REPUBLIKA SLOVENIJA
MINISTRSTVO ZA OKOLJE IN PROSTOR
AGENCIJA REPUBLIKE SLOVENIJE ZA OKOLJE

HIDROLOŠKI LETOPIS SLOVENIJE 2004

THE 2004 HYDROLOGICAL YEARBOOK OF SLOVENIA

AGENCIJA REPUBLIKE SLOVENIJE ZA OKOLJE

NASLOVNICA - COVER PAGE

Krka v Podbukovju (foto: Jure Jerovšek).
The Krka River in Podbukovje (photo: Jure Jerovšek).

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VSEBINA

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PREDGOVOR

Združeni narodi so leta 2004 ob svetovnem dnevu voda opozorili na zaskrbljujoče povečevanje obsega in pogostosti naravnih nesreč povezanih z vodo. Tudi v svetovnem merilu je bilo leto 2004 značilno po velikih naravnih nesrečah, ki so jih povzročili izredni hidrološki dogodki. Po številu smrtnih žrtev in materialni škodi pa so izstopali rušilni popotresni poplavni valovi, ki so najbolj prizadeli obale Indijskega oceana.

Po globalnih meteoroloških ocenah je bilo leto 2004 četrto najtoplejše leto v obdobju 1880-2004. Toplejša so bila leta 1998, 2002 in 2003. Tudi v Sloveniji je bilo to leto toplejše od dolgoletnega povprečja, vendar odklon ni presegal ene stopinje Celzija. Skupno je bilo v letu 2004 za desetino več padavin kot običajno, v posameznih predelih Slovenije pa je padlo tudi do 15 odstotkov manj padavin kot v dolgoletnem povprečju. Primanjkljaj je bil največji na Obali in Krasu.

V povprečju je bilo leto 2004 v Sloveniji precej bolj namočeno od let 2002 in 2003. V primerjavi z referenčnim obdobjem je bilo leto 2004 v Sloveniji v okviru hidrološkega povprečja. Nekoliko nadpovprečni količini padavin je sledila tudi nekoliko nadpovprečna evapotranspiracija, kar je povzročilo le nekoliko manjši površinski odtok.

V letu 2004 ni bilo izrazitega pomanjkanja vode, čeprav se v nekaterih delih vodonosnikov severovzhodne Slovenije zaloge podzemne vode še niso obnovile. Pretoki slovenskih rek so sledile običajni časovni razporeditvi: visoke vode spomladi, hudourniške visoke vode pozno poleti in obsežnejše poplave jeseni. Poplave so bile v večjem obsegu konec oktobra in v prvih dneh novembra. Narasla reka Gradaščica je na žalost zahtevala celo smrtno žrtev. Tudi morje je zlasti novembra in decembra nekajkrat poplavilo nižje dele slovenske obale.

V okviru mednarodnega projekta razvoja infrastrukture evropske službe za višino morja ESEAS-RI je bila v letu 2004 prenovljena mareografska postaja Koper za neprekinjene meritve različnih hidroloških, geodetskih in meteoroloških veličin. Agencija Republike Slovenije za okolje se je s tem projektom vključila v proces pridruževanja najbolj razvitim evropskim pomorskim državam na tem področju. Članstvo v organizaciji European Sea Level Service (ESEAS) ji tudi v prihodnosti omogoča skladen razvoj z državami članicami.

Agencija RS za okolje je leta 2004 dosegla pomemben mejnik tudi na področju zagotavljanja kakovosti. Slovenski institut za kakovost in meroslovje je Agenciji izdal certifikat za sistem vodenja upravnih in strokovnih nalog varovanja in spremljanja stanja okolja na državni ravni ter izvajanje državne meteorološke, hidrološke in seizmološke službe, ki izpolnjuje zahteve standarda ISO 9001:2000.

mag. Jože Uhan,
vodja sektorja za hidrologijo

FOREWORD

On the occasion of the 2004 World Water Day, the United Nations warned of the alarming increase in the extent and frequency of natural disasters connected to water. On a global scale, the year 2004 was characterised by significant natural disasters caused by extraordinary hydrological events. In terms of the death toll and material damage, the destructive tsunamis stood out. These devastating waves mostly affected the shores of the Indian Ocean.

According to the global meteorological assessments, 2004 was the fourth warmest year in the 1880-2004 period. Only the years 1998, 2002 and 2003 were warmer. Even in Slovenia, this year was warmer than the normals, though the deviation did not exceed one degree Celsius. In total, the precipitation in Slovenia as a whole in 2004 was higher than normal by a tenth, while in some parts of the country the precipitation was up to 15 percent lower than normal. The deficit was greatest on the Coast and in the karst regions.

On average, the year 2004 in Slovenia was significantly wetter than 2002 and 2003. In comparison with the reference period, 2004 was within the hydrological mean in Slovenia. The slightly above average quantity of precipitation was followed by a slightly above-average evapotranspiration and the combination of both caused only a slightly lower surface runoff.

There was no significant water shortage in 2004, even though groundwater reserves have still not been restored to normal in some parts of the aquifers of northeastern Slovenia. The discharges of the Slovenian rivers followed their regular seasonal pattern: high waters in the spring, torrential high waters in the late summer and extensive flooding in the autumn. Extensive flooding occurred at the end of October and in the first days of November, with the swollen Gradaščica River sadly even claiming one victim. The sea also flooded the low-lying parts of the Slovenian Coast a few times, especially in November and December.

Within the framework of the ESEAS-RI international project for the development of the European infrastructure of the European Sea Level Service, the Koper tide gauge station for the continuous measurement of various hydrological, geodesic and meteorological quantities was renovated in 2004. With this project, the Environmental Agency of the Republic of Slovenia was included in the process of joining the most developed European maritime countries in this area. Membership in the European Sea Level Service (ESEAS) organisation will also enable harmonious development with the other EU Member States in the future.

The Environmental Agency of the Republic of Slovenia also reached an important milestone in 2004 in the area of quality assurance. The Slovenian Institute of Quality and Metrology (SIQ) issued the Agency with a certificate for the system of administrative and expert tasks concerning the protection and monitoring of the state of the environment on the national level and the implementation of the national meteorological, hydrological and seismological service complying with the requirements of the ISO 9001:2000 standard.

Jože Uhan, MSc
Head of the Hydrology Sector

SPREMEMBE V MREŽI MERILNIH MEST HIDROLOŠKEGA MONITORINGA

mag. Marjan Bat

Tako kot merilna mesta mreže državnega monitoringa voda so tabele s podatki v Hidrološkem letopisu razdeljene v štiri sklope oziroma poglavja: A. Površinske vode, B. Podzemne vode, C. Izviri in D. Morje.

V poglavju A so objavljeni vodostaji 158 merilnih mest na vodotokih ter Blejskem in Bohinjskem jezeru. Na 34 lokacijah so vodostaje beležili opazovalci, na 124 pa limnigrafi in/ali elektronski merilniki. Prvič objavljamo podatke za Savo na v.p. Jesenice na Dolenjskem (šifra 3900). Merilno mesto je pomembno, ker na njem merimo 99 odstotkov iztoka slovenskega Posavja na Hrvaško, hkrati pa v Jesenicah na Dolenjskem opravljamo tudi vzorčenja vode za določanje kakovosti (glej poročilo Monitoring kakovosti površinskih vodotokov v Sloveniji v letu 2004 - http://www.arso.gov.si/). Informativne podatke o vodostajih, pretokih in temperaturah vode sproti posredujemo javnosti preko interneta. Vodomerni postaji Žebnik na Sopoti (šifra 4650) in Orešje na Sevnični (4705) sta po prekinitvi ponovno začeli delovati. Vodomerna postaja Miren na Vipavi je bila prestavljena na novo lokacijo in je dobila novo šifro (8601). Pretoki Vipave na stari in novi lokaciji so enaki, tako v tem pogledu opazovanja niso bila prekinjena. Podatki vodomerne postaje Sodna vas (4770) niso popolni, ker so preko leta strugo Mestinjščice regulirali, in jih nismo objavili. Pretoke objavljamo za 151 vodomernih postaj, temperature za 44, vsebnost in transport suspendiranega materiala pa za 5 vodomernih postaj. Od leta do leta najbolj niha število merilnih mest s podatki o temperaturi vode, kjer smo pri zagotavljanju neprekinjenih podatkovnih nizov najbolj odvisni od zanesljivosti opazovalcev, ki opravljajo meritve s termometrom. Podatkov merilnih mest, kjer prihaja do pogostih ali daljših prekinitev opazovanj, v letopisu namreč ne objavljamo, hranimo pa jih v naši podatkovni zbirki.

V letu 2004 je bilo na merilnih mestih izvedenih 1109 hidrometričnih meritev, skoraj 10 odstotkov več kot leto poprej. Od tega je bilo 893 meritev s hidrometričnim krilom in 216 z akustičnim dopplerjevim merilnikom pretokov (ADMP). ADMP je bil torej uspešno vpeljan v redno delo Agencije. Tudi večje skupno število meritev glede na leto 2003 je ena od posledic posodobitve metrične opreme. Kot je bilo načrtovano, se je že med letom 2004 pri meritvah na večjih vodotokih in ob večjih pretokih uporabljal ADMP. Aritmetična sredina izmerjenih pretokov je 93 m3/s. S krilom so se opravljale meritve na manjših vodotokih ob manjših pretokih (aritmetična sredina izmerjenih pretokov je 5,9 m3/s). Kar sedem meritev je bilo v letu 2004 narejenih pri pretokih nad 500

CHANGES IN THE NETWORK OF THE HYDROLOGICAL MONITORING GAUGING STATIONS

Marjan Bat

Both the tables of data in the Hydrological Yearbook and the gauging stations of the national hydrological monitoring network are grouped into four sections or chapters: A. Surface Water, B. Groundwater, C. Springs and D. The Sea.

In chapter A, the stages at 158 hydrological stations on watercourses and at Lakes Bled(Blejsko jezero) and Bohinj (Bohinjsko jezero) are published. The stages were recorded by observers in 34 locations and by water level recorders and/or electronic gauges in 124 locations. The data for the Sava River at the Jesenice na Dolenjskem hydrometric station is published for the first time (code 3900). This gauging site is important because 99 percent of the outflow from the Slovenian Posavje into Croatia is measured there, together with sampling for determining the water quality in the same location (see the report entitled *The Monitoring of the Quality of Surface Watercourses in Slovenia in 2004* (*Monitoring kakovosti površinskih vodotokov v Sloveniji v letu 2004*) - http://www.arso.gov.si/). The informative data on the water stages, discharges and temperatures are published on the Web in near real time. The hydrometric stations Žebnik on the Sopota (code 4650) and Orešje on the Sevnična River (4705) resumed operating again following a suspension. The Miren hydrometric station on the Vipava River was relocated to a new location and allocated a new code (8601). The discharges of the Vipava River at the old and new locations are the same so, in this respect, the observations were not suspended. The data from the Sodna vas hydrometric station (4770) was not complete because the channel of the Mestinjščica River was regulated over the year and the data was therefore not published. Discharges are published for 151 hydrometric stations, temperatures for 44 and the concentration and transport of suspended material for 5 hydrometric stations. From year to year, the number of gauging sites with data on the water temperature varies the most, so obtaining uninterrupted time series depends mostly on the reliability of the observers who take the temperature measurements with thermometers. The data from the gauging sites where there can be frequent and extended interruption to the observation are not published in the Yearbook, though this data is (are) kept in our database.

In 2004, there were 1109 hydrometric measurements performed at gauging sites, which is almost 10 percent more than the previous year. Of these, 893 measurements were performed with current meters and 216 with the Acoustic Doppler Current Profiler (ADCP), illustrating that the ADCP has been successfully introduced into the regular operations m3/s, na Savi v Hrastniku pri 900 m3/s. Leto poprej, ki je bilo hidrološko sušno, je bilo le 6 hidrometričnih meritev ob pretokih med 200 in 350 m3/s. Vsekakor so po zaslugi novega merilnika hidrometrične meritve glede na izmerjen pretok ustrezneje razpršene v intervalu med največjimi in najmanjšimi vrednostmi.

Gladine podzemnih voda so prikazane s podatki 131 merilnih mest. Prvič so objavljeni podatki treh vrtin na Ljubljanskem polju: V-01 Roje (na desnem bregu Save severno od Kleč), B-01 Bežigrad in V-0184 Zalog, ki občasno delujejo že od leta 1999. Na vseh treh neprekinjeno beležimo spreminjanje gladine podzemne vode s podatkovnimi zapisovalniki. Neprekinjeno beležimo gladine tudi v Spodnji Senici (S-1364) na Sorškem polju in Volčji Dragi (0640) v Spodnji Vipavski dolini. Občutno se je pogostost opazovanj povečala še v Stojncih (0240) na Ptujskem polju in Zgornjem Grušovlju (0100) v Spodnji Savinjski dolini, na ostalih merilnih mestih pa tekom leta ni prišlo do večjih sprememb glede pogostosti meritev. Zaradi neugodnih hidroloških razmer v letu 2003 so bili štirje vodnjaki na Prekmurskem in Dravskem polju v prvih mesecih leta 2004 še vedno suhi.

Mreža monitoringa izvirov je dobila v letu 2004 kar šest novih merilnih mest na Jezernici Divjega jezera ob Idrijci (postaja Divje jezero, šifra 8452), na Velikem Obrhu (Vrhnika, 5580), Krupi (Dolence I, 4985), Težki vodi (Stopiče, 7350), Rakitnici (Blate, 7498) in Loškem potoku (Travnik I, 7518). Popolnoma novo je le merilno mesto na Rakitnici, na ostalih pa so, če že ne na isti lokaciji pa vsaj v bližini, meritve že potekale. Od novoustanovljenih postaj objavljamo v letopisu letne preglede hidroloških razmer le za merilni postaji na Jezernici in Velikem Obrhu., ki sta pričeli delovati januarja oz. aprila. Kot v prejšnji številki so objavljeni tudi podatki za merilno mesto Divje jezero na Divjem jezeru (šifra 8451) in izvir Kamniške Bistrice. Po prekinitvi je bil izplen podatkov na merilnem mestu Podroteja na izviru Podroteja spet zadovoljiv. Prvič so objavljeni podatki za Metliški Obrh, kjer smo z opazovanji začeli sredi leta 2003. V Globočcu so meritve do nadaljnjega prekinjene.

Na mareografski postaji Luška Kapitanija so se začela dela v okviru projekta razvoja infrastrukture evropske službe za višine morja ESEAS-RI. Zato so bile meritve proti koncu leta prekinjene. Nemoteno je v tem obdobju delovala postaja v Luki Koper.

of the Agency. The increased total number of measurements compared to 2003 was also the result of the modernisation of the measuring equipment. The ADCP was used during 2004 for measurements on the larger watercourses and greater discharges as planned. The arithmetic mean of the measured discharges is 93 m^3/s. The measurements on the smaller watercourses and lesser discharges were performed with the current meter (the arithmetic mean of the measured discharges is 5.9 m^3/s). As many as seven measurements were performed in 2004 of (at) discharges in excess of 500 m^3/s and on the Sava River at Hrastnik, a measurement was performed with a discharge of 900 m^3/s. In the previous year, which was a dry year in hydrological terms, there were only 6 hydrometric measurements performed of (at) discharges of between 200 and 350 m^3/s. Because of the new ADCP, the hydrometric measurements are significantly more appropriately dispersed within the interval between the highest and lowest values of the discharge measured.

The groundwater levels are shown using data from 131 gauging sites. The data from three boreholes in the Ljubljansko field is published for the first time: V-01 Roje (on the right bank of the Sava River and north of Kleče), B-01 Bežigrad and V-0184 Zalog, which has been operating intermittently since 1999. At all three stations, the groundwater level is continuously recorded by data loggers. Changes in the groundwater level are also recorded continuously in Spodnja Senica (S-1364) on the Sorško field and Volčja Draga (0640) in the Lower Vipava Valley. The frequency of monitoring has significantly increased at Stojnci (0240) on the Ptujsko field and at Zgornje Grušovlje (0100) in the Lower Savinja Valley. There were no more significant changes regarding the frequency of measurements on the remaining monitoring sites during the year. Four wells in the Prekmursko and Dravsko fields were still dry in the first months of 2004 owing to the unfavourable hydrological conditions in 2003.

In 2004, the spring monitoring network increased by as many as six new spring observation stations on the Jezernica of Lake Divje jezero near Idrijca (the Lake Divje jezero spring observation station, code 8452), on Veliki Obrh (Vrhnika, 5580), Krupa (Dolence I, 4985), Težka voda (Stopiče, 7350), Rakitnica (Blate, 7498) and Loški potok (Travnik I, 7518). Only the observation station on Rakitnica is completely new, while measurements were previously being carried out in the other cases either in the same location or at least in the vicinity. Hydrological data from the newly established observation stations is published only for the spring observation stations at Jezernica and Veliki Obrh, which began operations in January and April respectively. As in the previous issue of the Yearbook, data is also published for the Lake Divje jezero observation station on Lake Divje jezero (code 8451) and from the spring of the Kamniška Bistrica River. Following the interruption, the amount of data from the Podroteja observation station on the spring of Podroteja was again satisfactory. Data is published for the first time from Metliški

Obrh, where observations started in the middle of 2003. At Globočec, measurements have been suspended until further notice.

At the Luška Kapitanija tide gauge station, work began on the ESEAS-RI project developing the infrastructure of the European Sea Level Service. This is why the measurements were suspended towards the end of the year. The tide gauge station at Luka Koper operated without interruption during this period.

Vodomer v Soči v Kobaridu (foto: Jure Jerovšek).

Staff gauge in the Soča River in Kobarid (photo: Jure Jerovšek).

SEZNAM OPAZOVALCEV V MREŽI MERILNIH MEST HIDROLOŠKEGA MONITORINGA

THE LIST OF OBSERVERS IN THE NETWORK OF THE HYDROLOGICAL MONITORING GAUGING STATIONS

Opazovalec Observer	Vodomerna postaja Gauging station	Reka, jezero River, lake	Opazovalec Observer	Vodomerna postaja Gauging station	Reka, jezero River, lake
AVSEC IGOR	Gorenje jezero	Stržen	ILIJEV ZLATA	Jesenice	Sava Dolinka
AVŠIČ BOŠTJAN	Čatež	Sava	IVE ANTON	Preska	Tržiška Bistrica
BALOG MILENA	Hotešk	Idrijca	JANIČ KAREL	Nuskova	Ledava
BANIČ JOŽE	Podbočje	Krka	JEREB MATEVŽ	Žiri	Poljanska Sora
BAŠA SLAVKO	Šalara	Badaševica	JURGLIČ JASNA	Rožni vrh	Temenica
BAŠA SLAVKO	Podkaštel	Dragonja	KALIČ MATJAŽ	Otiški vrh	Meža
BAŠA SLAVKO	Pišine	Drnica	KALIČ MATJAŽ	Otiški vrh	Mislinja
BEVC FRANC	Šoštanj	Velunja	KAPŠ STANKO	Prečna	Prečna
BEVK MARIJA	Trzin	Pšata	KARNIČNIK ELIZABETA	Ruta	Radoljna
BIZJAK MARIJA	Rečica	Paka	KELENC BRANKO	Ranca	Pesnica
BIZJAK NADA	Okroglo	Sava	KELENC KATJA	Borl	Drava
BLAŽIČ FILIPINA	Prestranek	Pivka	KERČMAR GEZA	Hodoš	Velika Krka
BUCAJ LIDIJA	Kubed	Rižana	KERN JANEZ	Pšata	Pšata
BUH LJUDMILA	Komin	Ljubljanica	KNAFELJ JOŽICA	Podhom	Radovna
CANKAR DARINKA	Medno	Sava	KNAP VESNA	Muta	Bistrica
ČAS PAVLA	Solčava	Savinja	KOBLER ALOJZIJA	Železniki	Selška Sora
ČELESNIK ALENKA	Škocjan	Radulja	KOČEVAR FRANC	Gradac	Lahinja
ČERNIGOJ JOŽE	Ajdovščina	Hubelj	KOKALJ MAGDA	Ovsiše	Lipnica
DERŽAJ SILVA	Moste	Ljubljanica	KOMAC ZDRAVKO	Kršovec	Soča
DREMELJ MARIJA	Veliko širje	Savinja	KOROŠEC MATILDA	Makole	Dravinja
FEHER IRINKA	Kobilje	Kobiljski potok	KOŠIR FRANC	Sodražica	Bistrica
FERFOLJA ALOJZ	Miren	Vipava	KOTNIK JOŽE	Stari trg	Suhodolnica
FERFOLJA ALOJZ	Miren	Vipava	KOVAČ ANICA	Log pod Mangartom	Koritnica
FIDERŠEK JOŽE	Tržec	Polskava	KOVAČEC IVANA	Zamušani	Pesnica
FILIPIČ MARIJA	Pristava	Ščavnica	KRAJNIK RUDOLF	Suha	Sora
FORTUNA JOŽEFA	Bistra	Bistra	KRAMAR MILENA	Iška vas	Iška
FURLAN EMIL	Vipava	Vipava	KRANJC TADEJ	Dolenje	Vipava
GABER MARIJA	Draža vas	Oplotnica	KUHAR KAREL	Škofja vas	Hudinja
GABRIJELČIČ ZLATKO	Nova Gorica	Koren	LEBAN IVAN	Tolmin	Tolminka
GABRIJELČIČ ZLATKO	Solkan	Soča	LESJAK MATILDA	Levec	Ložnica
GLOBEVNIK MELITA	Gorenja Gomila	Krka	LESKOVEC ALOJZ	Podroteja	Idrijca
GLOJEK MARTA	Kraše	Dreta	LEŠNIK ANTONIJA	Medlog	Savinja
GNIDICA ROBERT	Orešje	Sevnična	LEVIČNIK NIKO	Šentjakob	Sava
GOBEC SANDI	Sodna vas	Mestinjščica	LINDIČ MARTIN	Radenci	Kolpa
GOGALA DUŠAN	Cerknica	Cerkniščica	MALIS VILJEM	Hrastnik	Sava
GREGORIČ RADOŠ	Volčja Draga	Lijak	MARTINČIČ ANDREJ	Dolenje jezero	Stržen
HEBERLE OLGA	Mlino	Blejsko jezero	MATJAŽ BOŽIDAR	Jelovec	Mirna
HEBERLE OLGA	Mlino	Jezernica	MEJAČ ANTONIJA	Nevlje	Nevljica
HERZOG JERNEJA	Cankova	Kučnica	MESARIČ GIZELA	Polana	Ledava
HORVAT LADISLAV	Središče	Ivanjševski potok	MILAVEC ANDREJ	Malni	Malenščica
HREN ANTONIJA	Borovnica	Borovniščica	MILAVEC IVANKA	Hasberg	Unica

Opazovalec Observer	Vodomerna postaja Gauging station	Reka, jezero River, lake	Opazovalec Observer	Vodomerna postaja Gauging station	Reka, jezero, morje River, lake, sea
MLEKUŽ ALDO	Log pod Mangartom	Kanal Roje	ŠESTAN BORIS	Trpčane	Reka
MLINARIČ FRANC	Gornja Radgona	Mura	ŠESTAN BORIS	Trnovo	Reka
MOLIČNIK VINKO	Luče	Lučnica	ŠETINA MARIJA	Sveti duh	Bohinjsko jezero
MOLKA PAVLA	Radeče	Sava	ŠETINA MARIJA	Stara fužina	Mostnica
MRVAR ALBIN	Dvor	Krka	ŠETINA MARIJA	Sveti Janez	Sava Bohinjka
MUDRINIČ ALEKSANDER	Bodešče	Sava Bohinjka	ŠKOFLEK BISERKA	Velenje	Paka
MUDRINIČ ALEKSANDER	Radovljica	Sava	ŠKRBEC SIMON	Branik	Branica
MURKO STANISLAV	Gočova	Pesnica	ŠORN STANISLAV	Vir	Rača
MUSTAR MARIJA	Rašica	Rašica	ŠORN STANISLAV	Podrečje	Rača
NEMET LADISLAV	Zagaj	Bistrica	ŠTANCER DRAGO	Črnolica	Voglajna
NOVAK JOŽE	Postojnska jama	Pivka	ŠTIBELJ TONČKA	Vešter	Selška sora
OBERSTAR VIDA	Prigorica	Ribnica	ŠTURM ALBIN	Kobarid	Soča
OBŠTETAR BORUT	Dolenja Ttrebuša	Trebuša	ŠTURM ALBIN	Potoki	Nadiža
OMERZEL JOŽE	Metlika	Kolpa	ŠTURM ALBIN	Robič	Nadiža
OVČJAK MATEJ	Šoštanj	Paka	ŠVARC JANKO	Dvor	Gradaščica
PAVŠA SILVA	Golo brdo	Idrija	TIVOLD MARIJA	Martjanci	Martjanski potok
PEC FRANC	Loče	Dravinja	TOMINEC FRANC	Medvode	Sora
PERŠOLJA SILVO	Neblo	Reka	TRAUNER JULIJUS	Celje	Voglajna
PERŠOLJA SILVO	Neblo	Kožbanjšček	TRILLER MARJETA	Zminec	Poljanska Sora
PLEŠNIK FRANCKA	Gaberke	Velunja	TROJOK EVGEN	Čentiba	Ledava
PODBEVŠEK PETER	Laško	Savinja	TRŠINAR MILKA	Martinja vas	Mirna
PODLIPNIK JANEZ	Kranjska gora	Sava Dolinka	TRUNKELJ FRANČIŠKA	Trebnja gorica	Višnjica
POTOČNIK JOŽE	Podnanos	Močilnik	VERČNIK JOŽEF	Zreče	Dravinja
POTOČNIK NATAŠA	Črna	Meža	VIDIC ANA	Blejski most	Sava Dolinka
POTOKAR JANEZ	Litija	Sava	VODIŠEK IVANKA	Vodiško	Gračnica
POTREBUJEŠ IVAN	Petrina	Kolpa	VODOPIVEC JOŽE	Dornberk	Vipava
PRAŠNIKAR MARKO	Zagorje	Medija	VODOVNIK VLADO	Letuš	Savinja
ROVŠČEK MARIJA	Bača pri Modreju	Bača	VOŠNJAK MARTIN	Dolenja vas	Bolska
ROŽENBERGAR VOJKO	Kranj	Kokra	VUGRINEC ŠTEFANIJA	Videm	Dravinja
SADAR FANČI	Kamnik	Kamniška Bistrica	ZAGORC CVETO	Nazarje	Savinja
SAMEC OTON	Polže	Hudinja	ZAJC ANTON	Podbukovje	Krka
SEKLJIČ EDVARD	Pesje	Lepena	ZALOKAR MARJAN	Domžale	Mlinščica kanal
SIMONČIČ FRANC	Celje	Savinja	ZALOKAR MARJAN	Vir	Kamniška Bistrica
SKUBIC ANICA	Meniška vas	Radešca	ZALOŽNIK ZVONKO	Kokra	Kokra
SLANC MARIJA	Razori	Šujica	ZAPUŠEK MARIJA	Škale	Lepena
SLAVINEC ANGELA	Škale	Sopota	ZAVRŽEN VIOLA	Mlačevo	Grosupeljščica
SOTOŠEK AVGUST	Sodna vas	Mestinjščica	ŽAGAR BOJAN	Log čezsoški	Soča
STEGEL VIDA	Mali otok	Nanoščica	ŽAGAR BOJAN	Žaga	Učja
STRNIŠA JURE	Žebnik	Sopota	ŽAKELJ JANEZ	Vrhnika	Ljubljanica
ŠAFARIČ VIKTOR	Petanjci	Mura	ŽAKELJ JANEZ	Verd	Lubija
ŠAVLI MARIJA	Cerkno	Cerknica	ŽVAB PAVLA	Bohinjska Bistrica	Bistrica
ŠEPEC TEREZIJA	Rakovec	Sotla			
ŠESTAN BORIS	Cerkvenikov mlin	Reka	BAŠA SLAVKO	Koper	Jadransko morje
ŠESTAN BORIS	Ilirska Bistrica	Bistrica	BAŠA SLAVKO	Luka Koper	Jadransko morje

Opazovalec Observer	Postaja za podzemne vode Groundwater observation station
ARTAČ JOŽE	Brezovica
ARTENJAK STANKO	Spodnja Hajdina
BERANIČ IVAN	Jablane
BERANIČ SLAVA	Brunšvik
BIZJAK IVAN	Gotovlje
BONE BRANKO	Vipavski križ
CVETKO BOŽIDAR SANDI	Trgovišče
CVIKL ANTON	Zgornje Grušovlje
ČIH ELIZABETA	Gornji Lakoš
DROBNIČ FRANČIŠKA	Malence
ERJAVEC FRANC	Lipovci
FILIPIČ IGOR	Ključarovci
FIŠER ANA	Zgornja gorica
GALUN JANEZ	Kungota
JARKOVIČ FRANČIŠKA	Drama
JENKO MARTA	Meja
JEREBIC FRANC	Brezovica
KAČ IRENA	Arja vas
KAUČIČ ANTON	Plitvica
KMECLJ LEOPOLD	Škofja vas
KOLOŠA ELIZABETA	Radmožanci
KOVAČ MARIJA	Sinja gorica
KREGAR MARIJA	Dolenja vas
KRPAN ADRIJAN	Ajdovščina
KRUŠEC IVANA	Segovci
LEPEJ DARINKA	Starše
MALI VILJEM	Šempeter
MEDLE MARTINA	Šmalčja vas
MEDVEŠEK JOŽICA	Hrvaški Brod
MERLJAK LUKA	Renče
MESARIČ FELIKS	Bakovci
MULEC EDA	Žepovci
OUČEK FRANC	Rankovci
PEČNIK FRANC	Spodnji Stari grad
PINTER ERVIN	Nemčavci
PLEŠKO JOŽE	Kozarje
PLOŠINJAK FRANC	Stojnci
RAT ALOJZ	Letuš
REPNIK ANICA	Zgornje Jarše
REPNIK ANICA	Mengeš
REPNIK ANICA	Preserje
REPNIK ANTON	Parižlje
RODOŠEK DUŠAN	Veliki podlog
ROJC CVETKA	Volčja draga

Opazovalec Observer	Postaja za podzemne vode Groundwater observation station
SIMONČIČ IVAN	Gorica
SIMONIČ RAJKO	Dornava
SLAPNIK MILENA	Podgorje
STAMNIČAR DEJAN	Veščica
STROPNIK MARKO	Medlog-v1941
ŠAVRIČ DANIELA	Bukošek
ŠKRABAN AVGUŠTIN	Krog
TEMENT LIDIJA	Sobetinci
TONJA HELENA	Sveti duh
TOPLAK JOŽE	Renkovci
VILČNIK AVGUST	Ptuj
VINTAR NADA	Kalce-Naklo
WEINGERL JOŽE	Mali Segovci
ZADOBOVŠEK RUDOLF	Trnava
ZEVNIK MARIJA	Celje
ŽIBREK JELENA	Zgornje Krapje

PRIMERJALNE MERITVE PRETOKA SAVE NA JESENICAH NA DOLENJSKEM

mag. Roman Trček

Zaradi zagotavljanja kakovosti po standardu ISO 9001:2000, ki ga je prevzela Agencija Republike Slovenije za okolje (ARSO), ter primerjave in usklajevanja hidroloških podatkov za referenčne hidrometrične profile Slovenije in Hrvaške, smo 20. julija 2004 skupaj z Državnim hidrometeorološkim zavodom Republike Hrvatske (DHMZ) izvedli primerjalna merjenja pretoka Save v profilu vodomerne postaje Jesenice na Dolenjskem.

Osnovni podatki o hidrometričnem profilu

Iz Slovenije odteče največ vode po Savi. Površina njenega povodja predstavlja več kot polovico ozemlja države. Na Savi in pritokih je 114 od 189 vodomernih postaj državnega hidrološkega monitoringa ARSO, kar znaša dobrih 60 odstotkov vseh postaj na površinskih vodah. Zadnja v nizu 14-ih postaj na Savi, če upoštevamo tudi Savo Bohinjko in Savo Dolinko, je vodomerna postaja Jesenice na Dolenjskem (preglednica 1). Ta se nahaja približno 2 km pred mejnim profilom s Hrvaško, potem ko teče reka zadnje 3 km toka v Sloveniji po meji s sosednjo državo.

COMPARATIVE MEASUREMENTS OF THE DISHARGE OF THE SAVA RIVER AT JESENICE NA DOLENJSKEM

Roman Trček

Because of the quality assurance in line with the ISO 9001:2000 standard that the Environmental Agency of the Republic of Slovenia (ARSO) has adopted, and because of the comparison and harmonisation of the hydrological data for the reference hydrometric profiles of Slovenia and Croatia, comparative measurements were taken of the Sava River discharge at the cross-section of the Jesenice na Dolenjskem hydrometric station on 20 July 2004, together with the National Hydrometeorological Institute of the Republic of Croatia (DHMZ).

Basic Data on the Hydrometric Cross-Section

The major outflow from Slovenia is the runoff of the Sava River. The surface area of its catchment basin represents more than half of the country's territory. 114 of the 189 hydrometric stations of the ARSO national hydrological monitoring network are on the Sava River and its tributaries, which amounts to well over 60 percent of all the surface water stations. The last in the series of 14 stations on the Sava, if we also include the Sava Bohinjka and Sava Dolinka Rivers, is the Jesenice na Dolenjskem hydrometric station (Table 1). It is located approximately 2 km upstream of the border with Croatia, after the river runs for the last 3 km of its course in Slovenia along the border.

Prikaz lokacije hrvaške in slovenske vodomerne postaje Jesenice na Dolenjskem.

The Croatian and Slovenian hydrometric stations of Jesenice na Dolenjskem.

Preglednica 1: Osnovni podatki o vodomerni postaji Jesenice na Dolenjskem.

Ime vodomerne postaje Stremflow-gauge station name	Jesenice na Dolenjskem
Ime vodotoka River name	Sava
Šifra postaje Statione code	3900
Razdalja od izliva [km] Distance to confluence	728.4
Površina povodja [km2] Catchment area	10 800
Začetek delovanja Start of operation	julij 2002

Zaradi pomembnosti vodomernega profila v smislu iztoka vode iz države, je bila v letu 2002 postavljena prenovljena merilna postaja za hkratno spremljanje količin in kakovosti vode. Postaja je opremljena s sodobno merilno opremo, ki omogoča zvezno beleženje veličin in posredovanje le-teh v zbirni center v Ljubljani v realnem času.

Izvajanje meritev

Pri meritvah sta hidrometrični skupini ARSO in DHMZ uporabljali identično strojno opremo – akustični dopplerjev merilnik pretokov (ADMP) WH RioGrande 1200 kHz. Razlika je bila pri načinih oz metodah, ki so vgrajene v programsko opremo, ter pri načinu prenosov podatkov (radijski modem, kabel). Razlikovala se je programska oprema, ki je omogočala različne načine (ang. mode) meritev oz. vrednotenja rezultatov ter način prenosa podatkov (radijski prenos, kabel).

Prvi niz meritev z oznako SLO-1 je bil izveden s čolna na vesla, ki se je premikal ob jekleni vrvi (preglednica 2). Prečni profil meritev je bil v tem primeru oddaljen 10 m od merskega profila, t.j. dolžina čolna in vrvi, na kateri je pritrjen merilnik. V nadaljevanju sta bila izvedena še dva niza meritev slovenske ekipe (SLO-2, SLO-3). Oba sta bila narejena v profilu vodomerne postaje, čoln pa je imel motorni pogon. Razlika med nizoma SLO-2 in SLO-3 je bila uporaba različnih načinov za obdelavo ultrazvočne-

Table 1: Basic data on the Jesenice na Dolenjskem hydrometric station.

Due to the importance of this hydrometric cross-section in the sense of the runoff from the country, a renovated gauging station was set up in 2002 for the simultaneous measurement of the quantity and quality of the water. The station is equipped with modern measuring equipment enabling continuous real-time recording of quantities and their communication to the collection centre in Ljubljana

The Taking of Measurements

In carrying out measurements, the ARSO and the Croatian DHMZ hydrometric teams used identical hardware – the WH RioGrande 1200 kHz Acoustic Doppler Current Profiler (ADCP). The difference was in the modes or methods built into the software and in the mode of data transmission (radio modem and cable). The software that differed was that which enabled the different measurement modes or evaluation of the results, as well as the manner of data transfer (radio transmission and cable).

The first set of measurements, with the designation SLO-1, was carried out from a rowboat moving along a steel rope (Table 2). In this case, the transverse cross-section of the measurements was 10 m away from the measurement cross-section, namely the length of the boat and the rope onto which the profiler was fixed. In the continuation, two more sets of measurements were carried out by the Slovenian team (SLO-2 and SLO-3). Both were performed in the cross-section at the hydrometric station and the boat was motor-powered. The difference between the SLO-2 and SLO-3 sets was in the use of different modes for processing the ultrasound reflection. »Mode 12« was used in the first case and »Mode 1« in the second. The latter was used to allow the comparison of data with the Croatian team, who carried out a measurement (HR-1) around 20 m downstream from the hydrometric station cross-section (Table 2).

Hidrološka postaja na Savi - Jesenice na Dolenjskem.
(foto: Marko Bunger).

The hydrological station on the Sava River - Jesenice na Dolenjskem
(photo: Marko Bunger).

ga odboja. V prvem primeru je bil uporabljen »način 12« in v drugem »način 1«. Slednjega smo uporabili zaradi primerljivosti podatkov s hrvaško ekipo. Le-ta je izvedla meritev (HR-1) okrog 20 m dolvodno od profila vodomerne postaje (preglednica 2).

V hrvaškem profilu vodomerne postaje sta bila izvedena dva niza meritev (preglednica 3). Zaradi medsebojne oddaljenosti modemov in goste zaraščenosti brežin je imela slovenska ekipa težave pri prenosu podatkov z radijskim modemom. Nastavitve merilnikov obeh ekip so ostale iste kot pri meritvah v slovenskem vodomernem profilu (preglednica 4).

Two sets of measurements were carried out on the Croatian cross-section of the hydrometric station (Table 3). Because of the distance between the modems and the thick vegetation on the banks, the Slovenian team experienced problems with the transmission of data using the radio modem. The profiler settings of both teams remained the same as those in the measurements at the Slovenian hydrometric cross-section (Table 4).

Preglednica 2: Seznam meritev z ADMP v slovenskem profilu in njihove nastavitve.

Table 2: List of measurements with the ADCP in the Slovenian cross-section and their settings.

oznaka meritve measurement sign	pogon čolna boat drive	lokacija glede na profil mesurement location	način za meritev hitrosti water mode	način za sledenje tal bottom mode
s_SLO-1	ročni - jeklena vrv by hand – steel rope	10 m dolvodno 10 m downstream	način 12 mode 12	način 7 mode 7
s_SLO-2	motor engine	na vodomerni postaji at measuring profile	način 12 mode 12	način 7 mode 7
s_SLO-3	motor engine	na vodomerni postaji at measuring profile	način 1 mode 1	način 7 mode 7
s_HR-1	motor engine	20 m dolvodno 20 m downstream	način 1 mode 1	način 5 mode 5

Preglednica 3: Seznam meritev z ADMP v hrvaškem profilu in njihove nastavitve.

Table 3: List of measurements with the ADCP in the Croatian cross-section and their settings.

oznaka meritve measurement sign	pogon čolna boat drive	lokacija glede na profil mesurement location	način za meritev hitrosti water mode	način za sledenje tal bottom mode
h_SLO-1	motor engine	50 m dolvodno 50 m downstream	način 12 mode 12	način 7 mode 7
h_HR-1	motor engine	60 m dolvodno 60 m downstream	način 1 mode 1	način 5 mode 5

Preglednica 4: Tipične nastavitve merilnikov WH RioGrande 1200 kHz.

Table 4: The typical settings of the WH RioGrande 1200 kHz profilers.

ekipa team	prenos podatkov data transfer	globina ugreza merilnika [cm] transducers depth	debelina merilnega sloja cm] bin size	slepi hod [cm] blank after transmit	globina do sredine prvega sloja [cm] blanking distance	funkcija ekstrapolacije hitrosti extrapolation function	
						površina top / surface	na dnu bottom
SLO	radijski modem radion modem	7	10	5	26	potenčna (1/6) power curve	potenčna (1/6) – zadnjih 20% hitrosti power curve (last 20% depth)
HR	kabel cable	20	25	25	78	ista potenčna funkcija čez cel profil (1/6) the same power curve in the whole velocity profile	

Zadnji predmet primerjave sta bili meritvi s hidrometričnim krilom v profilu slovenske vodomerne postaje.

The last item of comparison was the measurements with the current meter in the cross-section at the Slovenian hydrometric station.

Preglednica 5: Lastnosti hidrometričnih kril in postopka merjenja z nimi za posamezno merilno ekipo.

Table 5: The characteristics of the current meters and the measurement procedure using the current meter for an individual measuring team.

ekipa team	proizvajalec krila Current meter producer	Premer elise [cm], material propeler diameter, material	število vertikal number of stations	Min./maks. št. točk v vertikali min/max number of points in station	čas meritve obratov [s] measuring interval	oddaljenost točke v vertikali od roba [cm] measuring point distance	
						gladine surface	dna bottom
SLO	OTT-hydrometrie	8, kromirana zlitina alloy metal	10	3/5	30	4	8
HR	OTT-hydrometrie	12.5, plastika plastics	10	2/5	60	30 oz. 20	15

Tudi pri opremi s hidrometričnim krilom in pri sami metodologiji izvajanja meritev so obstajale manjše razlike (preglednica 5).

Smaller differences also arose with the equipment, with the current meter and in the measurement methodology (Table 5).

Rezultati meritev

Med izvajanjem meritev se vodostaj ni bistveno spreminjal, kar je za verodostojnost primerjave meritev zelo pomembno.

Measurement results

While taking the measurements, the water stage did not change significantly, which is very important for authenticity when comparing measurements.

Preglednica 6: Rezultati primerjalnih meritev pretoka v slovenskem in hrvaškem profilu vodomerne postaje.

Table 6: The results of the comparative discharge measurements in the Slovenian and Croatian cross-section on station

oznaka meritve measurement sign	št. prehodov number of transects	sr. pretok [m³/s] mean discharge	standardni odklon pretoka [m³/s] standard deviation of discharge	srednja hitrost [m/s] mean velocity	maks.hitrost [m/s] max. velocity	površina prereza [m²] area	srednja globina [m] mean depth	maks. globina [m] max. depth	Širina Prereza [m] width
S_SLO-1	4	150	4.70	1.15	2.43	130	1.83	2.86	71.3
S_SLO-2	2	149	0.38	1.08	2.15	138	1.94	3.05	71.0
S_SLO-3	4	155	1.01	1.14	2.89	136	1.87	3.21	72.6
S_HR-1	4	156	3.87	1.26	2.42	124	1.98	2.99	63.0
S_SLO-1kr	1	157	-	1.17	1.59	135	1.87	2.92	72.0
S_HR-1kr	1	158	-	1.17	1.61	135	1.87	2.90	72.0
H_HR-1	4	164	1.45	1.29	3.01	127	2.01	3.09	63.3
H_SLO-1	3	148	5.15	1.14	2.83	131	1.97	2.97	66.3

Analiza rezultatov meritev z ADMP

Rezultati meritev pretoka in njihovo odstopanje glede na meritev s_SLO-1 so prikazani v preglednici 7.

Analysis of the Results of the easurements Using the ADCP

The results of the discharge measurements and their deviation in comparison with the s_SLO-1 measurement are as follows (Table 7).

Preglednica 7: Primerjava izmerjenega pretoka glede na meritev s_SLO-1.

Table 7: The comparison of the discharge measured in comparison with the s_SLO-1 measurements.

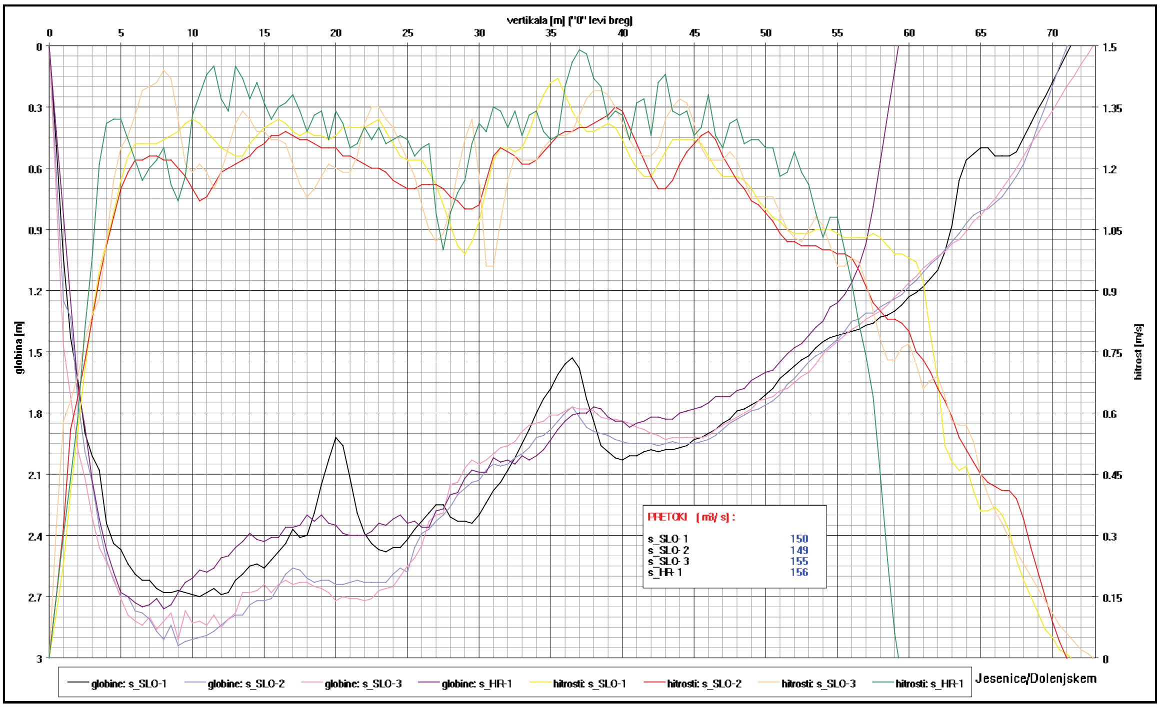
oznaka meritve measurement sign	št. prehodov number of transects	sr. pretok [m3/s] mean discharge	standardni odklon pretoka m3/s] standard deviation of discharge	razlika [%] difference	način za meritev hitrosti water mode
s_SLO-1	4	150	4.70	-	način 12 mode 12
s_SLO-2	2	149	0.38	-0.7	način 12 mode 12
s_SLO-3	4	155	1.01	3.3	način 1 mode 1
s_HR-1	4	156	3.87	4.0	način 1 mode 1
h_HR-1	4	164	1.45	9.3	način 1 mode 1
h_SLO-1	3	148	5.15	-1.3	način 12 mode 12

Z izjemo meritve h_HR-1 se vsi rezultati nahajajo v okviru ±4 %. Večje odstopanje lahko pripišemo manj ugodnemu profilu hrvaške vodomerne postaje, predvsem na desnem bregu (skale, razdelitev toka). Glede na primerjavo rezultatov in uporabljenih nastavitev lahko sklepamo, da uporaba »način 1« rahlo preceni pretok glede na »način 12«. Prednosti slednjega vidimo na grafičnem prikazu izmerjenih hitrosti, kjer je pri uporabi »načina 1« opazna večja fluktuacija hitrosti.

With the exception of the h_HR-1 measurement, all the results are within the ±4% range. Larger deviations can be ascribed to the less favourable cross-section of the Croatian hydrometric station, primarily on the right bank (with rocks and current splitting). Considering the result comparison and the settings applied, it can be concluded that the use of »Mode 1« slightly overestimates the discharge compared with »Mode 12«. The advantages of the latter are seen in the graphic representation of the velocities measured where a greater fluctuation of velocity is observed with the application of »Mode 1«.

Simultano izvajanje meritev pretoka s hidrometričnim krilom (foto: Roman Trček, 20.7.2007).

The simultaneous performance of discharge measurements with the current meter (photo: Roman Trček, 20.7.2007).



Rezultati primerjalnih meritev z ADMP v slovenskem profilu vodomerne postaje.

The results of the comparative measurements using the ADCP in the Slovenian hydrometric station cross-section.

Pri analizi poteka hitrosti preko prečnega profila lahko ugotovimo odstopanje od 0.2 m/s do 0.05 m/s. Odstopanje je večje v obeh maticah toka in se manjša ob bregovih. V odstotkih znaša odstopanje izmerjenih hitrosti ±6 %. Ostale razlike izmerjenih hitrosti so bolj ali manj posledica merjenj v različnih profilih struge in vpliva makroturbulence – vrtinci reda velikosti širine struge.

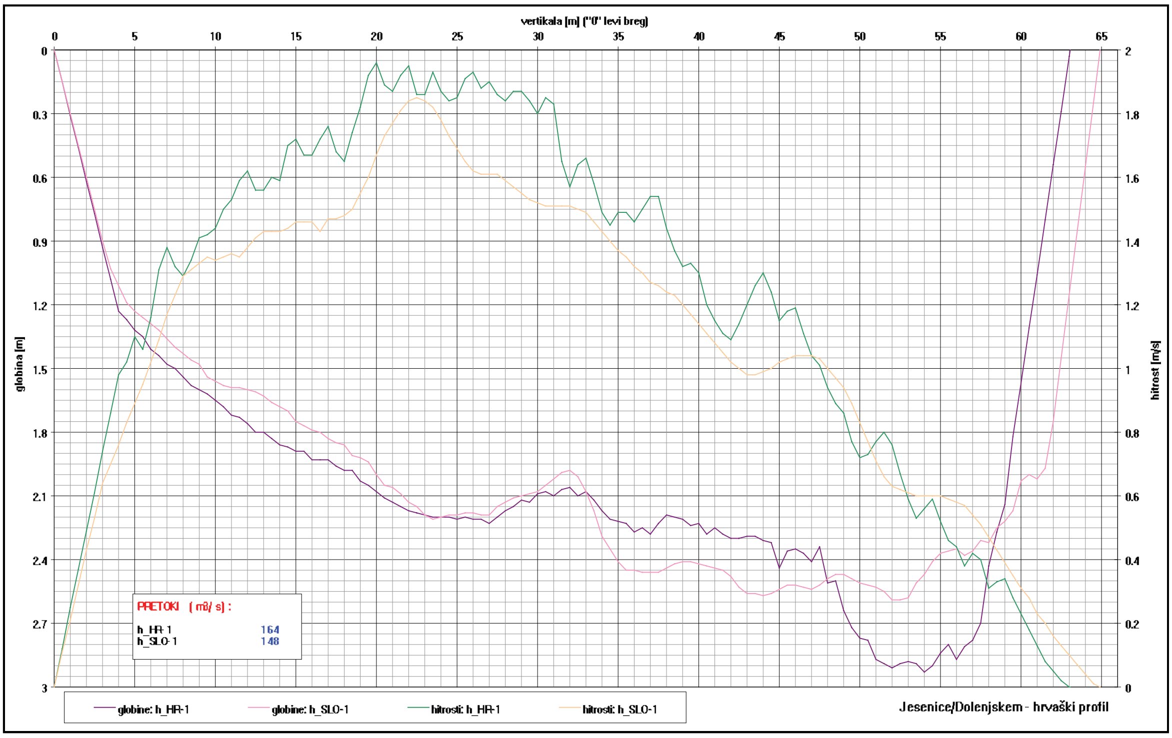
Analiza rezultatov izmerjenih globin pokaže, da so meritve odvisne od izbora mikrolokacije profila. Potek prečnega profila meritev s_SLO-2 in s_SLO-3 se razlikuje minimalno (±1.5 %). Izstopa potek prečnega profila meritve s_HR-1, kar je lahko posledica uporabe »načina 5« za boljše sledenje geometriji tal (preglednica 2) oz. napake pri oceni oddaljenosti od brega. »Način 5« ima težave predvsem pri meritvi globin pod vrednostjo 1 m.

Grafični prikaz rezultatov meritev v hrvaškem profilu vodomerne postaje nam ponuja podobne zaključke, kot smo jih navedli v predhodni analizi. Razlike v rezultatih so kombinacija dejanskih razlik izmerjenih profilov in razlik zaradi različnih nastavitev. Izpad prenosa podatkov po radijski zvezi, ko je bilo sprejetih le 60 odstotkov izmerjenih vertikal, je omogočal testiranje zanesljivosti podatkov v takih razmerah. Po primerjavi rezultatov slovenskih meritev globin in hitrosti z izmerjenimi rezultati hrvaške hidrometrične ekipe ugotovimo, da kljub nepopolnemu prenosu podatkov dobimo dokaj objektivne rezultate, zato jih lahko vključimo v skupno analizo.

In the analysis of the course of the velocity over the transverse cross-section, deviations can be established ranging from 0.2 m/s to 0.05 m/s. The deviation is greater in both the maximum current velocity areas and is lower along the banks. The deviation of the velocities measured in percentages amounts to ±6 %. The other differences between the measured velocities are more or less the result of the measurements in different river channel cross-sections and the influence of macro turbulence – eddies the size of the channel width.

Analysis of the results of the depth measurements shows that the measurements are dependent on the selection of the micro location of the cross-section. The course of the transverse cross-section of the s_SLO-2 and s_SLO-3 measurements differ minimally (±1.5%). The course of the transverse cross-section of the s_HR-1 measurements does deviate however, which could result from the application of »Mode 5« for better tracking of the river bed geometry (Table 2) or an error in the assessment of the distance from the bank. »Mode 5« experiences problems primarily in the measurement of depth below 1 m.

The graphic representation of the results from the Croatian cross-section at the hydrometric station offers similar conclusions to those we put forth in the previous analysis. The differences between the results are a combination of actual differences in the measured cross-sections and those caused by different ADCP settings. The shortfall in the radio data transmission, where only 60 percent of the measured verticals were received, enabled the testing of data reliability under such conditions.



Rezultati primerjalnih meritev z ADMP v hrvaškem profilu vodomerne postaje.

The results of the comparative measurements using the current meter in the Slovenian hydrometric station cross-section.

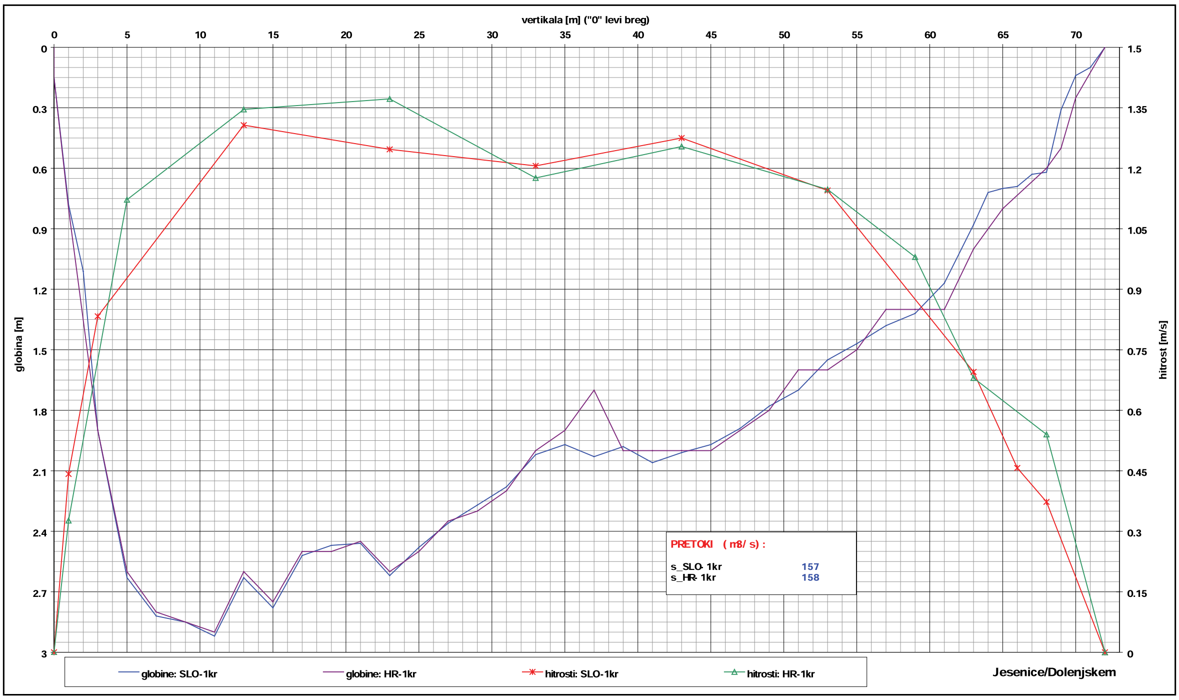
Analiza rezultatov meritev s hidrometričnimi krili

Primerjalni meritvi s hidrometričnim krilom na Jesenicah na Dolenjskem sta pokazali, da uporabljata obe ekipi zelo podobne metrične postopke. Posledica tega so tudi zelo podobni rezultati vseh veličin, od pretoka do maksimalnih in srednjih globin oz. hitrosti (preglednica 6). Ujemanje rezultatov potrjuje pravilnost izbire opreme, vertikal, merskih točk in časa merjenja, kot tudi skladnost numeričnih algoritmov za izračun izvedenih veličin pretoka, površine, srednje hitrosti ipd.

After comparison of the Slovenian depth and velocity measurements with the results measured by the Croatian hydrometric team, it was found that, despite the incomplete data transmission, fairly objective results were received, which is why they could be included in the joint analysis.

Analysis of the Results of the Current Meter Measurements

The comparative measurements with the current meter at Jesenice na Dolenjskem have shown that both teams are using very similar measuring procedures. This results in extremely similar results for all the quantities, from the discharge to the maximum and mean depths or velocities (Table 6). The agreement of the results confirms the correctness of the choice of equipment, the verticals, point velocities and the measuring time as well as the coherence of the numerical algorithms for calculating the measurements carried out on the discharge, surface area, mean velocity, etc.



Rezultati primerjalnih meritev s hidrometričnim krilom v slovenskem profilu vodomerne postaje.

The results of the comparative measurements using the ADCP in the Croatian hydrometric station cross-section.

Primerjava uporabljenih metod

Analiza številskih rezultatov meritev nakazuje na manj kot pet odstotkov precenjen pretok pri uporabi metode s hidrometričnim krilom (preglednica 6). Tudi grafična primerjava pokaže na ujemanje rezultatov meritev v okviru ±3 %, kar je z vidika zagotavljanja kakovosti meritev zadovoljivo .

Do zaključka, da metoda s hidrometričnim krilom rahlo preceni pretok, so prišli že mnogi izvajalci primerjalnih meritev (referenca). Poglavitni razlog za odstopanje je predvsem omejeno število merskih vertikal in njihova razporeditev preko profila, kar močno vpliva na obliko hitrostnega profila. Problematiko vidimo na grafičnem prikazu meritev, ki sicer nakazuje oblikovanje dveh matic toka, vendar pa zmanjšanja hitrosti na oddaljenost od levega brega (okrog 28 m) ne upošteva.

Druga razlika v našem primeru, ki ima večji vpliv na končni rezultat, so višje izmerjene hitrosti na zadnji tretjini prečnega profila proti desnemu bregu (od širine 50 naprej). Najverjetnejši razlog za to je dejstvo, da so tokovnice v tem delu struge usmerjene v notranjost profila kot posledica lokalne zožitve toka zaradi jezbice. Izmerjena hitrost s hidrometričnim krilom v tem delu ni bila pravokotna na prečni prerez. Ker je to eden od pogojev za pravilno (številsko namesto vektorskega) množenje hitrosti in površine, je zato pri integraciji hitrosti in površine prečnega prereza prišlo do rahlega povečanja vrednosti pretoka.

Comparison of the Methods Used

The analysis of the measurement results indicates that overestimation of the discharge is less than five percent when using the current meter method (Table 6). The graphic comparison also shows the coherence of the measurement results within a range of ±3%, which is satisfactory in terms of ensuring the quality of the measurements.

By employing comparative measurements, many researchers have come to the conclusion that the current meter method slightly overestimates the discharge. The main reason for the deviations is primarily the limited number of measured verticals and their location over the cross-section, which significantly affects the velocity distribution. We see the problem in the graphic depiction of the measurements, which otherwise indicates the formation of two maximum current velocity areas. However it does not consider the reduction in velocity in the distance from the left bank (around 28 m).

The second difference in our case, which has a greater effect on the final result, is the higher measured velocities in the last third of the cross-section towards the right bank (from the width of 50 onwards). The most probable reason for this is that the streamlines in this part of the river channel are oriented towards the inside of the cross-section as a result of the local constriction of the current by the spur. The velocity measured with the current meter in this area was not perpendicular to the transverse cross-section. As this was one of the conditions for the correct (numerically instead of vectorially) multiplication of the velocity and surface area, a slight

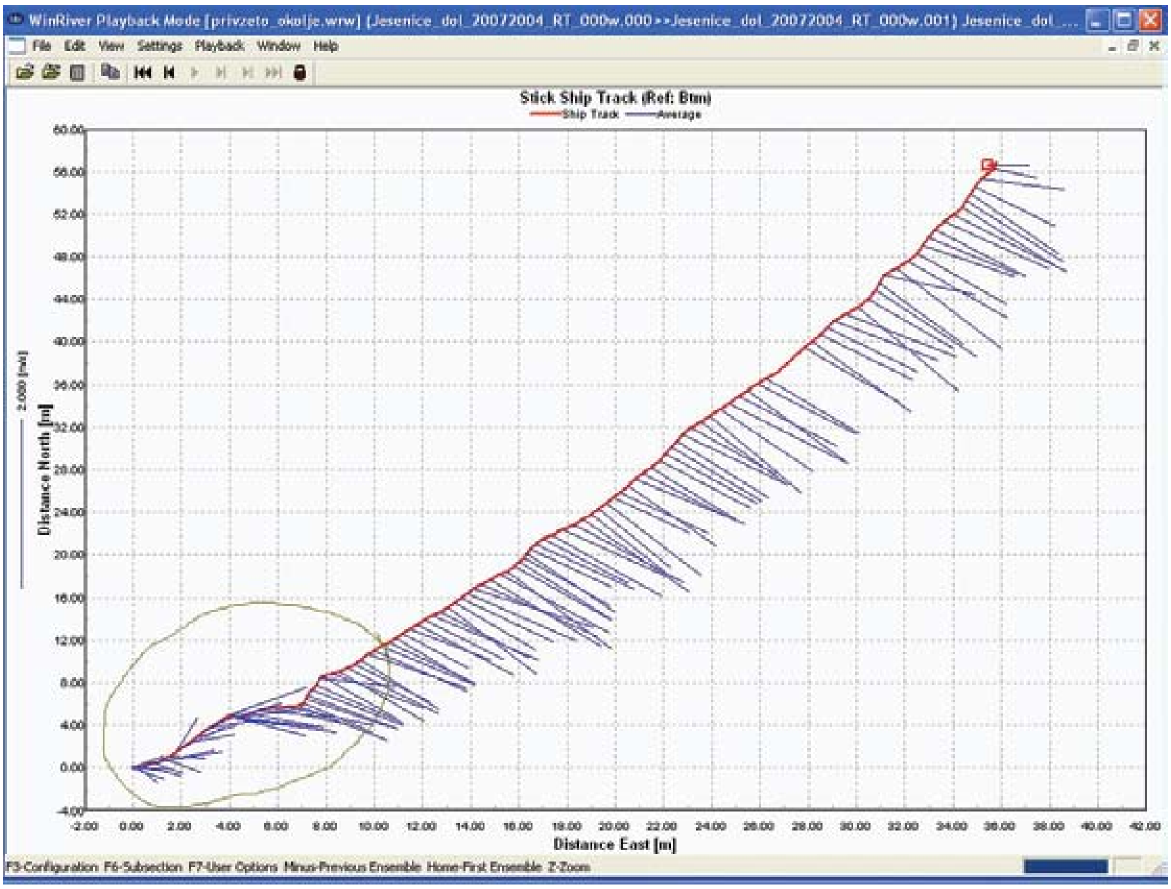
Sklep

Primerjalne meritve so pokazale usklajenost merilnikov ADMP, saj sta pri podobnih nastavitvah podala podatke o pretoku, ki se je razlikoval za manj kot odstotek. Uporaba »programskega načina 1« rahlo preceni pretok tudi za 3 – 4 % (preglednica 7), kar je posledica predvsem manj natančne izmere hitrosti glede na »programski način 12«. V primeru izgube podatkov pri radijskem prenosu do 40 odstotkov so podatki lahko še vedno v meji ±4 % od najverjetnejše vrednosti, vendar je tveganje za zaupanje podatkom večje kot sicer. Zaradi različne uporabe »programskih načinov« za sledenja tal (»način 5« in »način 7«) v izbranem prečnem profilu ni bilo zaslediti večjega odstopanja rezultatov, odstopanja bi nastala pri plitkejših prečnih profilih, s povprečno globino pod 1 m. Obe merilni ekipi uporabljata podobno metodologijo in opremo za meritve pretoka s hidrometričnimi krili, rezultat meritev po tej metodi praviloma rahlo preceni pretok (do 5 %), kritična sta izbor lokacije meritve (motnje v toku) in razporeditev vertikal po prerezu.

increase in the discharge value occurred when integrating the velocity and the surface area of the transverse cross-section.

Conclusion

Comparative measurements have illustrated the uniformity of the ADC profilers as, with the same settings, they yielded discharge data that differed by less than one percent. The use of »Program Mode 1« slightly overestimates the discharge by as much as 3 to 4% (Table 7), which is primarily the result of the less accurate measurement of the velocity compared with »Program Mode 12«. In the event of data loss of up to 40 percent in the radio transmission, the data is still within the limit of ±4% of the most probable value, though the risk in trusting the data is greater than otherwise. Because of the different use of »Program Modes« for tracking the river bed (»Mode 5« and »Mode 7«), no greater deviation of results in the selected transverse cross-section could be detected. The deviations occurred in the shallower transverse cross-sections with an average depth of below 1 m. Both the measuring teams use similar methodology and equipment for the measurement of discharges with current meters. The result of the measurements using this method, slightly overestimate the discharge as a rule (by up to 5 %), whereby the selection of the measurement location (disturbances in the current) and the distribution of the verticals across the section are critical.



Razporeditev tokovnic vzdolž slovenskega profila vodomerne postaje (pogled zvrha).

The distribution of streamlines along the Slovenian cross-section at the hydrometric station (view from above).