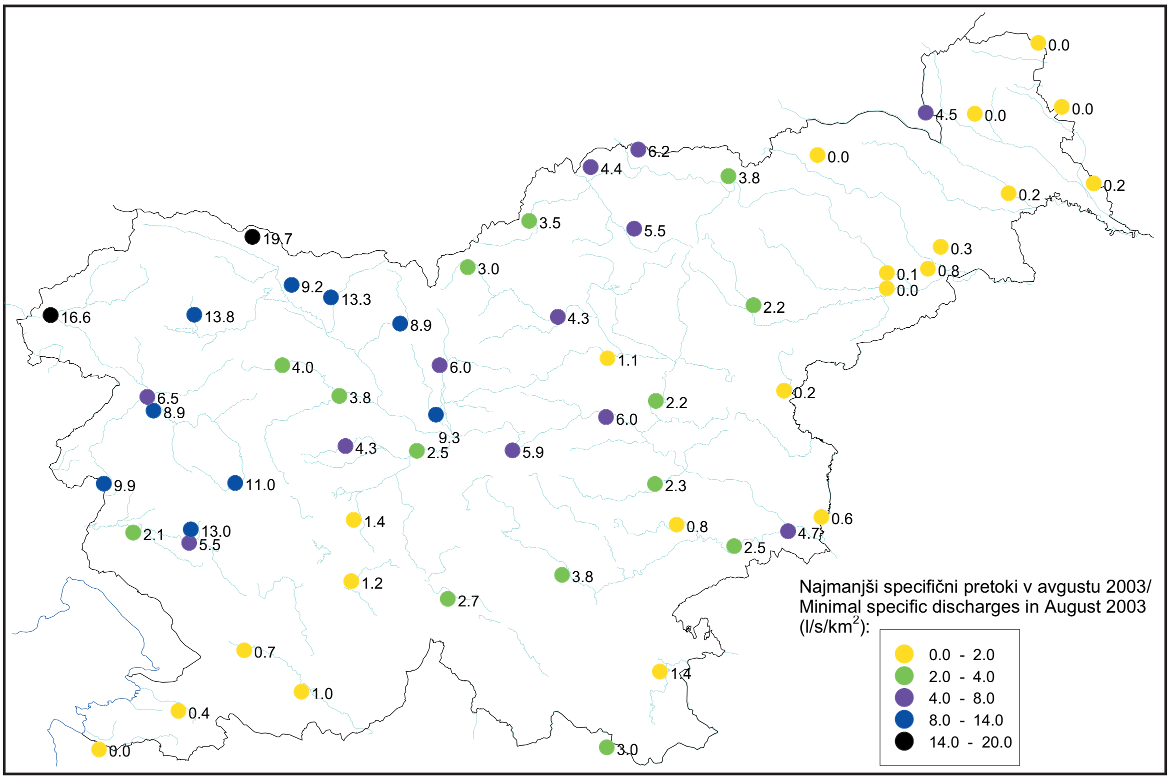

Vipava: Dolenje
30
25
20
15
10
5
0
Q (m³/s)
0
100
200
300
400
500
P (mm)
jan
feb
mar
apr
maj
jun
jul
avg
sep
okt
nov
dec
Qs 2003
Qnp 2003
Slap (1971-2000)
Slap 2003
sQs
sQnp
nQnp







Graf 23: Srednji (Qs) in minimalni mesečni pretoki (Qnp) v letu 2003 ter obdobne mesečne vrednosti pretokov: srednji obdobni (sQs), srednji mali (sQnp) in najmanjši mali (nQnp) mesečni pretoki, obdobne mesečne količine padavin obdobja 1971-2000 in mesečne količine padavin v letu 2003 z reprezentativnih padavinskih postaj.
Graph 23: Mean (Qs) and minimum monthly discharges (Qnp) in 2003 and the monthly discharge values of the reference period: mean (sQs), mean low (sQnp) and the lowest low (nQnp) monthly discharges, monthly amounts of precipitation for the 1971-2000 period and the monthly quantities of precipitation in 2003 from the representative rain gauging stations.



Karta 6: Najmanjši srednji dnevni specifični odtoki v avgustu 2003 na izbranih vodomernih postajah.
Map 6: The lowest mean daily specific runoffs in August 2003 at selected water gauging stations.

Savica v Ukancu (foto: Marko Burger, april 2003).
The Savica River in Ukanc (photo: Marko Burger, April 2003).

Po izvedenih obdelavah podatkov in analizah je nizkovodno stanje v letu 2003 ekstremen pojav in presega leto 1993. Značilnost hidrološke suše v letu 2003 je dolgotrajno neprekinjeno obdobje z malimi pretoki, ki je ponekod trajalo kar tretjino leta.

Regional features of drought conditions in 2003 are best characterized by specific runoffs in the month of August when the drought was most prominent (Map 6). The lack of water was most evident in southern, eastern and north-eastern Slovenia where specific runoffs were lowest, namely between 0 and 2 l/s/km^2 (with the exception of the Mura River). The Primorska Region rivers of Dragonja, Drnica and Reka in its downstream section dried up as did streams in north-eastern Slovenia. Specific runoffs in central Slovenia amounted to between 4 and 10 l/s/km^2. Rivers in the north-western part of the country in August had the largest specific runoffs amounting even up to 20 l/s/km^2.

Upon the processing of data and analyses having been performed, the low water situation in 2003 was established as being an extreme occurrence which was even more severe in terms of drought when compared to the year of 1993. The characteristic feature of the hydrological drought in 2003 was a long-term continuous period with low discharges, which in some places lasted for a third of the year.

B. PODZEMNE VODE

GLADINE PODZEMNIH VODA V ALUVIALNIH VODONOSNIKIH

Zlatko Mikulič

V letu 2003 so bile zaloge podzemnih voda večji del leta nizke, z izjemo vodonosnika Vrbanskega platoja. Leto je bilo izjemno sušno, saj so bile na nekaterih postajah merilne mreže zabeležene najnižje gladine podzemne vode do sedaj.

Višine gladin podzemnih voda v aluvialnih vodonosnikih na Slovenskem so v splošnem odvisne od ravnovesja med dotoki vode na eni strani, ter odtoki, izgubami in umetnimi odvzemi na drugi strani. Viri napajanja podzemne vode so padavine na območju vodonosnikov in v neposrednem padavinskem zaledju na obrobju ravnin, kakor tudi pronicanje iz rek in potokov na območju vodonosnikov. Negativni členi omenjenega ravnovesja pa so odtoki podzemne vode iz vodonosnikov oz. dreniranje v vodotoke ter evapotranspiracija – izhlapevanje vode in oddajanje vlage v ozračje skozi pore rastlin. Evapotranspiracija je posebej pomemben dejavnik v plitvih vodonosnikih severovzhodne Slovenije, kjer je tudi razmerje med količinami padavin in evapotranspiracije najmanj ugodno. Umetni odvzemi so predvsem s črpanjem za oskrbo z vodo, v širšem pomenu tudi odvajanje podzemne vode z melioracijskimi posegi. Za pojasnjevanje vodnih razmer podzemnih voda je torej potrebno upoštevati prostorsko in časovno spremenljivost količine padavin, evapotranspiracije in višino vode v rekah, ki mejijo na vodonosnike, ali pa jih prečkajo.

V letu 2003 so bili na območju vodonosnikov izrazito neugodni vsi podnebni dejavniki, ki pomembno vplivajo na režim podzemnih voda: male količine padavin, povišane temperature zraka in rekordno dolgo trajanje sončnega obsevanja. Na območju vseh vodonosnikov je padlo precej manj padavin od povprečja primerjalnega obdobja 1961-1990, srednja letna temperatura zraka je praviloma presegala povprečno vrednost za poldrugo stopinjo Celzija, vročih dni je bilo rekordno veliko.

Napajanje iz padavin je bilo na vseh vodonosnikih precej manjše kot običajno, ker so bile količine letnih padavin v razponu od slabih dveh tretjin do dobrih treh četrtin dolgoletnega povprečja. Naj-

B. GROUNDWATERS

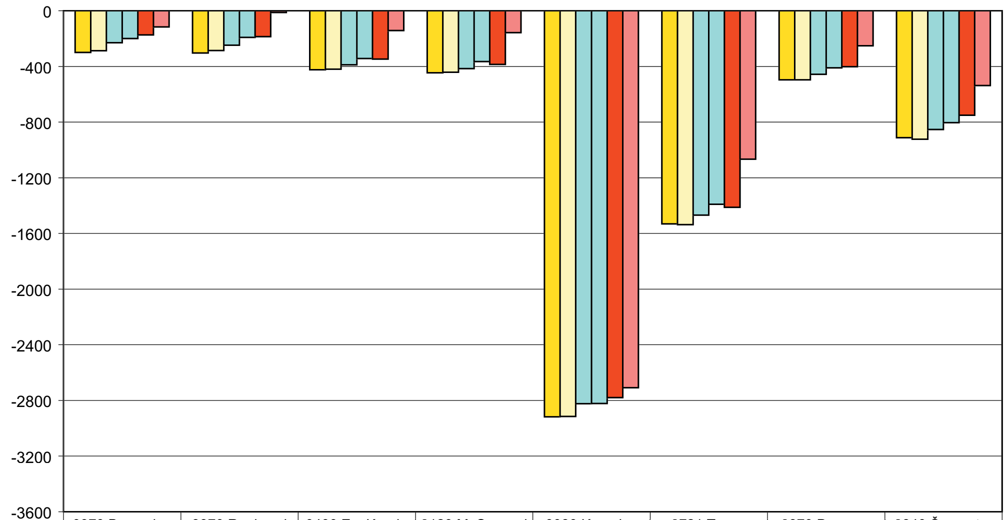
GROUNDWATER LEVELS IN ALLUVIAL AQUIFERS

Zlatko Mikulič

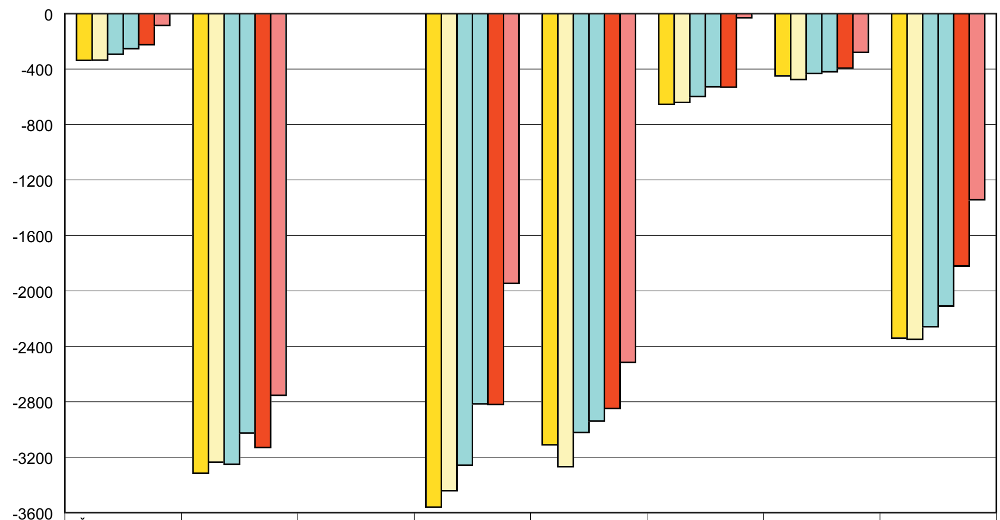
Groundwater reserves in 2003 remained low for the most part of the year with the exception of the aquifer Vrbanski plato. The year was an extremely dry one as all time low groundwater levels were recorded at several groundwater stations.

The groundwater levels in alluvial aquifers in Slovenia generally depend on the balance between the inflows, on one hand, and outflows, losses and artificial water abstractions on the other. The source of groundwater recharge is the precipitation in the area of aquifers and its direct precipitation catchment area on the outskirts of plains, as well as the drainage from the rivers and streams in the area of aquifers. Negative elements of the aforementioned balance are groundwater outflows from the aquifer or the drainage into watercourses and evapotranspirations – the evaporation of water and the emitting of moisture into the atmosphere through the pores of plants. Evapotranspiration is a particularly important factor in the shallow aquifers of the north-eastern part of Slovenia where the ratio between precipitation quantities and evapotranspiration is the least favorable. The artificial abstractions are particular cases of pumping for the water supply, while in its broader meaning, also the drainage of groundwater by melioration operations. For interpreting water conditions of groundwaters, it is therefore important to consider the spatial, as well as the temporal variability of the amount of precipitation, the evapotranspiration and the water levels in rivers bordering on aquifers or crossing them.

In the area of aquifers in 2003, all climatic factors which importantly influence the groundwater regime – the small amounts of precipitation, high air temperatures and a record duration of solar radiation, were pronouncedly unfavorable. Precipitation amounts in the areas of all alluvial aquifers were well below 1961-1990 normals with mean annual air temperatures as a rule exceeding the multi-annual means by one and a half degrees Celsius and there were a record number of hot days.



	0970 Brezovica	3370 Rankovci	0400 Zg. Krapje	0120 M. Segovci	0080 Kamnica	0721 Tezno	0370 Dornava	0840 Šempeter
Hnk-2003	-299	-304	-424	-446	-2918	-1531	-496	-912
Hnk-obdobje / Hnk-period	-287	-286	-420	-441	-2915	-1537	-496	-923
Hs-2003	-230	-248	-388	-416	-2824	-1469	-457	-853
Hs-obdobje / Hs-period	-199	-191	-343	-366	-2822	-1391	-410	-804
Hvk-2003	-173	-186	-347	-385	-2780	-1413	-402	-750
Hvk-obdobje / Hvk-period	-116	-12	-142	-157	-2709	-1066	-252	-537



	VČ-5072 Latkova vas	0320 Meja	0360 Brnik	MP-0275 Mengeš	0541 Kleče	0152 Skopice	0111 Sp. S. Grad	0220 Šempeter
Hnk-2003	-337	-3315	0	-3560	-3111	-654	-449	-2342
Hnk-obdobje / Hnk-period	-335	-3236	0	-3442	-3269	-640	-476	-2350
Hs-2003	-293	-3251	0	-3258	-3021	-598	-431	-2259
Hs-obdobje / Hs-period	-253	-3026	0	-2815	-2939	-528	-419	-2109
Hvk-2003	-224	-3130	0	-2819	-2848	-530	-393	-1820
Hvk-obdobje / Hvk-period	-85	-2753	0	-1945	-2516	-30	-279	-1343

Graf 24: Primerjava značilnih gladin podzemnih voda v letu 2003 z značilnimi gladinami za primerjalno obdobje 1961-1990 (Hs = srednja letna/obdobna gladina, Hnk = najnižja letna/obdobna gladina, Hvk = najvišja letna/obdobna gladina).
Graph 24: Characteristic groundwater levels in 2003 compared to multi-annual characteristic levels of the 1961-1990 reference period (Hs = mean annual/multi-annual level, Hnk = the lowest annual/multi-annual level, Hvk = the highest annual/ multi-annual level).

manj padavin je bilo na območjih vodonosnikov severovzhodne Slovenije in Celjske kotline z več kot tretjinskim primanjkljajem. Tudi na območjih z največ padavin, v Ljubljanski in Krški kotlini, smo beležili primanjkljaj okoli ene četrtine povprečne letne vsote. V letu 2003 je bila v Sloveniji ena najhujših zabeleženih meteoroloških suš, saj je v Prekmurju padlo najmanj padavin v zadnjega pol stoletja, v Ljubljani pa je bilo bolj sušno le leto 1953. Vzroki za letni primanjkljaj so v izpadu padavin spomladi in poleti, v dobi največje evapotranspiracije, kar najbolj odločilno vpliva na letni režim zalog podzemne vode. Odločilna je bila izjemno huda suša v marcu, ki je bil praktično brez padavin. V normalnih letih je marec običajno ugoden mesec za obnavljanje vodnih zalog podzemne vode, saj tedaj ponavadi sovpadata infiltraciji deževnice in snežnice na območju vodonosnikov. V letu 2003 pa je bila na teh območjih snežna odeja tanka, obenem je padlo komaj nekaj odstotkov padavin, običajnih za ta mesec. Tudi vsi meseci od marca do avgusta, ponekod do vključno septembra, so bili sušni s količinami padavin pod dolgoletnimi povprečji. V treh ali celo štirih mesecih od šestih oz. sedmih je padlo manj od polovice mesečnih povprečnih vrednosti. Po avgustu so bile do konca leta padavine obilnejše, vendar tudi tedaj niso bile v vseh mesecih dosežene običajne vrednosti. Tako je na primer v Prekmurju v novembru in decembru padlo le okoli polovice mesečnega povprečja padavin.

Ob opisanem pomanjkanju padavin je bil režim podzemnih voda prizadet na območju vseh aluvialnih vodonosnikov tudi zaradi velikih izgub vode z nadpovprečno veliko evapotranspiracijo. Evapotranspiracija je bila v letu 2003 povišana predvsem zaradi višje temperature zraka in nadpovprečnega sončnega obsevanja. Trajanje sončnega obsevanja je bilo na območjih vseh vodonosnikov za okoli petino nad povprečjem, na območju Celjske kotline pa celo za več kot eno tretjino. Odklon povprečne letne temperature zraka je bil na vseh vodonosnikih pozitiven za več kot eno stopinjo Celzija. Na območju vodonosnikov Ljubljanske, Celjske in Krške kotline je bila srednja letna temperatura za skoraj dve stopinji Celzija višja od povprečja 1961-1990. Na povečane izgube vode so še posebej vplivale povišane maksimalne dnevne temperature zraka, ki so bile povsod okoli dveh stopinj nad dolgoletnim povprečjem, na območju vodonosnika Ljubljanskega polja pa celo poltretjo stopinjo. Stres rastlin v poletnem času in oddajanje vlage v atmosfero je bilo povečano zaradi rekordno velikega števila dni z maksimalno dnevno temperaturo zraka nad petindvajset stopinj Celzija. Na območju vodonosnikov je bilo takih dni vsega skupaj za tri in pol do štiri mesece. V obdobju od maja do avgusta je srednja mesečna temperatura zraka vseskozi presegala dolgoletna mesečna pov-

The groundwater recharge from precipitation infiltration was considerably smaller than usual in all aquifers because the quantities of annual precipitation were in the range from less than two thirds to slightly over three quarters of the normals. The least amount of precipitation occurred in aquifer areas in north-eastern Slovenia and the Celje Basin with a deficit of more than a third. Moreover, even in areas with the most precipitation in the Ljubljana and Krško Basins, a deficit of around one fourth of the mean annual value was recorded. The meteorological drought in 2003 was one of the worst recorded in Slovenia with the least amount of precipitation in Prekmurje in the last half century while in Ljubljana only the year 1953 had been drier. The causes for the annual deficit lay in the lack of precipitation in the spring and summer during a period of the highest evapotranspiration which most decisively affects the annual regime of groundwater reserves. The key decisive factor was the extraordinarily severe drought in March with practically no precipitation. During normal years, March is usually a favourable month for the recharge of groundwater reserves for at this time the infiltration of rainwater and melting snow in aquifer areas usually coincide. In 2003, the snow cover was thin in these areas, while at the same time barely several percentages of precipitation usual for this month were observed. Also all months from March to August and in some places also September were characterized by drought with precipitation quantities well below the normals. Three or even four months out of six or seven months saw precipitation quantities below the monthly mean values. Following August and until the end of the year, precipitation was more abundant; however, even then usual precipitation values were not reached for all the months. Thus, in Prekmurje for example there was only around one half of the mean monthly amount of precipitation in November and December.

In adition to the aforementioned precipitation deficit, the groundwater regime was affected in the area of all alluvial aquifers also due to the extreme losses of water through above average evapotranspiration. Evapotranspiration in 2003 was higher predominantly due to higher air temperatures and above average solar radiation. The duration of solar radiation was around one fifth above the average for all aquifer areas, and in the region of the Celje Basin, it was longer by more than a third. The deviation from the average annual air temperature was higher for all aquifers by more than one degree Celsius. In the aquifer areas of the Ljubljana, Celje and Krško Basins, the mean annual temperature was almost two degrees Celsius higher than the mean for 1961-1990 reference period. The increased daily maximum air temperatures especially affected the increased water losses. The temperatures were around two degrees prečja. V juniju in avgustu so bile povprečne temperature povišane tudi za več kot pet stopinj Celzija. V teh izjemno neugodnih razmerah je povečana evapotranspiracija v obdobju vegetacije rastlin hudo načenjala zaradi izpada padavin že tako zmanjšane vodne zaloge.

Kako zelo neugodne so bile vremenske razmere v letu 2003 za režim količin podzemne vode nazorno kažejo meteorološki podatki za Ljubljano in Mursko Soboto. Vse od leta 1951 naprej je bilo v Ljubljani ravno v letu 2003 zabeleženo največ dni z maksimalno dnevno temperaturo zraka nad petindvajset stopinj, kakor tudi največ dni z maksimalno dnevno temperaturo zraka nad trideset stopinj Celzija – slednjih vsega skupaj za skoraj osem tednov. V Murski Soboti je padlo najmanj padavin od leta 1951, v vsem letu 2003 okoli petsto litrov na kvadratni meter, kar je za okoli tristo litrov manj od dolgoletnega povprečja.

Tudi na slovenskih rekah, ki mejijo na vodonosnike, je bila v letu 2003 huda suša. Praviloma so bili najmanj vodnati vodotoki v severovzhodni Sloveniji, z izjemo reke Mure, ki dobiva vodo večinoma iz alpskega povirja v Avstriji. Hudo sušo v tem letu odraža celoletni pretok rek, ki je znašal praviloma okoli šest desetin dolgoletnega povprečja primerjalnega obdobja 1971-2000. V Podravju je bil celoletni pretok okoli štiri desetine povprečja. V Prekmurju pa so bile sušne razmere prav kritične, saj je imela v letu 2003 Ledava komaj eno petino dolgoletnega pretoka. Za obnavljanje zalog podzemne vode s pronicanjem iz rek so bili še posebej neugodni večmesečni nizki vodostaji vodotokov. V vseh mesecih so bili mesečni pretoki manjši od mesečnih povprečij primerjalnega obdobja. Le v januarju, novembru in decembru so se te vrednosti približale dolgoletnim povprečjem, v ostalih mesecih pa so bile okoli ene polovice, ali še nižje. Kritično je bilo neprekinjeno obdobje nizkih pretokov od maja do septembra, ko se je po rekah pretakalo okoli ene tretjine povprečnih mesečnih količin, junija pa celo komaj eno četrtino. To veliko pomanjkanje vode v rečnih koritih na začetku poletja je tudi botrovalo hudi poletni suši podzemnih voda.

Za obnavljanje vodnih zalog podzemnih voda je bila vodnatost rek ugodna v januarju, potem po deset mesečnem presledku ponovno šele v novembru in deloma v decembru. V splošnem je bil vpliv površinskih voda na višine gladin podzemne vode devet mesecev leta neugoden, pri čemer je treba še enkrat poudariti poguben vpliv večmesečne zvezne hidrološke suše rek. Pretoki rek so bili praviloma najnižji v vročem avgustu, kar je še stopnjevalo poletno sušo podzemnih voda. Na območju severovzhodne Slovenije pičle količine ponikle površinske vode v podzemlje niso omilile hude hidro-

higher than the multi-annual mean everywhere and were at the aquifer area Ljubljansko polje higher by as much as two and a half degrees. Stress of plants during the summer and transpiration were increased due to the record large number of days with maximum daily air temperatures exceeding twenty-five degrees Celsius. In the aquifer areas, there were altogether three and a half to four months of such days. Throughout the period of May to August, the mean monthly air temperature continuously exceeded the monthly means for the multi-annual period. In June and August, mean temperatures were also higher by more than five degrees Celsius. In such extraordinarily unfavourable conditions, the increased evapotranspiration during the period of plant vegetation intensified the loss of water affecting the lack of water reserves that have already been diminished due to the lack of precipitation.

How unfavourable weather conditions really were for the groundwater regime in 2003 is shown by certain meteorological data for Ljubljana and Murska Sobota. Since 1951 onwards, the greatest number of days with maximum daily air temperature exceeding twenty-five degrees as well as the greatest number of days with maximum daily air temperature exceeding thirty degrees Celsius was recorded in Ljubljana in 2003 – totalling a period of nearly eight weeks. The least precipitation since 1951 was recorded in Murska Sobota in 2003 with only 500 litres per square metre, being three hundred litres less than the normals.

Severe drought conditions also prevailed on Slovenian rivers bordering aquifers in 2003. As a rule, rivers in north-eastern Slovenia were the least water abundant with the exception of the Mura River whose main source of water is the alpine headwaters in Austria. The extreme drought in this year is shown through the total annual discharge which as a rule amounted to around six tenths of the mean for the multi-annual reference period of 1971-2000. The discharge of rivers in Podravje throughout the year was around four tenths of the average. In Prekmurje, drought conditions were truly critical for in 2003 the Ledava River had barely one fifth of the multi-annual mean discharge. The low water levels lasting quite a number of months were especially unfavourable for the recharge of groundwater reserves through the infiltration from rivers. During all months, monthly discharges were lower than the mean monthly values of the reference period. Only in January, November and December were these values somewhat comparable to the multi-annual mean while in remaining months, values were around one half or lower. The continuous period of low discharges from May to September was critical with barely one third of mean monthly discharges observed in rivers while in June, these reached barely one quarter. This considerable loške suše podzemnih voda vse leto. Tam je mnogo vodotokov med letom tudi presahnilo.

Opisane meteorološke in hidrološke razmere so pomembno vplivale na režim nihanja vodnih zalog podzemnih voda med letom, sumarno so se tudi odrazile v letnih statističnih značilnostih višine vode.

Značilne letne gladine Hnk, Hs in Hvk (graf 24) so grobi pokazatelj vodnih zalog, oziroma statistično povprečenega režima na celoletni ravni. Ti statistični parametri omogočajo grobo oceno prostorske spremenljivosti, ne morejo pa zajeti časovne spremenljivosti med letom. Primerjava srednjih letnih gladin Hs kaže, da so bile zaradi suše celoletne vodne zaloge v letu 2003 povsod pod povprečnimi. Sušo še bolj izrazito ponazarja primerjava nizkih letnih konic Hnk, ki so vse blizu nizkim konicam primerjalnega obdobja, oziroma so na več merilnih mestih bile dosežene rekordno nizke gladine. Kot posledica suše so bile tudi najvišje letne konice Hvk daleč pod obdobnimi, v nekaj primerih so bile celo nižje od srednjih obdobnih gladin. V letu 2003 je bil ponovno opažen pojav, ki se zaradi suš od leta 2000 naprej, že nekaj let zapovrstjo kaže kot nova značilnost režima podzemnih voda: celotni razpon nihanja gladin podzemnih voda je premaknjen navzdol brez

deficit of water in river channels at the beginning of the summer also contributed to the extreme summer groundwater drought.

The river stages in January were favourable for the recharge of groundwater reserves, and then following a ten-month period of unfavourable conditions again in November and partially in December. In general, the influence of surface waters on groundwater levels proved unfavourable for nine months whereby it is important to once again stress the detrimental effect of the continuous hydrological drought of rivers which lasted for a number of months. River discharges as a rule were at their lowest during the hot month of August which only contributed to the summer drought of groundwater. In north-eastern Slovenia, the scarce amounts of surface water infiltrating into the underground failed to mitigate the severe hydrological drought of groundwater throughout the entire year. A number of watercourses also dried up in these areas.

The meteorological and hydrological conditions described significantly influenced the regime of fluctuations of groundwater reserves during the year and were also reflected in annual statistical characteristics of water levels.

Preglednica 13: Primerjava značilnih gladin podzemnih voda v letu 2003 z značilnimi gladinami primerjalnega obdobja 1961-1990.
Table 13: Characteristic groundwater levels in 2003 compared to characteristic levels of the 1961-1990 reference period.

Postaja Location	Vodonosnik Aquifer	2003			Obdobje / Period					
		Hnk (cm)	Hs (cm)	Hvk (cm)	Časovni niz Time series	Hnk (cm)	Hnp (cm)	Hs (cm)	Hvp (cm)	Hvk (cm)
BREZOVICA	PREKMURSKO POLJE	299	230	173	1980-2000	287	251	199	140	116
RANKOVCI	PREKMURSKO POLJE	304	248	186	1961-2000	286	244	191	110	12
ZGORNJE KRAPJE	MURSKO POLJE	424	388	347	1964-2000	420	383	343	283	142
MALI SEGOVCI	APAŠKO POLJE	446	416	385	1991-2000	441	409	366	274	157
KAMNICA	VRBANSKI PLATO	2918	2824	2780	1981-2000	2915	2877	2822	2757	2709
TEZNO	DRAVSKO POLJE	1531	1469	1413	1971-2000	1537	1479	1391	1268	1066
DORNAVA	PTUJSKO POLJE	496	457	402	1961-2000	496	464	410	328	252
ŠEMPETER	SPODNJA SAVINJSKA DOLINA	912	853	750	1982-2000	923	888	804	641	537
LATKOVA VAS	DOLINA BOLSKE	337	293	224	1975-2000	335	306	253	166	85
MEJA	SORŠKO POLJE	3315	3251	3130	1987-2000	3236	3095	3026	2891	2753
MENGEŠ	DOLINA KAMNIŠKE BISTRICE	3560	3258	2819	1976-2000	3442	3148	2815	2332	1945
KLEČE	LJUBLJANSKO POLJE	3111	3021	2848	1974-2000	3269	3080	2939	2735	2516
SKOPICE	KRŠKO POLJE	654	598	530	1980-2000	640	564	528	316	30
SPODNJI STARI GRAD	BREŽIŠKO POLJE	449	431	393	1971-2000	476	452	419	339	279
ŠEMPETER	VIPAVSKO-SOŠKA DOLINA	2342	2259	1820	1961-2000	2350	2264	2109	1761	1343

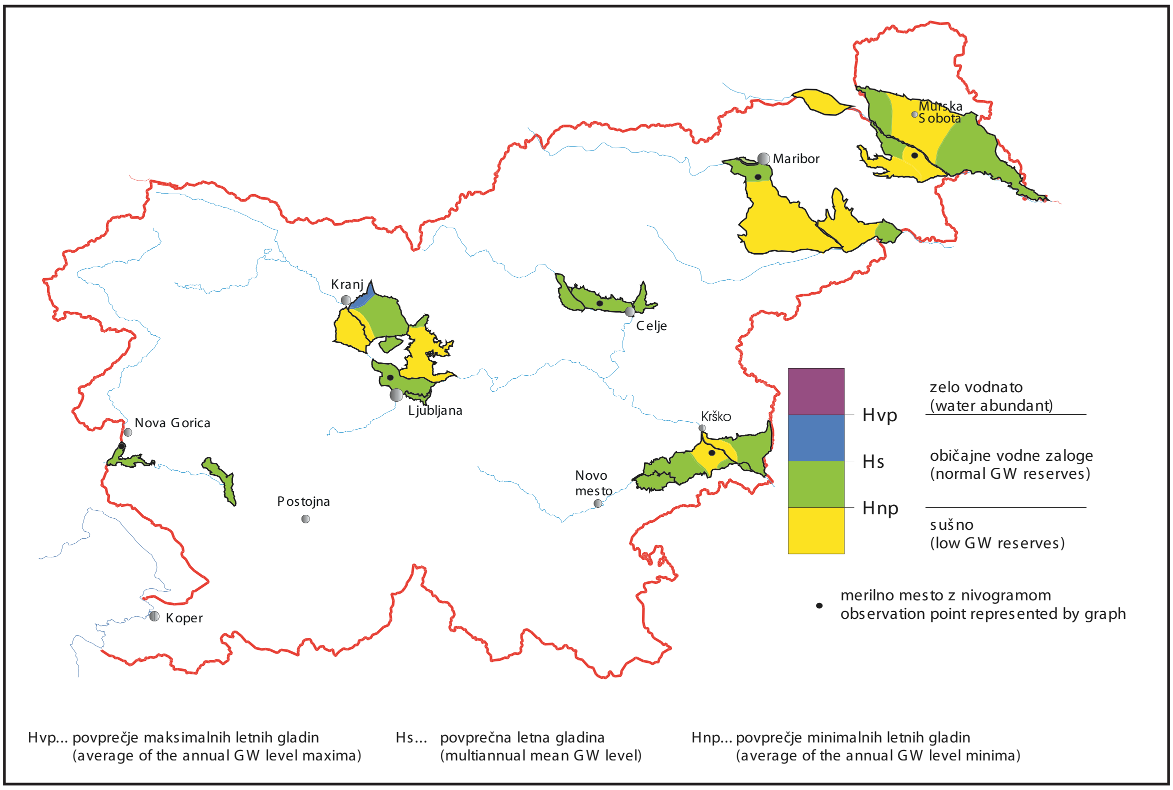
pojavov visokih gladin. Pojav, da so bile v vseh vodonosnikih visoke vodne konice nižje od obdobnih, pomeni, da v letu 2003 ni bilo obdobij zelo intenzivnega napajanja vodonosnikov.

Režim nihanja gladin oziroma zalog podzemnih voda v letu 2003 je bil poleg uvodoma opisanih dejavnikov vodne bilance pogojen tudi z režimom v predhodnem letu. Konec leta 2002 so se vodne gladine praviloma zniževale, v severovzhodni Sloveniji pa je bila še vedno suša. Tako je bilo izhodiščno stanje zalog podzemne vode na začetku leta 2003 neugodno v severovzhodni Sloveniji in na Dravsko-Ptujskem polju, drugod pa so bile zaloge v mejah normalnih.

V severovzhodni Sloveniji suša v aluvialnih vodonosnikih traja praktično neprekinjeno od leta 2000, kar je kvalitativno nov pojav večletnih suš. V Prekmurju se je nadaljeval nadvse zaskrbljujoč pojav iz leta 2002. Gladine so upadle do novih rekordno nizkih ravni, večji del leta so bile pod najnižjo ravnijo v zadnjih petdesetih letih in vodne zaloge se vse do konca leta niso obnovile na povprečno raven. To pomeni, da je tam tako kot v letu 2002, tudi v letu 2003 vsak odvzem podzemne vode posegal v statične zaloge. Prekmurje je bilo sušno vse leto, prav tako Apaško polje, le na Murskem polju so bila

The characteristic annual water levels Hnk, Hs and Hvk (Graph 24) roughly show water reserves or the statistical average regime on an annual basis. These statistical parameters allow a rough estimation of variability in space, but they cannot take into account the temporal variability during the year. The comparison of mean annual levels (Hs) indicates that annual water reserves everywhere in 2003 were below average due to drought. The drought is even better represented by comparing low annual peaks Hnk, which are close to low peaks for the reference period, and have at a number of groundwater stations achieved record low levels. Another effect of the drought was that the highest annual peaks Hvk remained far below the reference period values and in some cases even lower than the mean multi-annual levels. In 2003, once again the phenomenon was noticed which due to the drought from 2000 onwards has been evident as a new feature of the groundwater regime: the entire range of fluctuations of groundwater levels moved downwards lacking high water levels. This phenomenon, in which high water peaks of aquifers were lower than those of the reference period means that there were no periods of intensive recharge of aquifers in 2003.

The regime of fluctuations of water levels or groundwater reserves in 2003 was not only conditioned by the previously mentioned factors, but also by the regime of the previous year. At the end



Karta 7: Srednje letne gladine leta 2003 v največjih slovenskih aluvialnih vodonosnikih.
Map 7: Mean annual water levels in 2003 in major Slovenian alluvial aquifers.

krajša obdobja ugodnejših vodnih zalog čeprav tudi tedaj pod srednjo obdobno letno gladino.

Leto 2003 se je začelo hidrološko razmeroma ugodno v večini slovenskih aluvialnih vodonosnikov, saj je bil januar moker mesec. Zaloge podzemnih voda so bile v mejah normalnih v večini Slovenije in celo na sušnem Dravsko-Ptujskem polju so se zaloge nekoliko povečale. V sušni severovzhodni Sloveniji se je tedaj začelo zniževanje že tako in tako pičlih vodnih zalog iz leta 2002. V februarju se je začel večmesečni upad gladin podzemnih voda po celi državi. Tedaj so bile gladine že povsod pod letnim povprečjem primerjalnega obdobja. Velik izpad padavin v marcu je povzročil nadaljnje zniževanje gladin, vendar ni povzročil večjega širjenja suše podzemnih voda, saj v tem obdobju leta še ni velike evapotranspiracije. Značilno, suša je tedaj kot novo območje zajela le vodonosnik doline Kamniške Bistrice, ker je tam zaradi velikega gradienta toka podzemne vode praznjenje vodonosnika v površinske vodotoke – odvodnike zelo hitro. Kljub neugodnim vremenskim razmeram v naslednjih mesecih zniževanje gladin še ni bilo tako veliko, da bi povzročilo širjenje suše na nova območja v marcu in aprilu. Poglavitni razlog je že v opisani mali evapotranspiraciji. V maju, ko se začne intenzivna vegetacija rastlin, se je evapotranspiracija skokovito povečala in tedaj je bil upad zalog podzemnih voda tako velik, da je suša zajela vse aluvialne vodonosnike po državi razen globokega vodonosnika Ljubljanskega polja. V suhem, vročem juniju se je suša podzemnih voda stopnjevala in se potem z vse večjo intenziteto nadaljevala v poletje. V juliju je suša zajela še zadnji preostali vodonosnik Ljubljanskega polja, potem se je v vročem sušnem poletju nadaljevala po celi državi in se podaljšala v zgodnjo jesen. Vodne zaloge so se začele izboljševati šele oktobra, čeprav ne v vseh vodonosnikih. Tedaj so se razmere nekoliko izboljšale le v Ljubljanski in Celjski kotlini ter v Vipavsko Soški dolini, vendar gladine niso dosegle letnega povprečja dolgoletnega primerjalnega obdobja. V novembru so se razmere izboljšale še v Krški kotlini, čeprav tudi tedaj nikjer po državi zaloge niso dosegle letnega povprečja. Šele decembra so se zaloge v Celjski kotlini in Vipavsko Soški dolini zvišale nad letno povprečje. Na koncu leta sta imeli torej edino ti dve območji ugodne zaloge podzemnih voda, drugod so bile zaloge pod povprečjem, na območjih severovzhodne Slovenije in Dravsko-Ptujskega polja pa so bile še vedno sušne razmere. Od opisanih razmer odstopa le majhen vodonosnik Vrbanskega platoja, ki se pretežno napaja iz Drave. Drava ima povirje v Avstriji in njena vodnatost ni ključno odvisna od vremenskih razmer v naši državi, poleg tega ima še ugoden snežni vodni režim. V vodonosniku Vrbanskega platoja je bila suša le maja, ko se še ne talijo ledeniki v visokogorju, v preostalih

of 2002, water levels as a rule decreased while the drought remained in north-eastern Slovenia. Thus, the initial groundwater reserves at the beginning of 2003 were unfavourable in north-eastern Slovenia and the Dravsko-Ptujsko polje while elsewhere reserves remained within normal amounts.

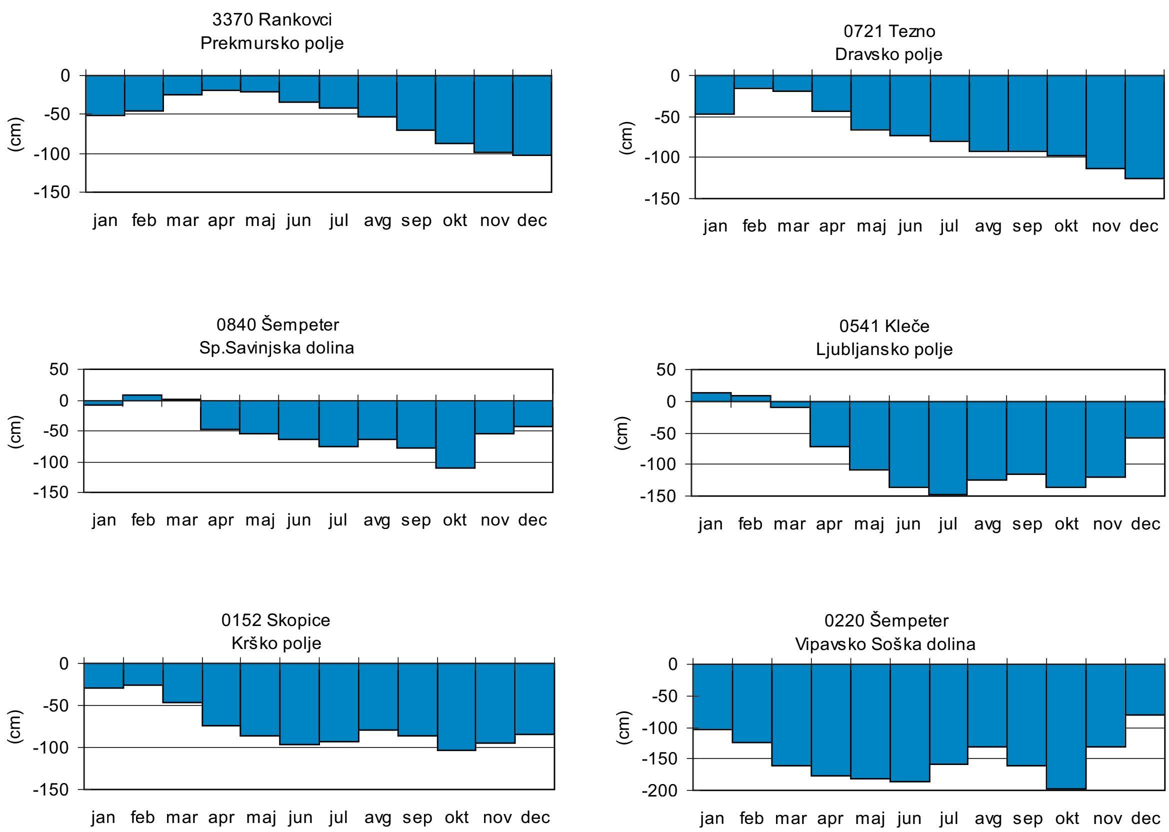
In north-eastern Slovenia, the drought in alluvial aquifers remains uninterrupted since the year 2000, which is qualitatively a new phenomenon of the multi-annual droughts. In Prekmurje, a particularly disturbing phenomenon has continued since 2002. Water levels have fallen to new record lows while for the majority of the year, they remained below the lowest levels in the last fifty years with water reserves failing to renew to the average level all the way up to the end of the year. This means that every groundwater abstraction both in 2002 and 2003 affected the static reserves. Prekmurje remained dry all year round as did Apaško polje and only in Mursko polje were water reserves more favourable for short periods although even then, they were below the mean annual water level.

Hydrological conditions were favourable at the beginning of 2003 in the majority of Slovenian alluvial aquifers for January was a wet month. Groundwater reserves were normal in the most part of Slovenia with reserves somewhat increasing even in the dry Dravsko-Ptujsko polje. In the dry north-eastern part of Slovenia, the scarce water reserves from 2002 again began decreasing. In February, a multi-month process of decreasing in groundwater levels began throughout the country. At this point in time, water levels were already below the multi-annual mean. The scarcity of precipitation in March led to a continued decrease in water levels, which nevertheless did not cause any larger expansion of drought of groundwater as evapotranspiration at this time of year is not high. As characteristic, the drought had until then only spread to the aquifer of the Kamniška Bistrica valley since due to a great hydraulic gradient of the groundwater flow the emptying of the aquifer into surface watercourses – recipients is quite rapid. Despite unfavourable weather conditions in the following months, the decrease in water levels still did not attain values, which would cause expansion of the drought to new areas in March and April. The predominant reason for this was the small amount of evapotranspiration mentioned above. In May when plant vegetation (plant growth) intensified, evapotranspiration rapidly increased whereby the fall in groundwater levels was so large that the drought spread to all alluvial aquifers in the country except for the deep aquifers of the Ljubljansko polje. During the dry and hot month of June, the drought intensified even more and continued into the summer. In July, the drought had reached the last remaining aquifer of Ljubljansko polje continuing throughout the entire country during the hot and dry summer and extending into early autumn. Water reserves only began improving in October but not however mesecih so bile gladine v mejah normalnih. V tem vodonosniku je bila gladina celo sedem mesecev nad letnim povprečjem.

Mesečna odstopanja gladin v letu 2003 od mesečnih povprečij za primerjalno dolgoletno obdobje (graf 25) so odraz hude suše. Z izjemo Ljubljanske in Celjske kotline so bila v vsem letu povsod mesečna povprečja nižja od primerjalnih vrednosti. Majhni presežki mesečnih povprečij so bili v Ljubljanski in Celjski kotlini januarja in februarja.

Pri letnem poteku nihanja gladin so bile zabeležene visoke konice leta praviloma januarja, kar je posledica celoletnega zniževanja gladin in so še en pokazatelj hidrološke suše. Ponekod so bile najvišje gladine v letu februarja, še redkeje pa novembra ali decembra. Najnižje letne gladine so bile praviloma septembra in avgusta, ponekod v severovzhodni Sloveniji pa konec leta kot posledica celoletnega zniževanja gladin.

at all aquifers. At that time, the conditions somewhat improved only in the Ljubljana and Celje Basins and in the valley of Vipavska Soška dolina although water levels still failed to attain the multi-annual mean. The situation also improved for the Krško Basin in November, although even then, water reserves throughout the country failed to attain the annual mean. It was not until December that water reserves in the Celje Basin and Vipavska Soška dolina increased above the annual mean. By the end of the year, only these two regions had favourable groundwater reserves, while reserves elsewhere were below the average and drought prevailing in the areas of north-eastern Slovenia and Dravsko-Ptujsko polje. Only the small aquifer Vrbanski plato deviates from the described conditions for its groundwater is predominantly recharged by the Drava River. The Drava has its headwaters in Austria and its river discharge is not significantly dependent on weather conditions in Slovenia and additionally maintains a favourable nival – water regime. The aquifer at the Vrbanski plato only experienced drought in May prior to the melting of glaciers in high mountains whereby water levels remained within normal boundaries in the remaining months. For seven months, the water level at this aquifer even remained above the mean.



Graf 25: Odstopanja srednjih mesečnih gladin podzemne vode v letu 2003, glede na srednje mesečne gladine za primerjalno dolgoletno obdobje 1961-1990.
Graph 25: Deviations of mean monthly groundwater levels in 2003 from the mean monthly multi-annual means of the reference period of 1961-1990.

Po splošnih značilnostih režima podzemnih voda je bilo leto 2003 hidrološko sušno leto. Še posebej je leto zaznamovala huda hidrološka suša v vodonosnikih severovzhodne Slovenije, kjer je trajala vse leto. V teh predelih je neprekinjena večletna suša že od pomladi leta 2000, v letu 2003 pa so se gladine znižale na najnižjo zgodovinsko zabeleženo raven podzemnih voda. Tam se gladine niso vrnile na normalno raven že od leta 2002. Tako se že dve leti črpa statične zaloge podzemne vode.

Leto 2003 je bilo že četrto leto zapovrstjo, ko so bile sušne razmere bolj izrazite kot navadno, kar kaže na izrazit odklon od dolgoletnega režima podzemnih voda.

The monthly deviations of water levels in 2003 from the monthly means of the reference period (Graph 25) are the result of extreme drought. With the exception of the Ljubljana and Celje Basins, water levels remained below the monthly multi-annual means throughout the year. Smaller surpluses over the monthly means were noted in the Ljubljana and Celje Basins in January and February.

In the annual time line of fluctuation of water levels, high annual peaks were recorded as a rule in January and were the result of falling groundwater levels throughout the year and one more indicator of hydrological drought. In some areas, the maximum annual water levels were recorded in February and even more rarely in November or December. The minimum annual water levels were as a rule recorded in September and August and in some parts of north-eastern Slovenia also at the end of the year as a result of falling groundwater levels during the year.

Based on general characteristics of groundwater regimes, 2003 was a hydrologically dry year. The year was especially marked by the extreme hydrological drought in aquifers in north-eastern Slovenia lasting throughout the year. In these regions, the multi-annual drought has continued uninterrupted since the spring of 2000 and in 2003 water levels fell to the all time groundwater level lows. In these areas, water levels have not returned to normal levels since 2002, which is why there has been a depleting of static groundwater reserves since 2002.

The 2003 year was the fourth consecutive year where dry conditions were more pronounced than usual, indicating a pronounced deviation from the multi-annual groundwater regime.

Izvajanje meritev podzemne vode na Krškem polju (foto: Niko Trišić).
Groundwater level measurement at Krško polje (photo: Niko Trišić).

C. IZVIRI

VODOSTAJI, TEMPERATURE IN SPECIFIČNE ELEKTRIČNE PREVODNOSTI IZVIROV

Niko Trišić

Številni izviri v Sloveniji so pomemben vir za oskrbo z vodo. Nekateri med njimi so že vrsto let uvrščeni v program hidrološkega monitoringa površinskih voda. Za izvire Hublja, Vipave, Bistrice v Ilirski Bistrici, Rižane, Krke in Krupe imamo nize podatkov o vodostajih in pretokih za več kot 40 let. Med najstarejšimi hidrološkimi postajami na območju Slovenije je vodomerna postaja Vrhnika na Ljubljanici (Oberlaibach), ki je bila ustanovljena v drugi polovici 19. stoletja. Iztoke izvirov Velike in Male Ljubljanice se meri na današnji lokaciji na desnem bregu Ljubljanice od l. 1926. Beleženi so podatki o vodostaju in temperaturi, izvajala pa so se tudi vzorčenja in analize osnovnih fizikalno-kemičnih parametrov.

Leta 2003 se je monitoring izvirov v sklopu ARSO izvajal na izvirih Divje jezero in Podroteja v porečju Idrijce, izviru Kamniške Bistrice in na izviru Globočec v porečju Krke. Postavljeno je bilo novo merilno mesto na izviru Metliški Obrh, ki je zajet za vodno oskrbo Metlike in okolice. Zaradi kratkega in nepopolnega niza, podatkov za Metliški Obrh v Letopisu nismo objavili. Zaradi okvare merilnega aparata na izviru Podroteja, je bil niz podatkov na tej postaji prekinjen in je primerjalna obdobna analiza okrnjena.

Izvir Kamniške Bistrice (foto: Niko Trišić, april 2003).
The Kamniška Bistrica spring (photo: Niko Trišić, April 2003).

C. SPRINGS

WATER LEVELS, TEMPERATURES AND SPECIFIC ELECTRICAL CONDUCTIVITY OF SPRINGS

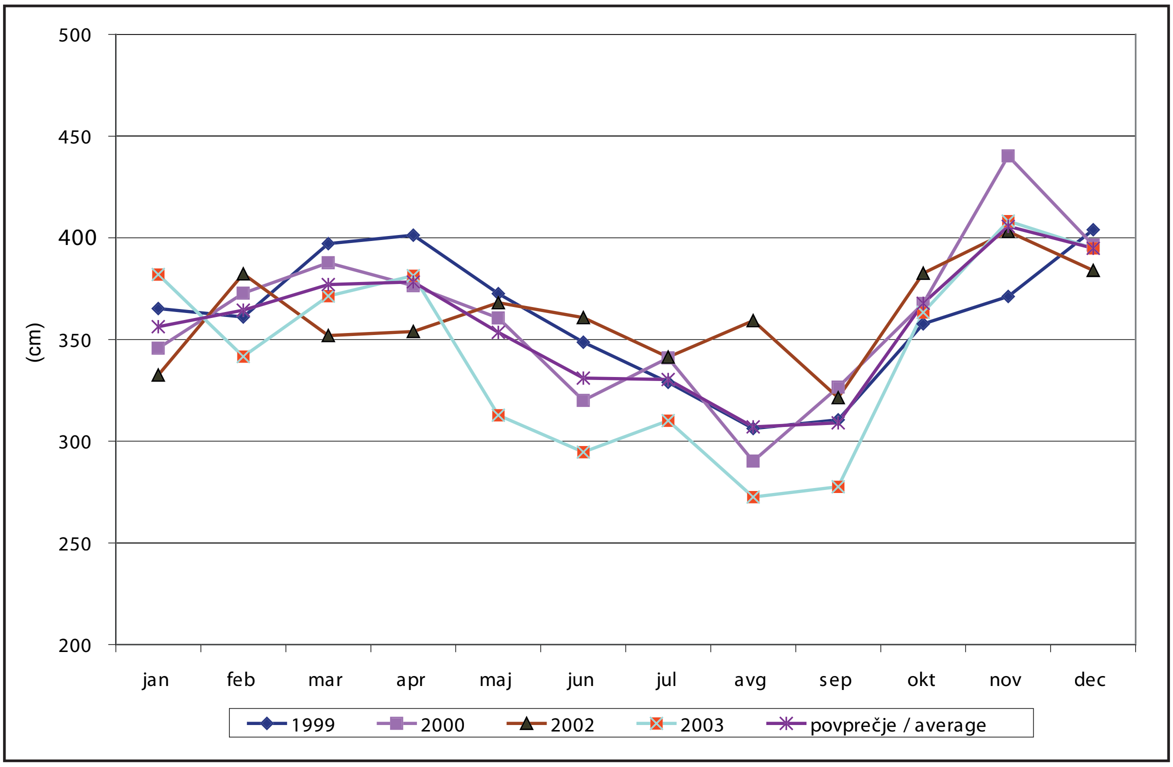
Niko Trišić

Numerous springs throughout Slovenia represent an important source of water supply. Several of them have for a number of years been covered by hydrological monitoring of surface waters. Data time series on river stages and discharges for the springs Hubelj, Vipava, Bistrica in Ilirska Bistrica, Rižana, Krka and Krupa have been kept for over 40 years. The water gauging station Vrhnika on Ljubljanica (Oberlaibach) ranks among the oldest hydrological stations in the territory of Slovenia and was established in the second half of the nineteenth century. The yields of the Velika and Mala Ljubljanica springs have been measured at the same location on the right bank of the Ljubljanica since 1926. Data on river stages and temperatures have been recorded and sampling and analyses of basic physical-chemical parameters have been performed.

In 2003, spring monitoring was carried out within the scope of the Environmental Agency of the Republic of Slovenia (ARSO) at the springs of lakes Divje jezero and Podroteja in the Idrija Basin, the spring of the Kamniška Bistrica and the spring of Globočec in the Krka Basin. A new spring observation station was set up at the spring of Metliški Obrh which is capped for the water supply of Metlika and its surroundings. Due to the short and interrupted time series of data from Metliški Obrh, these were not included in the Yearbook. The defect of the gauging device at the spring of Podroteja led to the interruption of the time series from this station curtailing the analysis of the comparative period.

Preglednica 14: Najvišji in najnižji letni vodostaji na izviru Divje jezero v obdobju 1999-2003.
Table 14: Highest and lowest annual water levels at the source of Divje jezero during the period of 1999-2003.

Leto Year	Najvišji / najnižji vodostaj (cm) Max / Min water level (cm)	
1999	519	273
2000	562	273
2001	616	/
2002	/	281
2003	551	263



Graf 26: Srednje mesečne vrednosti vodostajev na Divjem jezeru v obdobju 1999-2003.
Graph 26: Mean monthly values of water levels on Divje jezero during the period of 1999-2003.

Preglednica 15: Srednji mesečni vodostaji na izviru Divje jezero (cm).
Table 15: Mean monthly water levels of Divje jezero spring (cm).

Leto Year	jan Jan	feb Feb	mar Mar	apr Apr	maj May	jun Jun	jul Jul	avg Aug	sep Sep	okt Oct	nov Nov	dec Dec	Letni Annual
1999	365	361	397	401	373	349	329	306	310	358	371	404	360
2000	346	373	388	376	361	320	341	290	327	368	440	396	396
2001	-	-	-	-	-	-	-	-	-	-	-	-	-
2002	332	382	352	354	368	361	341	359	321	383	403	384	363
2003	382	342	371	381	313	295	310	273	278	363	408	395	343
Povprečje Average	356	364	377	378	354	331	330	307	309	368	406	395	365

Režim vodostajev na izviru Divje jezero je bil v letu 2003 običajen, s prvim maksimumom v marcu oz. aprilu ter drugim v jesenskih mesecih. Zaradi hidrološke suše so bili srednji mesečni vodostaji in iztoki iz vodonosnika med majem in septembrom 2003 najnižji v opazovanem obdobju 1999-2003. V avgustu 2003 smo beležili absolutno najnižji vodostaj, 263 cm, komaj nekaj višji je bil minimum v septembru. Struga Jezernice, ki je površinski iztok Divjega jezera, je ob nizkih stanjih suha, vodonosnik pa se v celoti prazni skozi izvire pri Podroteji, ki predstavljajo lokalno erozijsko bazo. Ob meritvah Idrijce smo 5. 8. 2003 iz razlike pretoka reke nad in pod izvirom Podroteja določili pretok izvira, ki je

The regime of water levels at the spring of Divje jezero was normal in 2003 with the first maximums at the end of March and beginning of April and the second in the autumn months. Due to the hydrological drought, mean monthly water levels and outflows from the aquifer in May and September were the lowest for the observed period of 1999-2003. In August 2003, the absolute minimum water level of 263 cm was recorded with the water level in September being barely any higher. The riverbed of the Jezernica which is the surface outflow from Divje jezero is dry at low water levels while the aquifer completely empties out via sources at Podroteja which represent a local erosion base.

znašal 1,024 m³/s. Ocenjujemo, da je podatek blizu realni minimalni vrednosti iztoka izvira Podroteja. Ob nizkih vodnih stanjih predstavlja izvir Podroteja večino pretoka Idrijce v profilu vodomerne postaje Podroteja.

Ker pa imata izvira Divje jezero in Podroteja isto padavinsko zaledje, lahko podatke o režimu vodostajev izvira Divjega jezera upoštevamo kot značilne za izvir Podroteja.

Beleženi sta bili tudi temperatura in specifična električna prevodnost vode v izviru Divje jezero. Tako kot prejšnja leta je bila v l. 2003 ob nizkih vodostajih v poletnih mesecih temperatura izvira povišana, saj ni dotoka sveže vode. Vrednosti temperature izvira v spomladanskih, jesenskih in zimskih mesecih nihajo med 8,5 in 8,8 °C, nižja temperatura vode v februarju, < 8 °C, je posledica vpliva snežnice, ki se steka v jezero s pobočja okoli izvira.

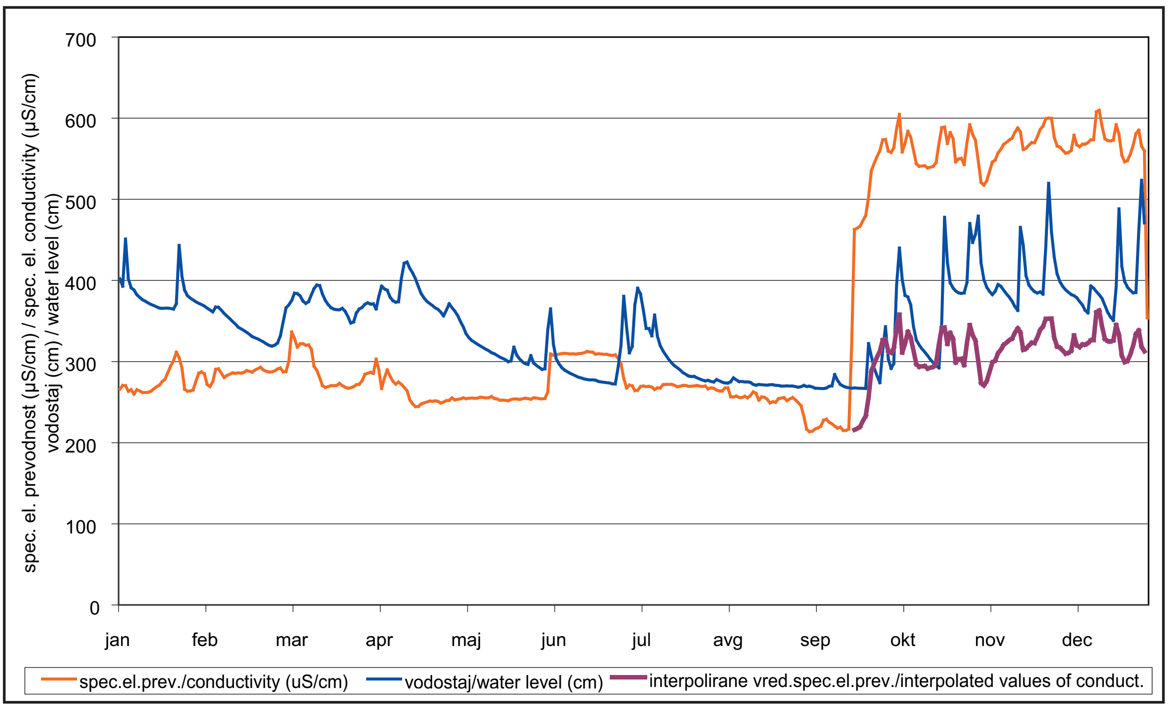
Meritve specifične električne prevodnosti (SEP) so potekale neprekinjeno preko celega leta. V septembru je specifična električna prevodnost skokovito narasla zaradi napake merilnika. Sondo smo poskušali umeriti, vendar je bila zataknjena in je ni bilo mogoče izvleči iz vode. Izmerjene vrednosti do 17. septembra so v razponu med 214 in največ 342 µS/cm. Na podlagi kontrolnih meritev in ocene zamika smo podatkovni niz SEP od 18. septembra do konca leta 2003 korigirali.

Upon hydrometric measurements of the Idrijca, the discharge from the spring which amounted to 1.024 m³/s was calculated taking the difference of the river's discharge above and below the Podroteja spring on 5 August 2003. It is estimated that this figure is quite close to the actual minimum values of the outflow of the Podroteja spring. At low water levels, the Podroteja spring represents the majority of the discharge of the Idrijca in the cross-section of the Podroteja water gauging station.

Since the springs of Divje jezero and Podroteja have the same catchment, the data from the water level regime of the spring of Divje jezero can also be considered as characteristic for the Podroteja spring.

Temperatures and specific electrical conductivity of water were also recorded at the spring of Divje jezero. As in previous years, the temperature of the spring in 2003 increased at low water levels during the summer months when there is no inflow of fresh water. The temperature of the spring in the spring, autumn and winter months varies between 8.5 and 8.8 °C while the lowest water temperature in February was below 8 °C, which was the consequence of melted snow flowing from the slope into the lake around the spring.

The measurements of specific electrical conductivity (SEC) were performed uninterruptedly throughout the entire year. In September, specific



Graf 27: Srednji dnevni vodostaji in specifične električne prevodnosti (merjene in korigirane vrednosti) na Divjem jezeru.
Graph 27: Mean daily water levels and specific electrical conductivity (measured and corrected values) at Divje jezero.

Izvira Divje jezero in Podroteja predstavljata hidrološke značilnosti iztoka iz območja Visokega dinarskega krasa v Sloveniji, z zaledjem na območju Trnovskega gozda in Hrušice. Izvir Globočec pri Zagradcu ob Krki na Dolenjskem je tudi na Dinarskem krasu, vendar njegovo zaledje ne sega na visoke kraške planote. Vplivno območje izvira Globočec je severni del Suhe krajine, skupaj z zaledjem površinske Tržiščice, ki ponikne v jami Tentera pri Žlebiču. V zaledju izvira je s sledilnimi poskusi dokazano raztekanje podzemnih voda ob različnih vodnih stanjih. Izvir je zelo ranljiv in je bil pri Ortneku že onesnažen ob izlitju mineralnih olj v Tržiščico. Tik nad izvirom Globočca so po naključju odkrili divje odlagališče strupenih odpadkov. Sanacija je bila zelo draga.

Izvir Globočec je pomemben vodni vir za oskrbo Suhe krajine. Odvzemi preko dneva dosegajo ob konicah porabe 40 l/s, povprečni dnevni odvzem pa je 20 l/s. Izvir je kaptiran, iztok pa kanaliziran in reguliran z zapornico. Aparat, ki je s sondami nameščen pod zapornico, beleži podatke s 15 minutno frekvenco, kjer so opazna nihanja vodostajev zaradi črpanja. Hidrološki režim izvira Globočec se razlikuje od režima izvirov Divje jezero in Podroteja po nižji amplitudi, izdatnosti izvira in razporeditvi nihanj vodostajev. Letni minimalni vodostaj Globočca je bil zabeležen v februarju, vendar je ta trenutna vrednost posledica črpanja. Najnižja srednja mesečna vrednost vodostaja je bila junija. V obdobju od konca maja do konca septembra na izviru ni zabeležen noben vodni val, ki je sicer na območju Visokega krasa nastopil dvakrat v tem obdobju, kar kaže na drugačne padavinske razmere v zaledju Globočca.

Na izviru Globočca merimo tudi temperaturo in specifično električno prevodnost. Zaradi vpliva zapornic in zajezitvenega bazena tik pod izvirom, so

Vzorčenje na izviru Globočec (foto: Niko Trišić, 22. julij 2003).
Sampling at the Globočec spring (photo: Niko Trišić, 22 July 2003).

electrical conductivity dramatically increased due to a defect of the measuring device. We attempted to calibrate the probe, but it was lodged and could not be pulled out of the water. The measured values up to 17 September were within a range of 214 and a maximum of 342 µS/cm. Data on SEC from 18 September until the end of 2003 were corrected by control measurements and an assessment of the delay.

The spring of Divje jezero and Podroteja represent hydrological characteristics of outflows from the High Dinaric Karst region in Slovenia with catchment areas in the regions of the Trnovski gozd and Hrušica. The spring of the Globočec at Zagradec at the Krka River in Dolenjska is also in the Dinaric Karst region; however, its catchment area does not reach the High Karst plains. The northern portion of Suha krajina together with the catchment area of the surface watercourse of Tržiščica, which disappears into the Tentera cave at Žlebič, represents an influential area of the Globočec spring. In the catchment area of the spring, it has been proven through tracing tests that groundwaters bifurcate at different water conditions. The spring is very vulnerable and was already polluted at Ortnek through the leak of mineral oils into the Tržiščica. An illegal dumping ground for hazardous wastes was discovered by chance in the catchment area of the Globočec spring. Rehabilitation proved extremely expensive.

The spring of the Globočec is an important source of water supply for Suha krajina. Abstractions over the course of the day reach 40 l/s at peaks of use and the average daily abstraction is 20 l/s. The spring is capped while the outflow is channelled and regulated with a sluice gate. The gauge fitted with probes and installed below the gate records data at a frequency of every 15 minutes, in which fluctuations of water levels due to water abstraction are recorded. The hydrological regime of the Globočec spring differs from those of the sources of Divje jezero and Podroteja with regard to lower amplitudes, yield and grouping of water level fluctuations. The annual minimum water level of the Globočec was recorded in February which was the result of abstractions. The lowest mean monthly water level value was recorded in June. During the period from the end of May until the end of September, no high yields were recorded at the spring which however occurred in the High Karst region twice within this period thus indicating different precipitation conditions in the Globočec catchment area.

Temperature and specific electrical conductivity are also measured at the Globočec spring observation station. Due to effects of the sluice gates and the accumulation reservoir just below the spring, data on temperatures at the spring during summer months are higher than temperatures measured in podatki o temperaturi izvira v poletnih mesecih višji od vrednosti v izviru. Globočec je za 1,5-2,0 °C toplejši od izvirov na območju Trnovskega gozda.

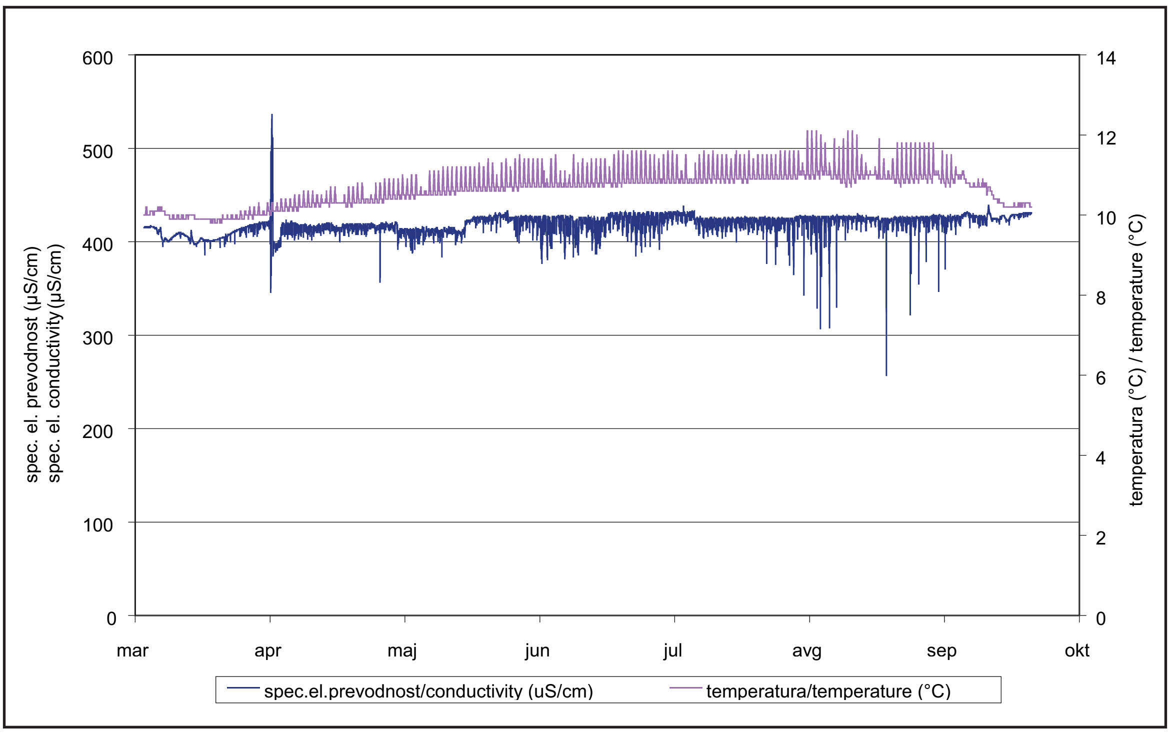
Letni potek merjenih vodostajev, temperature in specifične električne prevodnosti je drugačen od letnega poteka na izvirih z zaledjem Visokega krasa. Predvsem podatkovni nizi SEP so zabrisani s sunki, ki si jih razlagamo kot vpliv delovanja črpalk. Podobne sunke v nizih podatkov SEP smo beležili tudi na izviru Bistrice v Ilirski Bistrici.

Hidrološki monitoring se je na izviru Kamniške Bistrice nadaljeval tudi v letu 2003. Kljub nepopolnemu podatkovnemu nizu kaže izvir v osrednjem delu Kamniško-Savinjskih Alp enake značilnosti, kot smo jih opazili že v letu 2002. Osnovne značilnosti so predvsem nizka temperatura z razponom med 5,3-5,9 °C in razporedom nižjih temperatur v poletju in višjih v spomladanskem obdobju. Zaradi prekinitve niza v zimskem času te trditve ne moremo prenesti na celotno zimsko obdobje v letu. S tem se potrjuje interpretacija, ki smo jo podali že na podlagi podatkov v l. 2002. Toplejša, bolj mineralizirana voda pozimi je posledica baznega iztoka iz globin vodonosnika, hladnejša poleti pa je iztok snežnice iz pripovršinskega razpoklinskega dela vodonosnika. Režim nihanja temperatur je skladen z nihanjem in razporedom vrednosti specifične električne prevodnosti, oba parametra pa sta obratno sorazmerna poteku oz. režimu vodostajev.

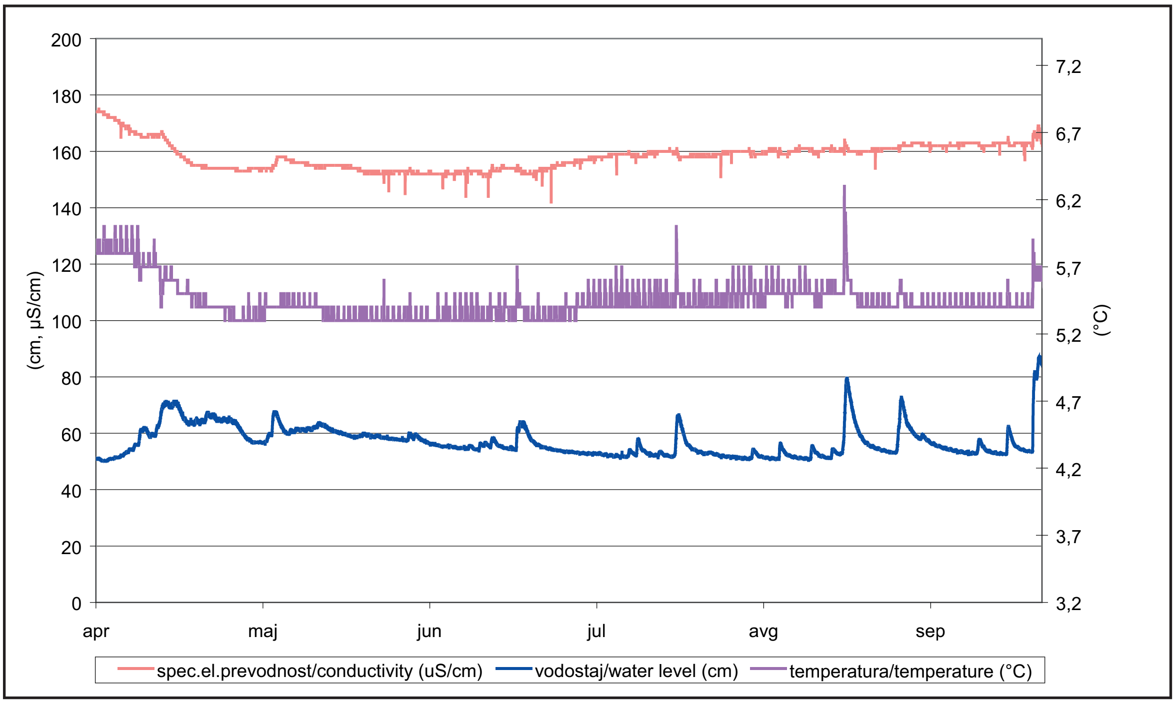
the spring itself. Globočec is from 1.5-2 °C warmer than other sources in the Trnovski gozd region.

The annual course of measuring water levels, temperatures and specific electrical conductivity differs from the annual course of measurements taken at springs with the High Karst catchment area. SEC data time series are especially prone to disruption in shocks believed to be uncharacteristic incorrect values caused by pump operation. Similar shocks regarding SEC data time series were also recorded at the spring of the Bistrica in Ilirska Bistrica.

Hydrological monitoring at the spring of Kamniška Bistrica continued in 2003 as well. Despite the incompleteness of the data time series, the spring in the central part of the Kamniško-Savinjske Alps displays identical features to those already observed in 2002. Basic features comprise predominantly low temperatures ranging from 5.3 to 5.9 °C and the grouping of lower temperatures during the summer and higher temperatures during the spring. Due to the termination of the time series in winter, this assertion is not valid for the entire winter period. However, we can confirm the interpretation already given on the basis of data from 2002. Warmer and more mineralized water in winter is the result of base runoff from the depths of the aquifer, while the runoff of melted snow from surface fissured part of the aquifer is cooler in summer. The regime of temperature fluctuations is proportionate to the fluctua-



Graf 28: Časovni potek temperatur in SEP na izviru Globočec v l. 2003.
Graph 28: Timeline of temperatures and SEC values at the Globočec spring in 2003.



Graf 29: Vodostaj, temperatura in specifična električna prevodnost na izviru Kamniške Bistrice v letu 2003.
Graph 29: Water levels, temperatures and specific electrical conductivity at the Kamniška Bistrica spring in 2003.

Pretok merimo v profilu cca. 120 m pod izvirom, vendar ti podatki ne podajajo vrednosti celotnega pretoka izvira, saj en del vode izdanja na drugi strani morenskega zasipa. V merskem profilu smo pri vodostaju 48 cm izmerili najnižji pretok, 0,469 m^3/s, 14. marca, najvišjega pa 29. maja pri vodostaju 62 cm z vrednostjo 2,089 m^3/s .

tions and the grouping of values of specific electrical conductivity whereby both parameters are inversely proportionate to the course, e.g. regime of water levels.

The discharge is measured in the cross-section of approx. 120 m downstream from the spring; however, these data do not give the value of the total discharge of the spring as one part of the water comes to the surface on the other side of the moraine backfill. In the measuring cross-section, we measured the lowest discharge of 0.469 m^3/s at a water level of 48 cm on 14 March 2003 and the highest of 2.089 m^3/s on 29 May 2003 at a water stage of 62 cm.

D. MORJE

PLIMOVANJE MORJA

Nejc Pogačnik, Mojca Robič

Plimovanje je periodično odzivanje trdne zemeljske skorje, ozračja in vodovja na motnje v težnostnem polju, ki jih povzročata privlačni sili Lune in Sonca. Torej je pojav, ki ne zajema samo vse svetovne vode, marveč tudi Zemljino ozračje in celo skorjo. Ker pa so v ozračju in v skorji te anomalije zelo majhne, jih v večini primerov zanemarimo. Nasprotno temu je plimovanje morja zelo pomembno za plovbo in obmorske prebivalce. Vpliv plimovanja pa se ob številnih veletokih občuti tudi v notranjosti kontinentov (Nil, Temza, Amazonka...). Plimovanje morja, ki ga povzročijo težnostne sile nebesnih teles, imenujemo astronomsko plimovanje. Ker Luna potuje okrog Zemlje, z njo pa tudi plimni val, se po celem svetu izmenjavata plima in oseka. Maksimumi (minimumi) plime in oseke se pojavljajo vsakih 6 ur in 12,5 minut. Zamik 12,5 minut je v glavnem posledica premika Lune na orbiti okrog Zemlje za približno 13 stopinj na dan. Skupna zakasnitev ob koncu dneva zato znaša približno 50 minut. V Jadranskem morju se tako navadno dnevno zamenjata dve plimi in dve oseki. Zaradi znanega cikličnega gibanja nebesnih teles je možno napovedati plimovanje vnaprej. V času mlaja in ščipa, ko sta Sonce in Luna v konjunkciji oz. opoziciji, se vplivi plimotvornih sil seštevajo in amplitude plimovanja so velike. Ob prvem in zadnjem krajcu, ko sta Sonce in Luna v kvadraturi, so amplitude manjše.

Pojava plime in oseke pa nista povsem monotona, torej vedno enaka. Spreminja se tako interval menjavanja kot tudi višina amplitude plimovanja. Slednja je odvisna od dveh stvari. Prva je eliptična pot Lune, kar pomeni, da bo imelo plimovanje večjo amplitudo, ko bo Luna bližje Zemlji. Druga je, da povzroča plimovanje tudi Sonce. Le to je sicer zelo oddaljeno od našega planeta, vendar je zaradi izredno velike mase prav tako pomemben dejavnik pri plimovanju. Ko so Sonce, Luna in Zemlja v isti liniji, bo prišlo do tako imenovane visoke plime, ko je Luna pravokotno na smer Zemlja – Sonce, pride do nizke oseke**.** V južnem Jadranu je razlika med plimo in oseko ponekod le 30 cm, v severnem Jadranu pa okrog 60 cm. V svetovnem povprečju znaša amplituda plimovanja 2 do 3 metre, najmanjše razlike med plimo in oseko pa so ob ekvatorju. Do razlike v višini plimovanja pride zaradi nagiba Lunine

D. SEA

SEA LEVELS

Nejc Pogačnik, Mojca Robič

Tide is the periodical response of the solid Earth's crust, the atmosphere and the rivers and lakes to the disruptions in the gravity field caused by the gravity forces of the Moon and the Sun. This is, therefore, a phenomenon that does not only affect all global waters but also the Earth's atmosphere and the entire crust. Because these anomalies are small in the atmosphere and the crust, they are disregarded in the majority of cases. As opposed to this, the tidal movements of the sea are very important for navigation and residents of coastal regions. The effect of tide is felt even in the interior parts of continents along numerous large watercourses (the Nile, the Thames, the Amazon, etc.). Sea tide caused by the gravity forces of celestial objects is called astronomical tide. Because the Moon travels around the Earth and with it the tidal wave, low and high tides alternate around the world. The maximums (minimums) of high and low tide appear every 6 hours and 12.5 minutes. The deviation of 12.5 minutes is primarily the result of the Moon's declination in the orbit around the Earth by approximately 13 degrees per day. The total delay at the end of the day, therefore, amounts to around 50 minutes. In the Adriatic Sea, two high and low tides respectively are usually exchanged within a day. Due to the known cyclical movement of celestial bodies, it is possible to forecast the tide in advance. During the times of the full moon and new moon when the Sun and the Moon are in conjunction or opposition, the effects of the tide-forming forces are added up and the tidal amplitudes are great. At the first and last quarters when the Sun and the Moon are in quadrature, these amplitudes are smaller.

The phenomena of high and low tides are not entirely monotonous or, in other words, always the same. The interval of the alternating of the tides as well as the tidal amplitude are changing. The latter is dependent on two factors. The first is the elliptical orbit of the Moon, meaning that tide will have greater amplitude when the Moon is closer to the Earth. The second is that the Sun also causes tidal movements. The Sun is very far from our planet; however, due to its great mass, it is a significant tidal factor. When the Sun, the Moon and the Earth are in alignment, the so-called high tide will occur.

krožnice glede na Zemljin ekvator (23 stopinj). Razloge za tako velike razlike gre iskati v že omenjenem nagibu področij glede na Lunino ekliptiko, pa tudi v velikosti morij, oblikovanosti morskega dna in položaju ter oblikovanosti kopnega, če naštejemo pomembnejše dejavnike. Vsi ti dejavniki vplivajo na določitev prognozirane astronomske višine morja, pri čemer imajo na višino morja pri nas močan vpliv tudi meteorološke razmere. Od meteoroloških dejavnikov sta najbolj vplivna veter in zračni pritisk. Z zniževanjem zračnega pritiska se gladina morja zviša. Južni ali jugovzhodni veter nariva vodne mase na obalo in prav tako povzroči zvišanje gladine. Obratno burja znižuje gladino, saj piha s kopnega proti odprtemu morju. Na zvišanje gladine morja v Kopru lahko vpliva tudi močnejši južni veter v Dalmaciji. Lastno nihanje morja se pojavi v zaprtih in delno zaprtih morjih. V Jadranu ima ob južnem vetru periodo okoli 21 ur, ob jugozahodniku pa le nekaj ur.

Razliko med izračunano astronomsko in dejansko izmerjeno višino morja imenujemo residualna višina. Njena vrednost je odvisna največkrat od meteoroloških dejavnikov, včasih pa tudi od lastnega nihanja morja.

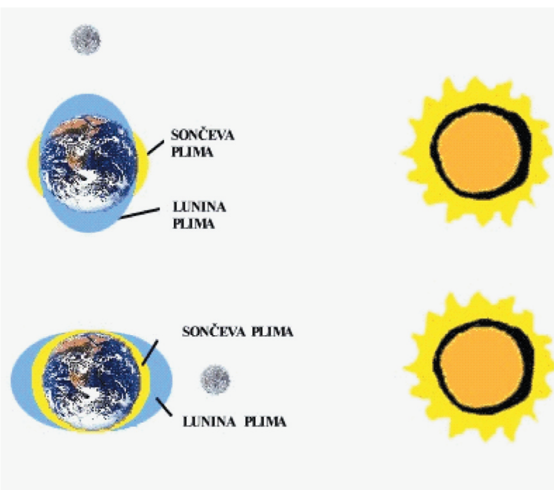
Pri spremljanju gladine morja obravnavamo urne (to so trenutne vrednosti ob polnih urah) in ekstremne vrednosti (navadno po dve visoki in dve nizki vodi v dnevu). Iz urnih podatkov izračunamo srednjo dnevno vrednost (SDV v tabeli D.3. v II. delu publikacije), iz teh srednjo mesečno (SMV v tabeli D.3.) in iz teh srednjo letno vrednost (SLV v tabeli D.3.).

When the Moon is perpendicular to the direction of the Earth-Sun, the low tide occurs. In the southern Adriatic, the difference between the high tide and the low tide is only 30 cm in some places whereas in the northern Adriatic, it is around 60 cm. In the global average, the tide amplitude amounts to 2 to 3 metres with the smallest differences between high tide and low tide being along the equator. The difference in the height of tide is due to the inclination of the Moon's orbit with respect to the Earth's equator (23 degrees). The reasons behind such great differences are to be found in the already mentioned inclination of areas with respect to the Moon's ecliptic, and also in the size of the seas, the relief of the sea bed and the position and relief of land – to name but a few more important factors. All of these factors affect the determination of the forecasted astronomical height of the sea whereby meteorological conditions exert a significant influence on the height of the sea in our region. Of the meteorological factors, wind and air pressure are the most influential. With the drop of air pressure, the sea level is increased. The southern and south-eastern winds push water masses towards the shore and also cause an elevation of the water level. Quite oppositely, the bora wind decreases the sea level as it blows from the land towards the open seas. In Koper, elevated sea level may be caused by the stronger southern wind in Dalmatia. Own fluctuation of the sea appears in enclosed and partially enclosed seas. In the Adriatic during the southern wind, it has a periodical frequency of around 21 hours, and during the south-westerly wind only a few hours.

The difference between the calculated astronomical and the actual measured sea level is called residual sea level. Its value most often depends on meteorological factors and occasionally also on the sea's own fluctuation.

In the monitoring of sea levels, the hourly (these are current values at full hours) and extreme values (usually, there are two instances of high and two of low waters in a day) are considered. From the hourly data, the mean daily values (SDV in Table D.3. in Part II) are calculated and from these the mean monthly values (SMV in Table D.3.) and finally from these also the mean annual values (SLV in Table D.3.).

In the monitoring of high waters, it is determined, which of the high waters in the day was higher (VVV) and from this, the average (SVVV in Table D.2. in Part II) is calculated. The mean high water as an average of both high waters in a day



Vpliv Lune in Sonca na plimovanje – zgoraj nebesna telesa v kvadraturi, spodaj v konjunkciji. (Vir:http://www.greeenhouse.gov.au/renewable/reis/techologies/ocean/tidal.html, http://www2.arnes.si/~rmurko2/PLIMOVANJE.htm)
The effect of the Moon and the Sun on tide – above: celestial bodies in quadrature, below: in conjunction. (Source: http://www.greeenhouse.gov.au/renewable/reis/techologies/ocean/tidal.html, http://www2.arnes.si/~rmurko2/PLIMOVANJE.htm)

Pri opazovanju visokih voda določimo, katera od visokih voda v dnevu je bila višja (VVV), iz njih izračunamo povprečje (SVVV v tabeli D.2. v II. delu publikacije). Izračunamo tudi srednjo visoko vodo, ki je povprečje obeh visokih voda v dnevu, oz. vseh v mesecu ali letu (SVV v tabeli D.2.), ter določimo najvišjo gladino morja v mesecu ali letu (NVVV v tabeli D.2. in D.4. v II. delu publikacije). Podobno velja za nizke vode, kjer določamo nižjega od obeh ekstremov (NNV), ter iz njih računamo povprečje (SNNV v tabeli D.2.). Srednja nizka voda (SNV v tabeli D.2.) je povprečje vseh nizkih voda v dnevu, mesecu ali letu. Najnižja gladina morja v mesecu ali letu je označena z NNNV in jo najdemo v tabelah D.2. in D.4.

V letu 2003 je bila srednja višina morja nekoliko nad višino v primerjalnem obdobju 1961-2000. Srednja letna višina morja (tabela D.3.) je bila 216,7 cm, kar je 4 cm nad dolgoletnim povprečjem. Srednje mesečne višine morja so preko leta močno nihale in dosegle v mesecu januarju in oktobru zelo visoke vrednosti. Nekoliko navzdol je izstopal februar, medtem ko gladina v juniju skoraj ni odstopala od povprečja. Vremenske razmere na koncu oktobra in novembra so v času nizke astronomske plime vplivale na dvig gladine morja in 1. novembra je bila izmerjena najvišja višina morja (308 cm) v letu 2003 (graf 37).

V prvih dneh leta 2003 so se nadaljevale vremenske razmere iz zadnjih dni leta 2002, ki so omogočale dvig gladine morja nad astronomsko plimo. Nizek pritisk in močan jugo sta v prvih dneh leta sovpadala z visoko astronomsko plimo in višine morja so na mareografski postaji Koper presegle 300 cm. Najvišja izmerjena gladina morja je bila 2. januarja zjutraj, 305 cm. Od 6. do 11. januarja se je veter še okrepil, vendar je bilo astronomsko plimovanje manjše in višine morja niso več dosegale tako visokih vrednosti. Po 11. januarju se je pritisk povečal, čemur je sledilo tudi zniževanje gladine morja. Do večjega povišanja gladine morja je prišlo še 22. in 23. januarja ter ob koncu meseca. Vse to je povzročilo, da je bila srednja mesečna višina morja januarja nadpovprečna, 226,8 cm.

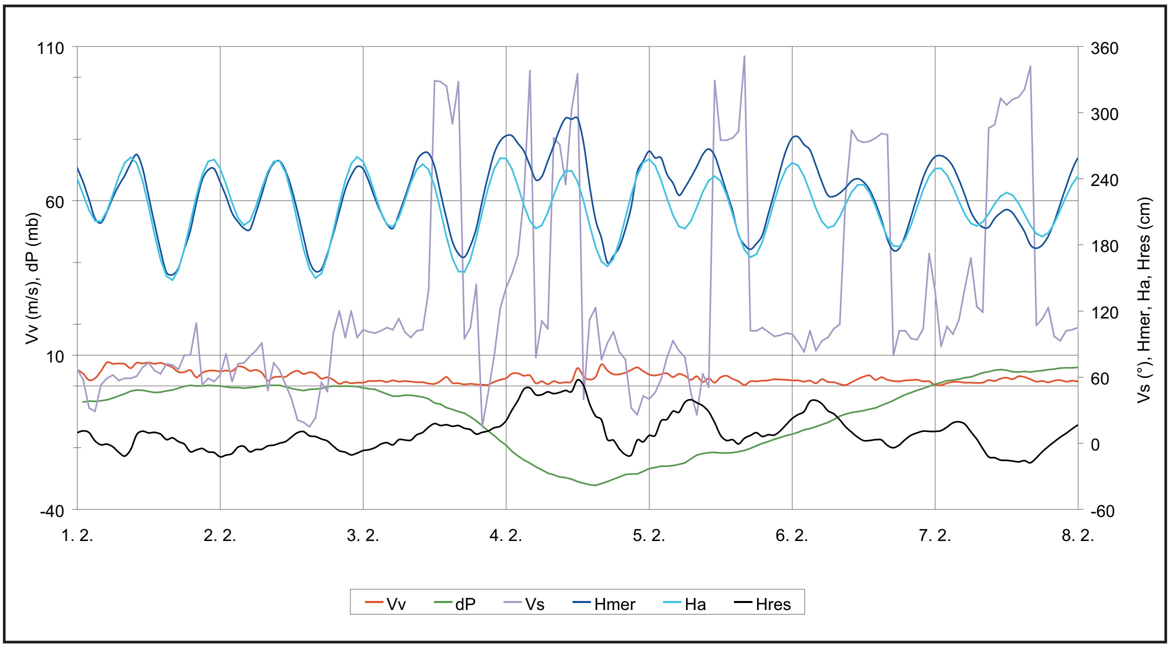
Tudi prve dni v februarju je bilo morje visoko in je 4. februarja doseglo najvišjo gladino, 301 cm. Temu je botroval izredno nizek zračni pritisk, ki je povzročil povišanje gladine morja za 58 cm glede na predvideno – astronomsko višino (graf 30). Sledilo je dolgo, 10-dnevno obdobje povišanega zračnega tlaka z burjo. V tem obdobju je bilo morje nizko, saj burja odriva morske mase proti odprtemu morju. Srednja mesečna višina morja je bila tako blizu povprečja.

or of all of these in a month or year (SVV in Table D.2.) is calculated. The highest sea level in a month or year (NVVV in Tables D.2. in D.4. in Part II) is determined. Similar is true of low waters where the lower of the two extremes (NNV) is determined and the average (SNNV in Table D.2.) is calculated from them. The mean low water (SNV in Table D.2.) is the average of all low water instances in a day, month or year. The lowest sea level in a month or year is marked NNNV and is found in Tables D.2. and D.4.

In 2003, the mean sea level was slightly above the level of the reference period of 1961-2000. The mean annual sea level (Table D.3.) was 216.7 cm which is 4 cm above the multi-annual mean. The mean monthly sea level fluctuated significantly over the year and reached very high values in January and October. February was an exception in terms of exhibiting lower sea levels while the sea level in June barely deviated from the average. Weather conditions at the end of October and November affected the rise of sea levels during the period of low astronomical tide and on 1 November, the highest sea level was recorded (308 cm) for 2003 (Graph 37).

Weather conditions that characterized the final days of 2002 continued in the first days of 2003 and enabled the rising of the sea level above the astronomical tide. Low pressure and a strong southerly wind coincided in the first days of the year with the high astronomical tide and sea levels exceeded 300 cm at the Koper tide gauge station. The highest measured sea level occurred in the morning of January 2, and amounted to 305 cm. From 6 to 11 January, the wind gained in strength; however, astronomical tidal action was smaller and the sea levels did not attain such high values. After 11 January, pressure increased and this was followed by the decrease of sea level. Greater rise of the sea level again occurred on 22 and 23 January and at the end of the month. All of this resulted in the mean monthly sea level in January being above-average at 226.8 cm.

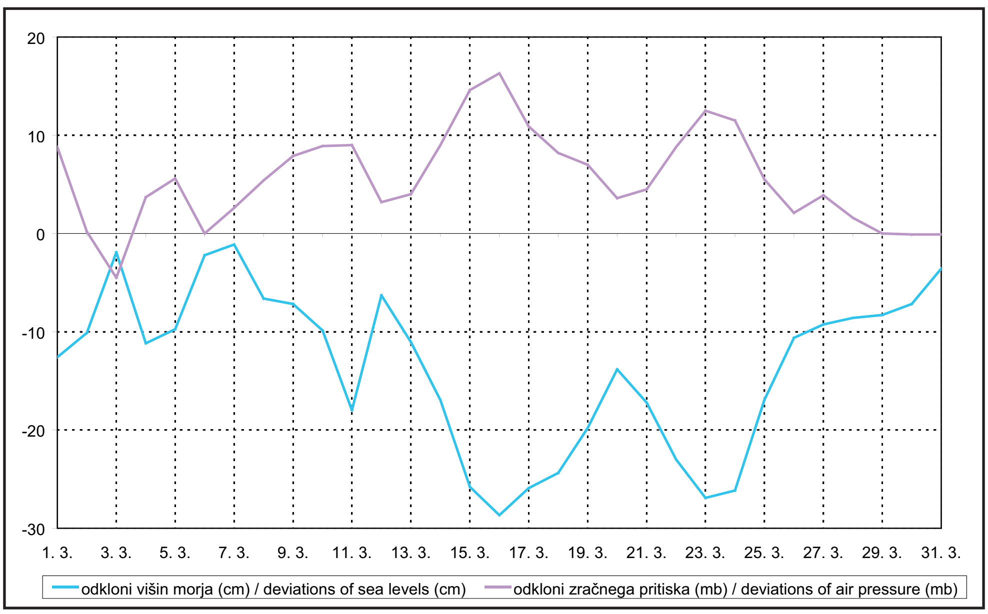
In the first days of February, the sea level was high and on 4 February, reached the highest sea level of 301 cm. This was caused by the extremely low air pressure that in turn caused the rising of the sea level by 58 cm with respect to the foreseen – astronomical level (Graph 30). This was followed by a long 10-day period of elevated air pressure accompanied by the bora wind. In this period, the sea was low as the bora pushes sea masses towards the open seas. The mean monthly sea level was thus close to the average.



Graf 30: Višina morja v februarju ob posebnih meteoroloških razmerah.
Legenda: Vv = hitrost vetra, dP = razlika zračnega pritiska od srednje vrednosti 1016 mb, Vs = smer vetra v stopinjah, Hmer = izmerjena višina morja, Ha = astronomska višina morja, Hres = residualna višina je razlika med izmerjeno in napovedano višino morja.
Graph 30: The sea level in February during exceptional meteorological conditions.
Legend: Vv = wind velocity, dP = deviation of air pressure from the mean value of 1016 mb, Vs = wind direction in degrees, Hmer = measured sea level, Ha = astronomical sea level, Hres = residual sea level is the difference between the measured and the forecast sea level.

Zračni pritisk je ostal visok še ves mesec marec in je skupaj z zmerno burjo povzročil, da je bila gladina morja ves mesec nižja od napovedane (graf 31). Vse značilne vrednosti so bile pod dolgoletnim povprečjem. Srednja mesečna vrednost, 201,8 cm, je bila najmanjša v letu.

Air pressure remained high for the entire month of March and in conjunction with a modest bora caused the sea level to be lower than the forecast one for the entire month (Graph 31). All the characteristic values were below the multi-annual mean. The mean monthly value of 201.8 cm was the



Graf 31: Srednje dnevne višine morja v marcu so bile vse dni pod dolgoletnim povprečjem.
Graph 31: The mean daily sea level in March remained below the multi-annual mean throughout the entire month.

Srednja mesečna gladina morja v aprilu je bila podobna povprečni in je znašala 213,1 cm. Višine morja so najbolj odstopale od napovedanih okrog 10. aprila (residualne višine okoli + 50 cm), vendar ni prišlo do sovpadanja z visokim astronomskim plimovanjem in gladina morja ni bila visoka. Najvišja in najnižja mesečna vrednost sta bili nekoliko podpovprečni.

Tudi vse značilne vrednosti v maju so bile podpovprečne. Morje je bilo ves mesec (z izjemo nekaj ur v prvih dneh in nekaj ur v zadnjih dneh meseca) nižje od napovedanega.

Gladina morja je ves junij malo odstopala od predvidene višine. Prvih nekaj dni in zadnjo tretjino meseca je bila nekoliko nižja, ostali del meseca pa nekoliko višja od pričakovanega. Odstopanja so bila manjša od 10 cm (graf 32). Srednja mesečna višina morja je bila 217 cm, kar je manj kot centimeter nižje od srednje vrednosti za obdobje 1960-1990.

Podobno je bilo tudi v mesecu juliju, saj so bila nekoliko večja odstopanja le v prvih dneh meseca, kasneje so bila odstopanja navzgor, vendar minimalna. Vse značilne vrednosti so bile nekoliko višje od srednjih obdobnih vrednosti.

Po zelo povprečnih zgodnjih poletnih mesecih, je bilo gibanje gladine morja v avgustu precej bolj pestro in neobičajno. Ves mesec je bila gladina morja povišana, posebej visoko je bilo morje ob koncu meseca. Najvišja višina morja, 306 cm, je bila zabeležena 31. avgusta kot posledica izredne vremenske situacije. Ob prehodu hladne fronte je

lowest in the year.

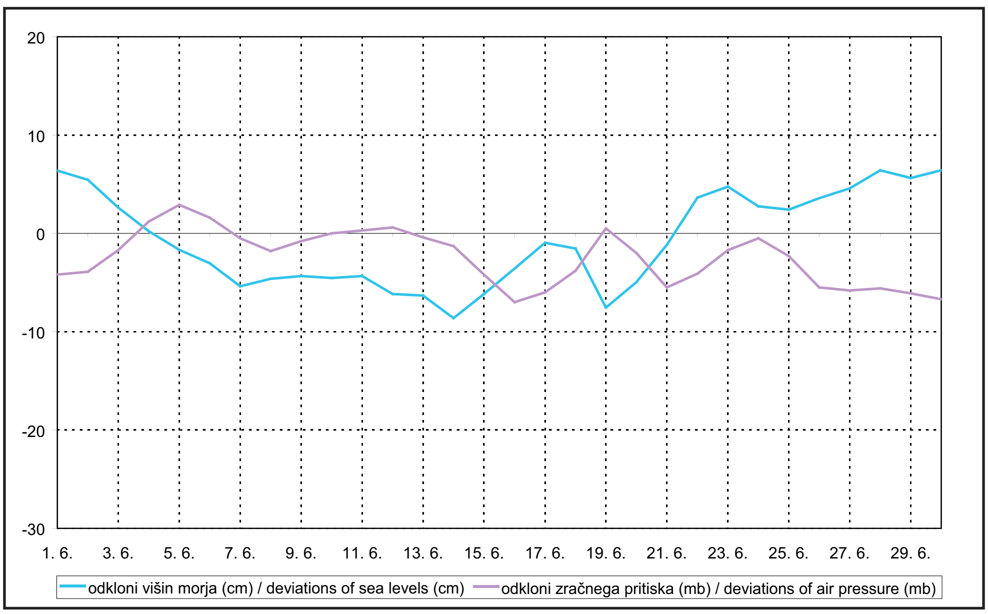
The mean monthly sea level in April was similar to the average and amounted to 213.1 cm. Sea levels deviated most from the forecasted levels around 10 April (residual levels around + 50 cm); however, they did not coincide with high astronomical tidal action and the sea level was not high. The highest and lowest monthly values were slightly below-average.

All the characteristic values in May were also below-average. The sea (with the exception of a few hours in the first days and a few hours in the last days of the month) was lower than the forecasted one for the entire month.

The sea level only slightly deviated from the foreseen one the entire month of June. In the first few days of the month and the last third of the month, the sea level was slightly lower while in the rest of the month, it was slightly higher than expected. Deviations were lower than 10 cm (Graph 32). The mean monthly sea level was 217 cm, which is less than a centimeter lower than the mean value for the 1960-1990 period.

July was similar with larger deviations occurring only in the first days of the month while later on, there were deviations upwards, which were, however, minimal. All the characteristic values were slightly higher than the mean values for the period.

After quite average early summer months, the movement of the sea levels in August was much more lively and unusual. For the entire month, the



Graf 32: Srednje dnevne višine morja so v juniju malo odstopale od povprečnih višin v obdobju.
Graph 32: The mean daily sea levels in June slightly deviated from the mean levels in the period.

zapihala izredno močna tramontana, s sunki do 29 m/s, kar je povzročilo močno valovanje in veliko povišanje gladine morja. Na srečo ta pojav ni sovpadal s plimo, ki je nastopila 2-3 ure prej (graf 33).

V poletnih mesecih nad našimi kraji navadno prevladuje visok zračni pritisk in stabilno vreme, kar na višine gladine morja vpliva tako, da so vrednosti gladin morja povprečne ali podpovprečne. V avgustu 2003 pa je bila situacija skoraj ves mesec neznačilna (graf 34).

September je bil spet povprečen, z zmernimi odstopanji v začetku meseca navzgor, ob koncu meseca pa navzdol.

Srednja višina morja v oktobru je bila nadpovprečna, 227,6 cm. To je bilo drugo najvišje mesečno povprečje v letu. Morje je bilo višje od pričakovanega predvsem v prvih dneh ter ob koncu meseca. Najvišja mesečna gladina morja (306 cm) je bila nadpovprečna, ne pa izjemno visoka in je bila izmerjena 5. oktobra. V zadnjih oktobrskih dneh je pihal močan jugovzhodni veter, ki je morje narival na obalo in skupaj z nizkim zračnim pritiskom povzročil močno povišano plimovanje morja. Največja izmerjena residualna višina je bila 78 cm. Ta ni sovpadala z visoko astronomsko plimo in zato ni prišlo do ekstremnih višin (graf 35).

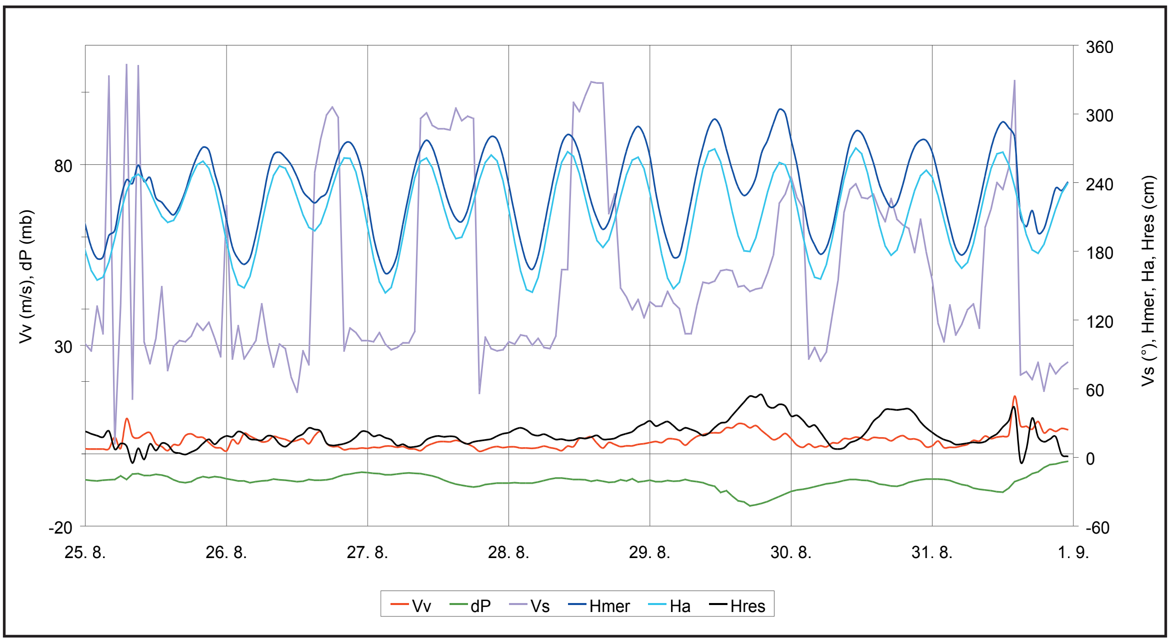
Visoko plimovanje se je nadaljevalo tudi v prvih dneh novembra. Srednja dnevna višina prvega

sea level was elevated with the sea being especially high at the end of the month. The highest sea level of 306 cm was recorded on 31 August as a result of extraordinary weather conditions. Upon the transition of the cold front, an extraordinarily strong tramontana wind began blowing with surges of up to 29 m/s, which caused significant wave motions and a significant elevation of the sea level. Luckily, the phenomenon did not coincide with the high tide that occurred 2 to 3 hours earlier (Graph 33).

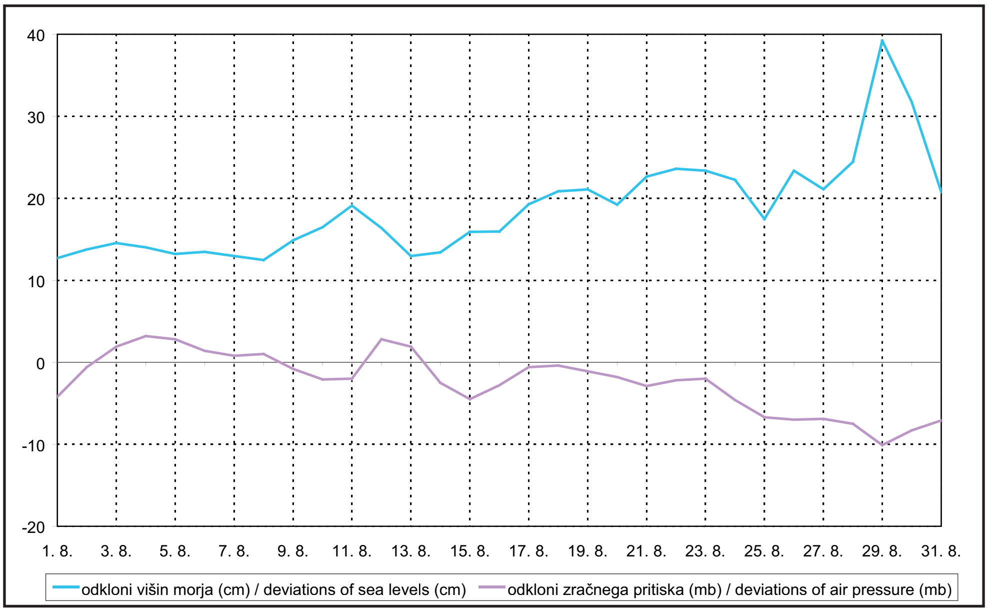
During the summer months, high air pressure and stable weather are usually prevalent for our region, which affects the sea levels in such a way that the sea level values are average or below-average. In August 2003, the situation was uncharacteristic for almost the entire month (Graph 34).

September was again average, exhibiting modest deviations upwards in the beginning of the month and downwards at the end of the month.

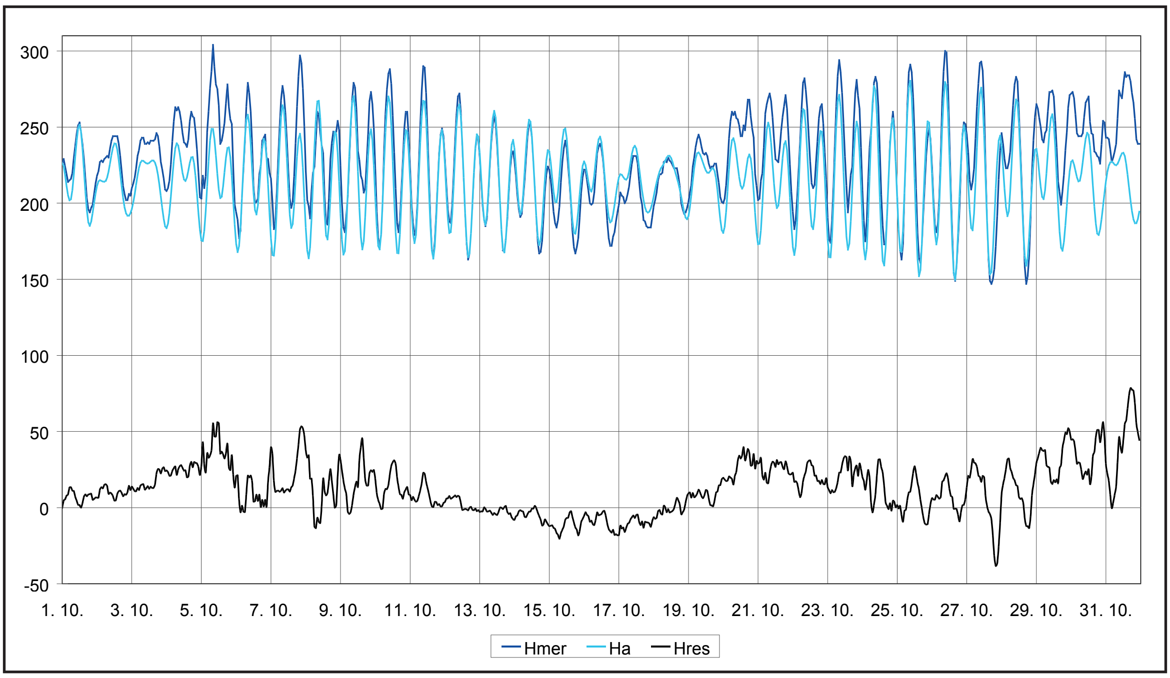
The mean sea level in October was above-average at 227.6 cm. This was the second highest monthly mean in the year. The sea was higher than expected predominantly in the first days and at the end of the month. The highest monthly sea level (306 cm) was above-average, but not extremely high and was measured on 5 October. In the last days of October, a strong south-easterly wind was blowing



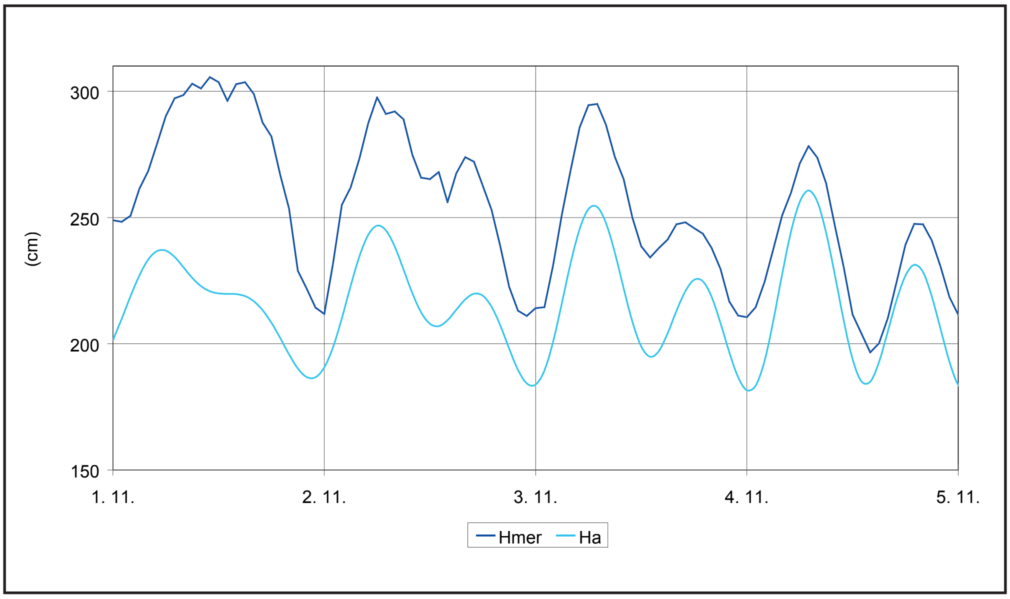
Graf 33: Višina morja v avgustu ob posebnih meteoroloških razmerah.
Legenda: Vv = hitrost vetra, dP = razlika zračnega pritiska od srednje vrednosti 1016 mb, Vs = smer vetra v stopinjah, Hmer = izmerjena višina morja, Ha = atmosferska višina morja, Hres = residualna višina je razlika med izmerjeno in napovedano višino morja.
Graph 33: The sea level in August during exceptional meteorological conditions.
Legend: Vv = wind velocity, dP = deviation of air pressure from the mean value of 1016 mb, Vs = wind direction in degrees, Hmer = measured sea level, Ha = astronomical sea level, Hres = residual sea level is the difference between the measured and the forecast sea level.



Graf 34: Srednje dnevne višine morja v avgustu so bile vse dni v mesecu nad dolgoletnim povprečjem.
Graph 34: The mean daily sea levels in August remained above the multi-annual mean throughout the entire month.



Graf 35: Zadnje dni oktobra so bile izmerjene višine morja do 78 cm nad astronomskimi višinami gladin morja. Izmerjene urne (Hmer) in astronomske (Ha) višine morja v mesecu oktobru 2003 ter razlika med njimi (Hres). Izhodišče izmerjenih višin morja je mareografska “ničla”, 216 cm, na mareografski postaji v Kopru.
Graph 35: In the last days of October, sea levels of up to 78 cm above the astronomical sea levels were measured. The measured hourly (Hmer) and astronomical (Ha) sea levels in October 2003 and the differences between them (Hres). The baseline of the measured sea levels is the maregraphic “zero” datum of 216 cm at the tide gauge station in Koper.



Graf 36: Vremenske razmere 1. novembra so povzročile veliko povišanje gladine morja.
Graph 36: Weather conditions on 1 November caused a significant rise of the sea level.

dne v novembru je bila najvišja v celem letu, kar 265,8 cm. Vremenska situacija je bila značilna, z močnim jugovzhodnim vetrom in zelo nizkim zračnim tlakom (do 20 mb pod dolgoletnim povprečjem), kar je povzročilo izjemno povišanje morske gladine. Residualna višina je tako dosegla maksimalnih 78 cm, kar je tudi najvišja vrednost v letu 2003. Kljub temu da je bila astronomska plima 1. novembra med najnižjimi v mesecu (graf 36), je bila zabeležena maksimalna višina morja, 308 cm.

Ob koncu novembra je bilo še eno obdobje občutnega povišanja gladin morja. Residualne višine so znašale tudi preko pol metra in kljub nizkim astronomskim višinam, so se izmerjene gladine morja približale 300 cm.

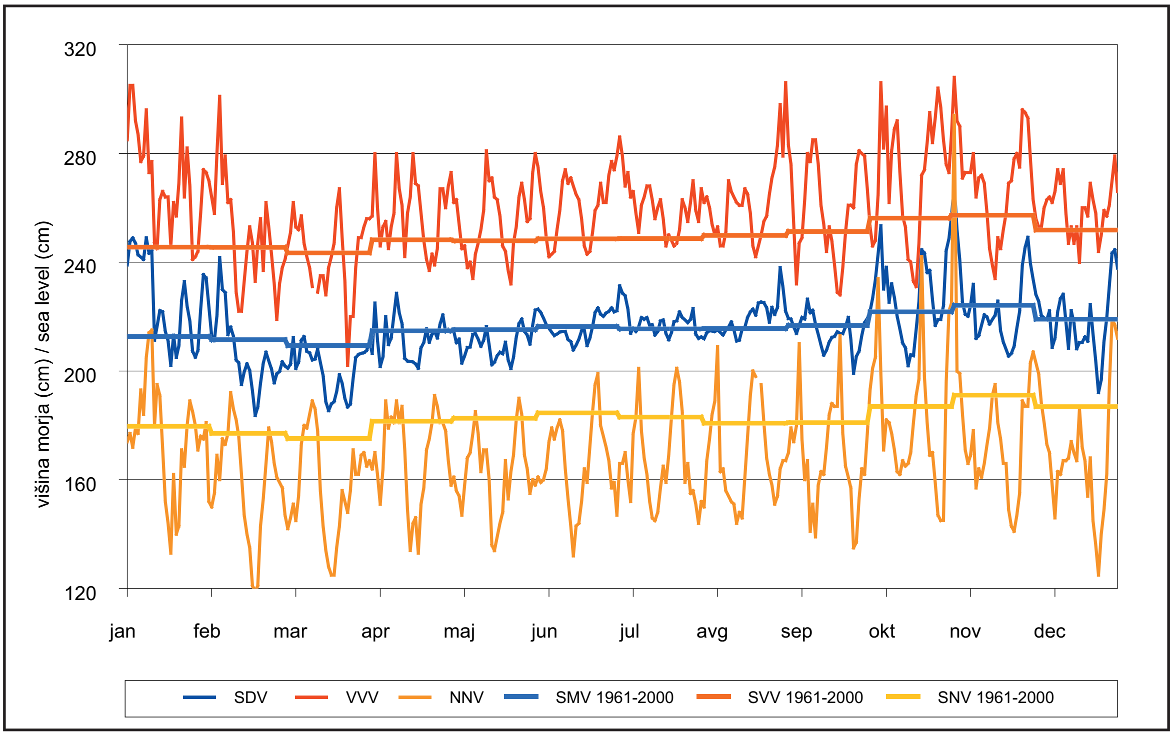
Višine morja so bile v decembru povprečne glede na dolgoletno obdobje. Nekoliko povišane so bile gladine v zadnjih dneh leta.

that pushed the sea towards the coast and in conjunction with low air pressure caused severe tidal action of the sea. The highest measured residual level was 78 cm. It did not coincide with the high astronomical tide, which is why no extreme levels occurred (Graph 35).

Significant tidal action continued also in the first days of November. The mean daily level on the first day of November was the highest of the year at 265.8 cm. The weather situation was characteristic with strong south-easterly winds and very low air pressure (up to 20 mb below the multi-annual mean), which caused an extreme rise of the sea level. The residual level thus reached a maximum of 78 cm, which is also the highest value for 2003. Despite the astronomical tide on 1 November being among the lowest in the month (Graph 36), a maximum sea level at 308 cm was recorded.

There was another period of significant elevation of the sea level at the end of November. Residual levels were over half a meter high and despite the low astronomical levels, the measured sea levels approached 300 cm.

Sea levels in December were average compared to the multi-annual period. Levels were slightly elevated in the last days of the year.



Graf 37: Povprečne dnevne višine morja, povprečne dnevne plime in oseke v letu 2003 in pripadajoče mesečne vrednosti iz obdobja 1961-2000.
Graph 37: Mean daily sea levels, mean high tides and low tides in 2003 and the accompanying monthly values from the 1961-2000 period.

E. VODNA BILANCA

VODNA BILANCA

Peter Frantar

Vodna bilanca je razdelitev vodnega kroga določenega območja na njegove sestavne člene. Izračun temelji na primerjavi neto odtoka ($Q_n = Q_v – Q_i$); neto odtok je razlika med dotokom in iztokom vode padavin (P), evapotranspiracije (ET) ter sprememb vodnih zalog (A – npr. količine podzemne vode)). Iz razpoložljivih podatkov sprememb vodnih zalog ne moremo količinsko ovrednotiti in smo jih zanemarili. To je pri obdobni vodni bilanci sprejemljivo, ne pa tudi v izredno sušnem letu 2003, ko so se vodne zaloge zelo verjetno zmanjšale. Vemo, da so se vsaj v nekaterih vodonosnikih gladine podzemnih voda nižale in ob koncu leta niso dosegle nivojev na začetku leta. Pri interpretaciji rezultatov je treba to upoštevati. Za izračun smo uporabili poenostavljeno enačbo vodne bilance, ki predpostavlja ravnovesje padavin z odtokom in evapotranspiracijo:

Padavine (P) = Odtok (Q) + Evapotranspiracija (ET)

Leto 2003 je bilo hidrološko še bolj suho od leta 2002, s katerim lahko primerjamo rezultate letne bilance. Bilanco smo izdelali za Jadransko in Črnomorsko povodje, ki smo ju pri računanju odtokov še notranje razdelili. Jadransko povodje smo razdelili na porečje Soče, ki zajema pritoke Soče in Vipave, ter na ti. povodje Jadranskih rek, ki zajema preostanek povodja Jadranskega morja. Črnomorsko povodje pa smo razdelili na Pomurje, Podravje in Posavje. Izračunane količine padavin in evapotranspiracije temeljijo na analizi posameznih enot glavnih povodij z uporabo geoinformacijske tehnologije.

Členi vodne bilance

Letno količino padavin in evapotranspiracije smo izračunali iz rastrskih kart Slovenije (velikost celice 100 m x 100 m). Za karto padavin so bile uporabljene nekorigirane padavine za leto 2003, za karto evapotranspiracije pa izračunana potencialna evapotranspiracija za isto leto. S prekrivanjem poligonov smo tako dobili skupno količino padavin in evapotranspiracije v posameznem porečju. Tako določeno evapotranspiracijo smo primerjali z »bilanč-

E. WATER BALANCE

WATER BALANCE

Peter Frantar

Water balance is the distribution of the water cycle at a certain area into its constituent components. The calculation is based on the comparison of net runoffs ($Q_n = Q_v – Q_i$); net runoff is the difference between the inflow and outflow of precipitation water (P), evapotranspiration (ET) and the changes in water reserves (A – for example the quantities of groundwater). The changes in water reserves cannot be quantitatively evaluated from the available data so they were disregarded. This is acceptable in the water balance for the multi-annual period but not in the year 2003 with extreme drought when water reserves most probably decreased. We know that at least in some aquifers groundwater levels were decreasing and at the end of the year did not attain the levels at the beginning of the year. This needs to be taken into account in the interpretation of results. We used a simplified water balance equation for the calculation, which represents the equilibrium of precipitation with runoff and evapotranspiration:

Precipitation (P) = Runoff (Q) + Evapotranspiration (ET)

In a hydrological sense, 2003 was an even drier year than 2002, with which we can compare results of the annual balance. A balance was produced for the Adriatic and Black Sea basins, which we additionally divided internally for the calculation of runoffs. The Adriatic basin was divided into the Soča river basin comprising the tributaries of the rivers Soča and Vipava and the so-called catchment area of the Adriatic Sea rivers comprising the remaining catchment area of the Adriatic Sea basin. The Black Sea basin was divided into Pomurje, Podravje and Posavje river basins. The calculated quantities of precipitation and evapotranspiration are based on an analysis of individual units of main catchment areas with the use of geo-information technology.

Components of water balance

The annual amount of **precipitation and evapotranspiration** was calculated from raster maps of Slovenia (cell size is 100 m x 100 m). For no« vrednostjo, izračunano po enačbi P – Q = ET. Leta 2003 je bila razlika med potencialno in »bilančno« evapotranspiracijo večja kot prejšnja leta. To pripisujemo izredno majhni količini padavin, ki je zelo odstopala od dolgoletnega povprečja.

Odtoki so praviloma najzanesljivejši člen vodne bilance porečij. V reprezentativnih vodomernih postajah se odtok določenega območja zbere na enem vodomernem profilu. Pri izračunavanju smo upoštevali pretoke vodomernih postaj, ki zajamejo večino dotokov in iztokov iz države ter ocene pretokov za vodotoke, ki imajo v Sloveniji le povirja. Za območja brez meritev smo pretoke določili z upoštevanjem specifičnih odtokov Q (l/km^2/s) hidrološko primerljivih vodomernih postaj.

Vodna bilanca po glavnih slovenskih porečjih

Pomurje je hidrogeografska regija s površino 1.390 km^2 in z najmanjšo povprečno količino padavin v Sloveniji. Leta 2003 je v Pomurju padlo v povprečju 576 mm padavin (v obdobju 1961-1990: 903 mm), kar je enako 25,4 m^3/s. Količina izhlapele vode je bila po izračunu potencialne evapotranspiracije skoraj 30 odstotkov večja od »bilančne« ET (izračunana po formuli ET = P – Q). Domnevni vzroki so najverjetneje plitvi vodonosni sistemi, izredno sušno leto 2003 in majhna količina padavin, ki prinesejo veliko razliko med obema evapotranspiracijama, saj je potencialna računana za enak tip pokrovnosti in ne glede na bližino podtalnice, ki jo v plitvih vodonosnikih rastline tudi v sušnejšem obdobju še lahko črpajo. Bilančna evapotranspiracija je 543 mm oz. 23,9 m^3/s. Najmanj padavin je leta 2003 padlo na skrajnem severu Pomurja, v porečju Velike Krke, 530 mm, največ pa jih je padlo v Slovenskih goricah, nekaj nad 700 mm. Količine tekoče vode v tej pokrajini so močno odvisne od dotokov iz sosednjih območij. Pri vtoku v Slovenijo smo upoštevali Muro, del porečja Kučnice in Ledave izven Slovenije. Pri odtoku iz države pa smo upoštevali Muro, Veliko Krko, Ledavo ter odtok s preostalega območja, ki ga ne zajamemo z vodomernimi postajami. Vsi dotoki v Pomurje so leta 2003 doprinesli 95,7 m^3/s, iz območja Pomurja pa je odteklo skupaj 97,2 m^3/s. Količina vode, ki je leta 2003 odtekla iz Pomurja, je v povprečju 1,5 m^3/s.

Podravje meri 3.265 km^2 in skozenj teče naša največja tranzitna reka Drava. Leta 2003 je bilo tu v povprečju 842 mm padavin (v obdobju 1961-1990: 1222 mm) kar je 87,2 m^3/s. Najmanj padavin v Podravju je bilo leta 2003 na vzhodnem delu – v osrednjem delu Slovenskih goric (okoli 615 mm), največ jih je bilo na zahodnem delu Podravja – na severnih pobočjih Olševe, kjer je padlo skoraj 1250 mm. Količino dotoka iz Avstrije smo določili s pretoki na Dravi v Dravogradu, na Bistrici v Muti ter

the precipitation raster, the uncorrected amount of precipitation for 2003 was used, while the calculated potential evapotranspiration for the same year was used for the evapotranspiration raster. By overlapping the polygons, the total amount of precipitation and evapotranspiration in individual river basin was obtained. Thus determined evapotranspiration was compared to the "balance" value calculated according to the equation P – Q = ET. In 2003, the difference between the potential and the "balance" evapotranspiration was greater than in previous years. This can be ascribed to the extremely low amount of precipitation, which deviated significantly from the multi-annual mean.

Runoffs are usually the most reliable elements of river basin water balance. Namely, at the representative water gauging stations, the total runoff of a certain area is gathered at one water gauging cross-section. In performing the calculation, we considered the discharges of water gauging stations which comprise the majority of inflows and outflows from the country, as well as the estimates of discharges for watercourses which only have headwaters in Slovenia. For the areas without measurement, we determined the discharges by considering the specific runoffs **q** (l/km^2/s) of the hydrologically comparable water gauging stations.

Water balance of the main Slovenian river basins

Pomurje (the river basin of the Mura River) is a hydro-geographic region with an area of only 1,390 km^2 and the lowest average amount of precipitation in Slovenia. In 2003 in Pomurje there was on average 576 mm of precipitation (in the period of 1961-1990: 903 mm), which equals 25.4 m^3/s. According to the calculation of potential evapotranspiration, the amount of the evaporated water was almost 30 percent higher than the "balance" ET (calculated according to the equation ET = P – Q). The supposed reasons are most probably the effects of the shallow aquifer systems, the extraordinary drought in 2003 and the small quantity of precipitation, which bring about a great difference between the two evapotranspirations as the potential evapotranspiration is calculated for the same type of coverage and not with respect to the proximity of groundwater, which plants in the shallow aquifers can still draw even in the dry period. Balance evapotranspiration is 543 mm or 23.9 m^3/s. In 2003, there was least precipitation in the northernmost part of Pomurje in the river basin of the Velika Krka River – 530 mm with the most precipitation in Slovenske gorice – slightly over 700 mm. The quantities of running water in this region are heavily dependent on the inflows from neighbouring areas. At the inflow into Slovenia, we considered the Mura River as well na povirju Pesnice. Skupni odtok vsega Podravja je Drava na iztoku iz Slovenije pri Ormožu. V Podravje je leta 2003 v povprečju priteklo dobrih 196 m^3/s vode, odteklo pa je skoraj 231 m^3/s. Neto prispevek Podravja k odtoku Drave je bil torej skoraj 34,5 m^3/s. Z upoštevanjem padavin ter neto odtoka dobimo podatek, da je iz Podravja bilančno izhlapelo 52,7 m^3/s vode.

Posavje zajema dobro polovico (11.750 km^2) površine Slovenije. Leta 2003 je bilo na območju slovenskega Posavja v povprečju 1077 mm (v obdobju 1961-1990: 1575 mm) padavin oz. 401,4 m^3/s. V porečju je bil velik razpon v količini padavin – od 600 mm v Posotelju do 2300 mm v ožjem območju zahodno od Bohinja. Pritoki v slovensko Posavje iz hrvaškega dela porečja Ljubljanice, Kolpe, Krke in Sotle so bili 22,6 m^3/s, skupen iztok iz Slovenije pa je bil 205 m^3/s. Neto odtok iz slovenskega Posavja je bil 182,4 m^3/s. Po bilančni enačbi izračunana evapotranspiracija je bila 219 m^3/s.

Posočje meri 2.320 km^2 in je po specifičnih odtokih najbolj vodnato porečje. Tudi leta 2003 je tu padlo največ padavin v Sloveniji, a v povprečju precej manj kot leto poprej – le 1645 litrov/m^2 oz. 121 m^3/s (v obdobju 1961-1990: 2383 mm). Preko 2000 mm padavin je v letu 2003 padlo le na območju Krnskega pogorja in najvišjih predelov južnih Bohinjskih gora (kjer je povprečje nad 3000 mm letno) ter v zaledju Belce in Idrijce. Najmanjša količina padavin v Posočju je bila leta 2003 v Vipavski dolini – nekaj nad 1000 mm, ponekod po dolini pa je padlo

Alpska reka Soča je ena bolj vodnatih slovenskih rek. Na njen pretok vpliva tudi zadržek padavin v obliki snega v visokogorju, ki se v reko odteka v toplejšem delu leta (foto: Peter Frantar).
The Alpine river Soča is one of most watery Slovenian rivers. Its discharge is influenced also by snow retinence in the high mountains, which is drained into the river in the warmer part of the year (photo: Peter Frantar).

as a part of the river basins of the rivers Kučnica and Ledava outside Slovenia. At the outflow from the country, we considered the rivers Mura, Velika Krka and Ledava as well as the runoff from the rest of the area, which is not covered by the water gauging stations. In 2003, all the inflows in Pomurje contributed 95.7 m^3/s, while a total runoff from the Pomurje area amounted to 97.2 m^3/s. The amount of water that flowed out of Pomurje in 2003 was 1.5 m^3/s on average.

Podravje (the river basin of the Drava River) measures 3,265 km^2 and contains the largest Slovenian transit river – the Drava. In 2003, there was on average 842 mm of precipitation (in the 1961-1990 period: 1222 mm), which is 87.2 m^3/s. In Podravje, the lowest amount of precipitation in 2002 was in the eastern part – the central part of Slovenske gorice (around 615 mm), while the highest amount was in the western part of Podravje – on the northern hillsides of Olševa Mountain, where there were almost 1250 mm of precipitation recorded. The amount of inflow from Austria was determined by the discharges of the Drava River at Dravograd, on the Bistrica River at Muta as well as on the headwaters of the Pesnica River. The total runoff from the entire Podravje river basin is the Drava River discharge at the state border at Ormož. In 2003, there were over 196 m^3/s of water on average flowing into Podravje and nearly 231 m^3/s of water flowing out. The net contribution of Podravje to the runoff of the Drava River was therefore nearly 34.5 m^3/s. If the precipitation and the net runoff are considered, the data shows that there was 52.7 m^3/s of water balance evaporation from the Podravje river basin.

Posavje (the river basin of the Sava River) extends well over a half of the surface area (11,750 km^2) of Slovenia. In 2003, there was on average 1077 mm of precipitation (in the 1961-1990 period: 1575 mm) or 401.4 m^3/s in the area of the Slovenian Posavje. The river basin exhibited an extensive range of the quantity of precipitation – from 600 mm in Posotelje (the river basin of the Sotla River) up to 2300 mm in the narrow area west of Bohinj. The inflows into the Slovenian Posavje from the Croatian part of the river basins of the rivers Ljubljanica, Krka and Sotla were 22.6 m^3/s while the total outflow from Slovenia was 205 m^3/s. The net runoff from the Slovenian Posavje was 182.4 m^3/s. The evapotranspiration calculated according to the balance equation amounted to 219 m^3/s.

Posočje (the river basin of the Soča River) measures 2,320 km^2 and is the most abundant river basin in terms of water quantities in Slovenia according to specific runoffs. Also in 2003, the highest amount of precipitation in Slovenia was registered here; however, on average there was much

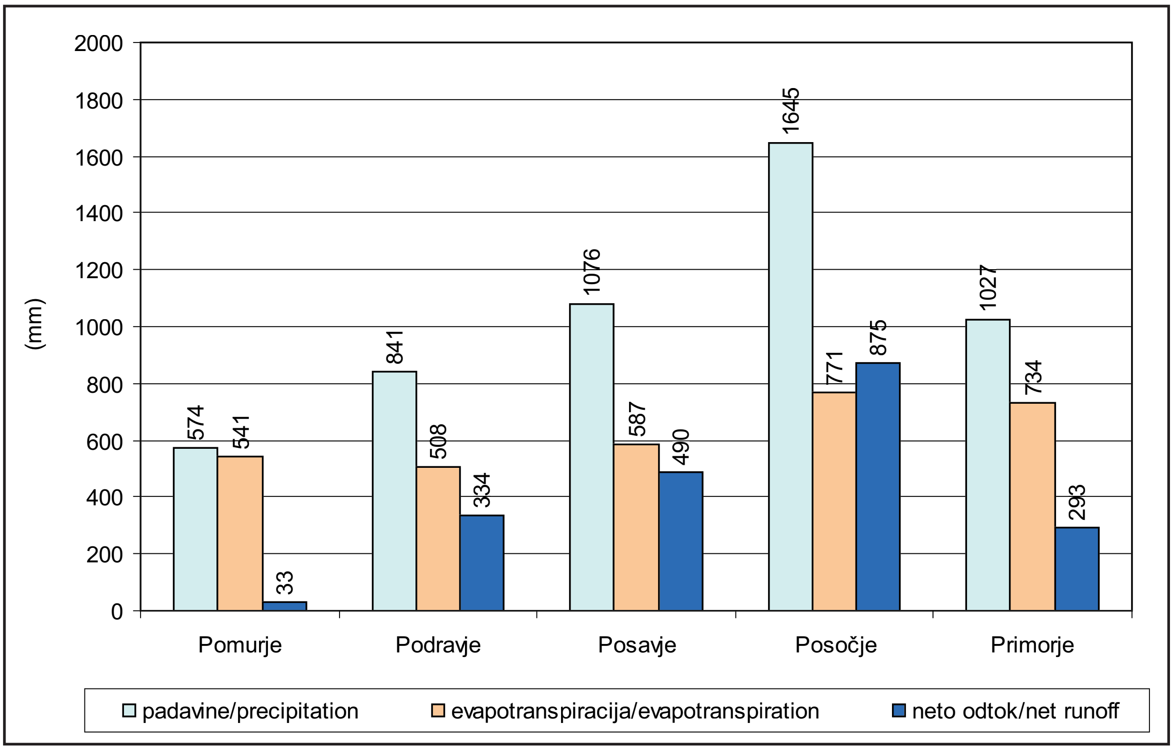
Preglednica 16: Členi vodne bilance leta 2003 po hidrogeografskih enotah Slovenije.
Table 16: Components of the water balance by hydro-geographic units of Slovenia in 2003.

(mm)	Pomurje	Podravje	Posavje	Posočje	Primorje
Padavine / Precipitation	574	841	1076	1645	1027
Evapotranspiracija / Evapotranspiration	541	508	587	771	734
Neto odtok / Net runoff	33	334	490	875	293
Odtočni količnik / Runoff coeficient	0.06	0.40	0.45	0.53	0.29

še manj. Skoraj vse Posočje pripada Sloveniji. Izjeme so povirja Učje, Nadiže ter deloma Idrije. Vsi ti dotoki vode prinesejo 3,6 m^3/s. Iz slovenskega Posočja voda odteka v največji meri po Soči, Vipavi in Nadiži, nekaj pa tudi po Idriji, Reki (v Goriških Brdih) in Korenu. Tako je leta 2003 odteklo okrog 67,9 m^3/s. Bilančna evapotranspiracija je bila v Posočju leta 2003 skoraj 56,8 m^3/s, neto odtok pa 64,3 m^3/s.

Povodje preostalih Jadranskih rek zajema 1.530 km^2, največji vodotok je Reka. Leta 2003 je tu padlo 1027 mm padavin (v obdobju 1961-1990: 1601 mm), kar je slabih 50 m^3/s. V nekaj kilometrskem obalnem pasu je padlo le nekaj nad 700 mm, na območju Snežnika in Krasa pa komaj nekaj nad 1000 mm. Dotoki v Slovenijo so tu v povirju Rižane in Reke ter v zaledju Dragonje. Skupaj je priteklo v Slovenijo manj kot 0,6 m^3/s vode. Iztokov je več: poleg večine Krasa ter obale, se v Italijo odtaka tudi

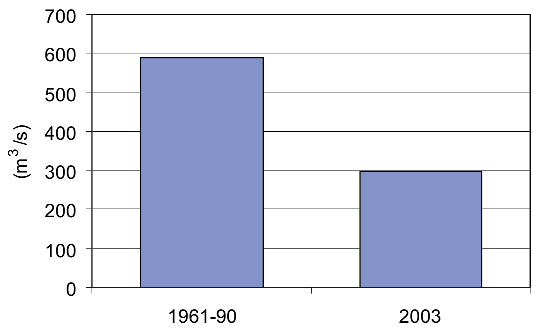
less precipitation than in the previous year – only 1645 liters per square meter or 121 m^3/s (in the period of 1961-1990: 2383 mm). There was over 2000 mm of precipitation in 2003 only in the area of the Krn mountain chain and in the highest parts of the southern Bohinj Mountains (where the average is over 3000 mm per year) and in the catchment areas of the rivers Belca and Idrijca. In 2003, the lowest amount of precipitation in Posočje was registered in the Vipava Valley – slightly over 1000 mm. In some parts of the valley, there was even less precipitation. Almost the entire Posočje river basin belongs to Slovenia. The exceptions are the headwaters of the rivers Učja, Nadiža and in part the Idrija River. All of these inflows of water bring 3.6 m^3/s of water. The water flows out of the Slovenian Posočje river basin primarily from the rivers Soča, Vipava and Nadiža and also from the rivers Idrija, Reka (in Goriška brda) and Koren. Thus, in 2003, around 67.9 m^3/s

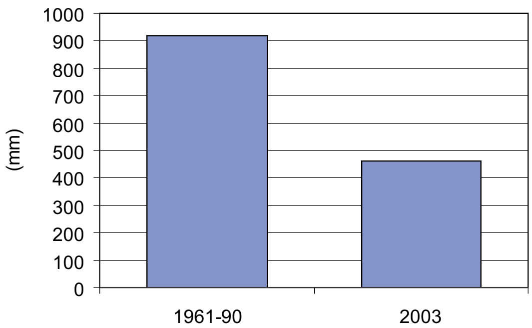


Graf 38: Členi vodne bilance leta 2003 po hidrogeografskih enotah Slovenije v mm.
Graph 38: Components of the water balance by hydro-geographic units of Slovenia in 2003 in mm.

Preglednica 17: Primerjava členov vodne bilance 2003 z dolgoletnim obdobjem 1961-1990.
Table 17: Comparison of components of the 2003 water balance with the 1961-1990 reference period.

(mm)	Podonavje		Jadran		Slovenija	
	1961-90	2003	1961-90	2003	1961-90	2003
Padavine / Precipitation	1445	988	2073	1402	1565	1067
Evapotranspiracija / Evapotranspiration	644	568	664	758	648	604
Neto odtok / Net runoff	801	420	1410	644	917	462
Odtočni količnik / Runoff coeficient	0.55	0.42	0.68	0.46	0.59	0.43





Graf 39: Odtok v referenčnem obdobju 1961-1990 ter letu 2003. Povprečna količina odtoka v glavnih povodjih na levem grafu v m^3/s, na desnem v mm.
Graph 39: Runoff in the 1961-1990 reference period and in 2003. The average amount of runoff in the main catchment areas is given in m^3/s in the left graph and in mm in the right graph.

Osapska reka, na Hrvaško pa teče voda iz povirja porečja reke Mirne. Skupni odtok iz tega povodja je bil leta 2003 14,8 m^3/s, neto odtok pa je 14,2 m^3/s. Leta 2003 je po bilančni metodi izhlapelo skoraj 37 m^3/s.

Primerjava z obdobno vodno bilanco

Leta 1998 sta Kolbezen in Pristov izdelala pregled členov vodne bilance Slovenije za obdobje 1961-1990. Uporabila sta korigirane obdobne vrednosti padavin. Vse člene vodne bilance leta 2003 smo primerjali z referenčno obdobno vodno bilanco 1961-1990 in sicer za Črnomorsko in Jadransko povodje.

V slovenskem delu Črnomorskega povodja je leta 2003 padlo manj padavin, kot je obdobno povprečje. Med leti 1961-1990 je bila povprečna količina padavin tega povodja 1445 mm, leta 2003 pa le 988 mm, kar je 32 odstotkov manj. Tudi evapotranspiracija je bila leta 2003 manjša kot v povprečju obdobja 1961-1990. Leta 2003 je v povodju bilančna evpotranspiracija znašala 568 mm vode, v obdobju 1961-1990 pa 644 mm. V obdobju 1961-1990 smo iz Slovenije v črnomorsko povodje prispevali skoraj 420 m^3/s vode oz. 800 mm. Leta 2003 je bil odtok manjši skoraj za polovico in je znašal 218 m^3/s oz. 420 mm. V primerjavi z dolgoletnim obdobjem je

of water flowed out. Balance evapotranspiration in Posočje in 2003 was almost 56.8 m^3/s and the net runoff 64.3 m^3/s.

The water catchment area of the rest of the Adriatic rivers covers 1,530 km^2, the largest watercourse being the Reka River. In 2003, 1027 mm of precipitation was registered (in the period of 1961-1990: 1601 mm), which is slightly less than 50 m^3/s. In the several kilometers of the coastal area, there was only slightly over 700 mm of precipitation while in the area of the Snežnik Mountain and the Karst, there was only slightly over 1000 mm. Inflows into Slovenia in this region are in the headwaters of the rivers Rižana and Reka as well as in the catchment area of the Dragonja River. In total, there was less than 0.6 m^3/s of water flowing into Slovenia. There are several outflows – besides most of the Karst region and the coast; also the Osapska reka River flows out into Italy while the water from the headwaters of the river basin of the Mirna River flow out into Croatia. The total runoff from this water catchment in 2003 was 14.8 m^3/s while the net runoff was lower at 14.2 m^3/s. In 2003, almost 37 m^3/s of water evaporated according to the balance method.

bilo leta 2003 v tem povodju precej manj padavin od povprečja, zato je bil odtok izredno majhen.

Tudi v slovenskem delu Jadranskega povodja je v letu 2003 padlo 32 odstotkov manj padavin kot v dolgoletnem obdobju. V tem letu je bila količina padavin 1402 mm, obdobno povprečje pa je 2070 mm. Evapotranspiracija je bila po letnih vodnobilančnih izračunih večja za dobrih 15 odstotkov – v letu 2003 skoraj 760 mm. Istega leta je bil povprečni odtok v Jadran samo 78 m^3/s (644 mm), medtem ko je dolgoletni povprečni odtok preko 170 m^3/s (1410 mm). Odtok v letu 2003 je bil od povprečja manjši za več kot polovico.

Leta 2003 je bilo v Sloveniji v primerjavi z referenčnim obdobjem za tretjino manj padavin, nekoliko nižja je bila evapotranspiracija, odtok pa je bil kar za polovico manjši. Leto 2003 ocenjujemo za izredno sušno.

Zelenci. Od padavin, padlih v zaledju izvira Save Dolinke, se v zrak vrne tretjina, preostanek pa v tolmunih privre in odteče v Črno morje.
(foto: Peter Frantar)
Zelenci. In the watershed of river Sava Dolinka spring one third of precipitation is evaporated to the air, the rest is drained into the Black Sea.
(photo: Peter Frantar)

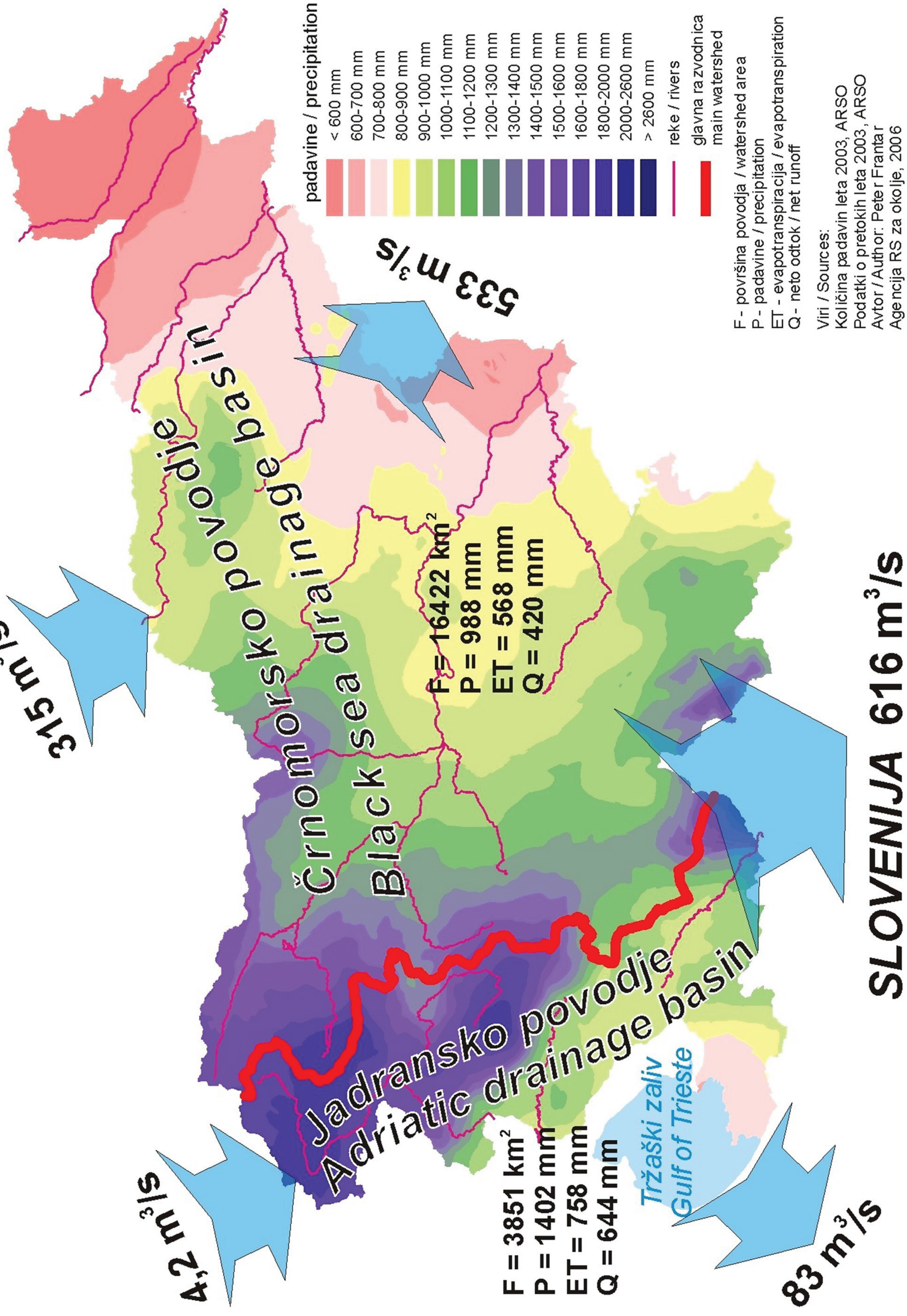
Comparison with the water balance for the multi-annual period

In 1998, Kolbezen and Pristov produced an overview of the components of the water balance of Slovenia for the 1961-1990 period. They used corrected precipitation values for the period. All the elements of the 2003 water balance were compared to the water balance in the 1961-1990 reference period, namely for the Black Sea and the Adriatic basins.

In the Slovenian part of the Black Sea Basin there was less precipitation in 2003 than the mean of the reference period. Between 1961 and 1990, the average precipitation amount of this catchment area was 1445 mm while in 2003 it was only 988 mm, which is 32 percent less. Evapotranspiration was also lower in 2003 than it was on average in the 1961-1990 period. In 2003, the balance evapotranspiration in the catchment area was 568 mm of water and in the 1961-1990 period 644 mm. In the 1961-1990 period, Slovenian rivers contributed almost 420 m^3/s or 800 mm into the Black Sea Basin. In 2003, the runoff was lower by almost a half and amounted to 218 m^3/s or 420 mm. In comparison with the multi-annual period, there was much less precipitation in this catchment area in 2003 than is average, which is why runoff was extremely low.

In the Slovenian part of the **Adriatic Basin,** there was also 32 percent less precipitation in 2003 than in the multi-annual period. In that year, the precipitation amount was 1420 mm while the mean for the period was 2070 mm. According to the annual water balance calculations, evapotranspiration was higher by over 15 percent – almost 760 mm in 2003. In the same year, the mean runoff into the Adriatic Sea was only 78 m^3/s (644 mm) while the multi-annual mean runoff was over 170 m^3/s (1410 mm). The runoff in 2003 was lower than the mean runoff by more than a half.

In 2003 in **Slovenia,** in comparison with the reference period, there was a third less precipitation. Evapotranspiration was slightly lower and the runoff was lower by as much as a half. That year was assessed as being an extremely dry one.



Karta 8: Karta vodnobilančnih členov v Sloveniji leta 2003.
Map 8: Map of water balance components in Slovenia in 2003.