I. DEL:
RAZVOJ NA PODROČJU HIDROLOŠKEGA MONITORINGA

PART I:
DEVELOPMENTS IN THE FIELD OF HYDROLOGICAL MONITORING

SPREMEMBE V MREŽI HIDROLOŠKIH MERILNIH MEST V LETU 2008

Mag. Roman Trček

Zaradi vsebinskih posebnosti delimo državno mrežo hidroloških opazovanj na mrežo za opazovanje površinskih voda, mrežo za opazovanje podzemnih voda, ki je sestavljena iz mreže na aluvialnih vodonosnikih in mreže na izvirih, ter mrežo za opazovanje morja.

Površinske vode

V državni mreži za meritve površinskih voda je v letu 2008 delovalo 176 vodomernih postaj (v nadaljevanju: v.p.). V tem letu je bilo avtomatiziranih 6 v.p., od teh je bila v.p. Medno zgolj prestavljena za 40 m gorvodno. Na v.p. Kal-Koritnica je bil v septembru zgrajen talni prag, kar je vplivalo na pretočno krivuljo. Novo zgrajene AMP v letu 2008 so torej:
- v.p. Preska na Tržiški Bistrici: gradbena dela so bila zaključena novembra 2008,
- v.p. Čentiba na Ledavi: gradbena dela so bila zaključena maja 2008,
- v.p. Škocjan na Reki: gradbena dela so bila zaključena oktobra 2008,
- v.p. Petanjci na Muri: gradbena dela so bila zaključena maja 2008
- v.p. Ruta na Radoljni: gradbena dela so bila zaključena aprila 2008.

Na v.p. Železniki na Selški Sori in v. p. Ranca na Pesnici so se gradbena dela začela konec leta 2008 in se zaključila v letu 2009.

Na omenjenih merskih mestih je bil začasno prekinjen niz podatkov. Meritve pretokov za potrebe izdelave pretočne krivulje so bile zgoščeno izvajane takoj po končanju gradbenih del. Kontinuirano spremljanje gladine je bilo izvedeno v obdobju nekaj mesecev po gradbenih delih in je v nekaterih primerih segalo v leto 2009.

Med letom je bilo narejenih 1131 hidrometričnih meritev (75 več kot v letu 2007), 619 z akustičnimi dopplerjevim merilnikom (ADMP) (52 več kot v letu 2007) in 505 z ultrazvočnim hidrometričnim krilom (FlowTracker – FT) (27 več kot v letu 2007). Sedemkrat je bil merski profil ob obisku vodomerne postaje suh. V letu 2008 ni bilo nobene meritve s klasičnim hidrometričnim krilom. Na 94 postajah so bili vodostaji zabeleženi z

CHANGES TO THE NETWORK OF HYDROLOGICAL MONITORING GAUGING STATIONS IN THE YEAR 2008

Roman Trček, MSc

Due to substantive differences the national network of hydrological monitoring is classified into the surface water monitoring network, groundwater monitoring network (consisting of the alluvial aquifers monitoring network and springs monitoring network), and the sea monitoring network.

Surface water

176 water gauging stations (hereinafter w. g. s.) operated in 2008 within the national surface water monitoring network. 6 w.g.s. were automated that year, of which w.g.s. Medno was merely shifted 40 metres upstream. A sill was constructed in September at w.g.s. Kal-Koritnica, which affected the rating curve. The newly constructed automatic gauging stations (AGS) in 2008 include:
- w.g.s. Preska on the Tržiška Bistrica River: the construction work was completed in November 2008,
- w.g.s. Čentiba on the Ledava River: the construction work was completed in May 2008,
- w.g.s. Škocjan on the Reka River: the construction work was completed in October 2008,
- w.g.s. Petanjci on the Mura River: the construction work was completed in May 2008
- w.g.s. Ruta on the Radoljna River: the construction work was completed in April 2008.

Construction work on the w.g.s. Železniki on the Selška Sora River and on w.g.s. Ranca on the Pesnica River started at the end of 2008 and was completed in 2009.

The gathering of datasets was temporarily halted at the aforementioned monitoring stations. The discharge measurements for the formation of the rating curve were carried out on a more frequent basis right after the completion of construction work. Continued monitoring of the water level was carried out a few months after completing construction work and in some cases extended into the year 2009.

During the year, 1,131 hydrometric measurements were conducted (75 more compared to 2007), of which 619 were carried out with the acoustic Doppler current profilers – ADCP (52 more limnigrafskimi zapisi, na 27 pa z digitalnimi zapisi avtomatskih merilnih postaj (AMP) ali podatkovnimi zapisovalniki. Vedno več merilnih mest ima po dva neodvisna merilnika vodostajev (ultrazvočni merilnik in plovec ali tlačna sonda). Na ta način je verjetnost izpada podatkov zelo zmanjšana.

Opazovanja so potekala na vseh 176 vodomernih postajah. Od tega so se izvajala redna dnevna opazovanja na 101 vodomerni postaji, na ostalih pa enkrat tedensko z območnimi opazovalci vodnogospodarskih podjetij. Ob izrednih razmerah je bilo narejeno veliko opazovanj visokovodnih stanj.

Temperature vode so se v letu 2008 merile na 70 merilnih mestih – na 39 postajah AMP na površinskih vodotokih in na dveh postajah na morju. Enkratdnevna opazovanja (izjema je ena postaja, kjer so opazovanja potekala enkrat tedensko) so se izvajala na 31 postajah. Nekaj termometrov je bilo živosrebrnih, nekaj pa alkoholnih. Na 16 postajah se je merilo z ročnim termometrom in AMP.

V letu 2008 so se zajemali vzorci vode za določanje vsebnosti in izračun transporta suspendiranega materiala na 11 vodomernih postajah. Na eni postaji se je zajem izvajal vsakodnevno – vzorcev je več kot 300, na štirih postajah pa je bilo zajetih okoli 100 vzorcev. Na ostalih postajah je bil zajem vzorcev vode le občasen – ob visokih vodah.

Podzemne vode

V državni mreži za meritve podzemnih voda na aluvialnih vodonosnikih je v letu 2008 delovalo 138 merilnih mest. V marcu je bila AMP Mercator prestavljena iz parka v notranje prostore trgovskega centra v Ljubljani. Omenjena postaja je sicer ena izmed petih AMP na mreži aluvialnih vodonosnikov.

Opazovanje izvirov je v letu 2008 potekalo na 16 merilnih mestih. Konec leta je bilo ukinjeno merilno mesto Metliški Obrh – Obrh. Septembra je prišlo do trajne okvare merilne opreme na merilnem mestu Rakitnica – Blate. Merilno mesto Mošenik je ostalo neopremljeno (podatkovni zapisovalnik) vse leto.

compared to 2007) and 505 with the ultrasonic velocimeters – FlowTracker FT (27 more compared to 2007). The measurement profile was arid on 7 occasions during visits to the water gauging station. None of the measurements in 2008 were performed with the traditional current meter.

At 94 stations, the water levels were read from the recording made by water-level recorders, while at 27 other stations they were read from digital recordings of automatic gauging stations (AGS) or data loggers. An increasing number of gauging sites have two independent water level gauges (an ultrasonic gauge and a float or pressure probe). This greatly reduces the probability of data loss.

Observation took place at all 176 water gauging stations. Of the aforementioned total, regular daily observation was carried out at 101 water gauging stations, while once weekly on the remaining stations by local observers of water management companies. When extreme conditions occurred, several observations of high water conditions were carried out.

Water temperatures were measured at 70 gauging sites in 2008 – at 39 automatic gauging stations on surface streams and at two stations at sea. Daily observations (except one station where the observations took place once weekly) were carried out at 31 stations. Some thermometers were classic mercury-in-glass thermometers, while others were alcohol thermometers. Manual thermometers and AGS were used at 16 stations.

In 2008, water sampling to determine the concentration of suspended material and calculate the transmission of suspended material took place at 11 gauging stations. At one station sampling was performed daily – more than 300 samples were taken, while around 100 samples were taken at four stations. The remaining stations performed only periodical sampling – at high water levels (floods).

Groundwater

138 gauging sites operated within the national network of groundwater monitoring on alluvial aquifers in 2008. In March, AGS Mercator was shifted from the park to the inner premises of the shopping centre in Ljubljana. The aforementioned station is one of the five AGS in the alluvial aquifer network.

The observation of springs took place at 16 gauging sites in 2008. By the end of the year, the

Slika 1: Gradbena dela na v.p. Ruta na Radoljni (foto: Rok Ferme)
Figure 1: Construction work on the w.g.s. Ruta on the Radoljna River (photo: Rok Ferme)

Slika 2: Meritev visokovodnega pretoka dolvodno; v.p. Cerkvenikov mlin na Reki (foto: Primož Gajser)
Figure 2: Measuring the flood flow downstream; w g.s. Cervenikov mlin on the Reka River (photo Primož Gajser)

Morje

Pri opazovanju morja v letu 2008 je bilo nekaj sprememb. Postaja v Luki Koper ni več delovala. Na oceanografski boji v Piranu je bilo veliko izpadov podatkov. Postaja Koper pri stavbi Uprave Republike Slovenije za pomorstvo je delovala skladno s pričakovanji.

Metliški Obrh – Obrh gauging station ceased operation. A serious error in the measuring equipment occurred in September at the Rakitnica – Blate station. The Mošenik gauging station remained unequipped (data logger) all year round.

Sea

There were a few changes to observations at sea in 2008. There was no loss of data at the tide gauge Koper which is located near Slovenian

Maritime Administration. A number of data loss instances occurred at the oceanographic buoy located at the sea 1NM away from the coast of city Piran to the west. The tide gauge Luka Koper was removed.

Slika 3: Vrtine in zunanja komunikacijska omarica na AMP Mercator na Ljubljanskem polju. Fotografija prikazuje kontrolo montaže črpalk (foto: Ladislav Podržaj).
Figure 3: Boreholes and external communication cabinet at the AGS Mercator on Ljubljansko polje (Ljubljana Field) The photo demonstrates the pump installation control (photo: Ladislav Podržaj).

SEZNAM OPAZOVALCEV V MREŽI MERILNIH MEST HIDROLOŠKEGA MONITORINGA

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

Opazovalec *Observer*	Postaja za podzemne vode *Groundwater observation station*
Artač Jože	Brezovica
Artenjak Stanko	Spodnja Hajdina
Beranič Ivan	Zg. Jablane
Beranič Slava	Brunšvik
Bizjak Ivan	Gotovlje
Bone Branko	Vipavski Križ
Cvetko Božidar Sandi	Trgovišče
Cvikl Anton	Zg. 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

Opazovalec *Observer*	Postaja za podzemne vode *Groundwater observation station*
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	Mengeš
Repnik Anica	Preserje
Repnik Anton	Parižlje
Rodošek Dušan	Veliki Podlog
Rojc Cvetka	Volčja Draga
Simončič Ivan	Gorica
Simonič Rajko	Dornava
Slapnik Milena	Podgorje

Opazovalec *Observer*	Postaja za podzemne vode *Groundwater observation station*
Kač Tomašič Irena	Arja vas
Kaučič Anton	Plitvica
Kmecl Leopold	Škofja vas
Kološa Elizabeta	Radmožanci
Kovač Marija	Sinja Gorica
Kregar Marija	Dolenja vas
Artač Jože	Brezovica
Krušec Ivana	Segovci
Lepej Darinka	Starše
Mali Viljem	Šempeter
Medvešek Jožica	Hrvaški Brod

Opazovalec *Observer*	Postaja za podzemne vode *Groundwater observation station*
Stamničar Dejan	Veščica
Stropnik Marko	Medlog
Šavrič Daniela	Bukošek
Škraban Avguštin	Krog
Tement Lidija	Sobetinci
Tonja Helena	Sveti Duh
Merljak Luka	Renče
Vilčnik Avgust	Ptuj
Weingerl Jože	Mali Segovci
Zadobovšek Rudolf	Trnava
Zevnik Marija	Celje
Žibrek Jelena	Zgornje Krapje

Opazovalec *Observer*	Vodomerna postaja *Gauging station*	Reka, jezero *River, lake*
Avšič Boštjan	Čatež	Sava
Balog Milena	Hotešček	Idrijca
Banič Jože	Podbočje	Krka
Baša Slavko	Podkaštel	Dragonja
Bevc Franc	Šoštanj	Velunja
Bevk Marija	Trzin	Pšata
Bizjak Marija	Rečica	Paka
Bizjak Nada	Okroglo	Sava
Blažič Filipina	Prestanek	Pivka
Bucaj Stanislav	Kubed	Rižana
Buh Ljudmila	Komin	Ljubljanica
Cankar Darinka	Medno	Sava
Čas Pavla	Solčava	Savinja
Černigoj Jože	Ajdovščina	Hubelj
Ferfolja Alojz	Miren I	Vipava
Fortuna Jožefa	Bistra	Bistra
Furlan Emil	Vipava	Vipava
Gabriel Miro	Rožni vrh	Temenica
Gabrijelčič Zlatko	Solkan	Soča
Glojek Marta	Kraše	Dreta
Gogala Dušan	Cerknica	Cerkniščica
Harbaš Marija	Kranjska Gora	Sava Dolinka
Heberle Olga	Mlino	Blejsko jezero
Heberle Olga	Mlino	Jezernica
Herzog Jerneja	Cankova	Kučnica
Horvat Ladislav	Središče	Ivanjševski potok
Ilijev Zlata	Jesenice	Sava Dolinka
Ive Anton	Preska	Tržiška Bistrica
Jereb Matevž	Žiri	Poljanska Sora
Jevševar Slavko	Škale	Lepena
Jurkošek Romana	Veliko Širje	Savinja

Opazovalec *Observer*	Vodomerna postaja *Gauging station*	Reka, jezero *River, lake*
Milavec Andrej	Malni	Malenščica
Milavec Ivanka	Hasberg	Unica
Mlinarič Franc	Gornja Radgona	Mura
Moličnik Vinko	Luče	Lučnica
Mudrinič Aleksander	Bodešče	Sava Bohinjka
Mustar Marija	Rašica	Rašica
Nemet Ladislav	Zagaj	Bistrica
Novak Jože	Postojnska jama	Pivka
Oberstar Vida	Prigorica	Ribnica
Obštetar Borut	Dolenja Trebuša	Trebuša
Omerzel Jože	Metlika	Kolpa
Pavša Silva	Golo Brdo	Idrija
Pažur Andrej	Petrina	Kolpa
Pec Franc	Loče	Dravinja
Potočnik Jože	Podnanos	Močilnik
Potokar Janez	Litija	Sava
Rovšček Milojka	Bača pri Modreju	Bača
Roženbergar Drago	Kranj	Kokra
Samec Oton	Polže	Hudinja
Sekljič Edvard	Pesje	Lepena
Skubic Anica	Mieniška vas	Radešča
Slavinec Angela	Škale	Sopota
Stegel Vida	Mali Otok	Nanoščica
Strniša Jure	Žebnik	Sopota
Šepec Terezija	Rakovec	Sotla
Šestan Boris	Trpčane	Reka
Šestan Boris	Trnovo	Reka
Šestan Boris	Cerkvenikov mlin	Reka
Šetina Marija	Sveti Duh	Bohinjsko jezero
Škoflek Biserka	Velenje	Paka
Škrbec Simon	Branik	Branica

Opazovalec *Observer*	Vodomerna postaja *Gauging station*	Reka, jezero *River, lake*
Kac Jože	Stari Trg	Suhadolnica
Kalič Matjaž	Otiški vrh	Meža
Kalič Matjaž	Otiški vrh	Mislinja
Kapš Stanko	Prečna	Prečna
Karničnik Elizabeta	Ruta	Radoljna
Kern Janez	Pšata	Pšata
Klemen Slanc Marija	Razori	Šujica
Koblar Alojzija	Železniki	Selška Sora
Kočevar Franc	Gradac	Lahinja
Košir Luka	Sodražica	Bistrica
Kovač Anica	Log pod Mangartom	Koritnica
Kovačec Ivana	Zamušani	Pesnica
Krajnik Rudolf	Suha	Sora
Leban Ivan	Tolmin	Tolminka
Lesjak Matilda	Levec	Ložnica
Leskovec Alojz	Podroteja	Idrijca
Malis Viljem	Hrastnik	Sava
Martinčič Andrej	Dolenje Jezero	Stržen
Mejač Antonija	Nevlje	Nevljica
Mesarič Gizela	Polana	Ledava

Opazovalec *Observer*	Vodomerna postaja *Gauging station*	Reka, jezero *River, lake*
Šorn Stanislav	Vir	Rača
Štancer Drago	Črnolica	Voglajna
Šturm Albin	Kobarid	Soča
Šuštar Andreja	Mlačevo	Grosupeljščica
Švarc Janko	Dvor	Gradaščica
Tominec Franc	Medvode	Sora
Trauner Julijus	Celje	Voglajna
Tršinar Milka	Martinja vas	Mirna
Trunkelj Frančiška	Trebnja Gorica	Višnjica
Vodišek Ivanka	Vodiško	Gračnica
Vodopivec Jože	Dornberk	Vipava
Vošnjak Martin	Dolenja vas	Bolska
Vugrinec Štefanija	Videm	Dravinja
Zagorc Cveto	Nazarje	Savinja
Zajc Anton	Podbukovje	Krka
Zalokar Marjan	Domžale	Mlinščica Kanal
Žagar Bojan	Log Čezsoški	Soča
Žakelj Janez	Vrhnika	Ljubljanica
Žakelj Janez	Verd	Lubija

Vzdrževanje hidrološke postaje Loče na Dravinji (foto: Arhiv ARSO)
Maintenance of gauging station Loče on the Dravinja River (photo: EARS archives)

HIDROLOG – NOV INFORMACIJSKI SISTEM DRŽAVNE HIDROLOŠKE SLUŽBE

Mag. Marjan Bat, Jože Miklavčič

Večina podatkov, izvedenih iz meritev v mreži državne hidrološke službe, ki jih objavljamo v Hidrološkem letopisu 2008, je bila obdelana v HIDROLOGU, novem informacijskem sistemu Urada za hidrologijo in stanje okolja (Urada) na Agenciji Republike Slovenije za okolje (ARSO). Sistem je rezultat večletnega dela, ki smo ga skupaj opravili podjetje Monolit informacijski sistemi d. o. o. in delavci Urada. V informacijskem smislu je HIDROLOG združil podsisteme državne merilne mreže za podzemne vode, izvire, površinske vode in morje. Doslej sta imela celovito informacijsko podporo monitoringa površinskih in podzemnih voda. Prvi je od konca osemdesetih let prejšnjega stoletja uporabljal **BHP** (**B**azo oziroma zbirko **H**idroloških **P**odatkov), v sistem povezane fortranske programe na računalniku VAX; drugi pa **SSOPPV** (**S**istem za **S**hranjevanje in **O**bdelavo **P**odatkov **P**odzemnih **V**oda), podatkovno zbirko, razvito okoli leta 1995 v programu FOXPRO, ki je že upoštevala načela relacijskih modelov podatkov. Ločena programska paketa sta omogočala vnos, kontrolo, obdelavo, shranjevanje in zajem podatkov. V obeh so se verificirali letni bloki dnevnih vrednosti. Programa nista imela grafične podpore. Podatki opazovanja morja in izvirov so se obdelovali z različnimi programi in shranjevali ločeno na osebnih računalnikih.

Proti koncu devetdesetih let prejšnjega stoletja smo na tedanjem Sektorju za hidrologijo Hidrometeorološkega zavoda RS začutili potrebo po sodobnem in enotnem informacijskem sistemu, zasnovanem na relacijskem modelu podatkov. Zavod je tedaj začel pri obdelavi podatkov uvajati sistem za upravljanje z bazami podatkov ORACLE, in odločitev, na kakšni osnovi bo deloval sistem, je bila s tem že sprejeta. Razmišljali smo, ali naj za naše potrebe kupimo že razvito orodje za delo s hidrološkimi podatkovnimi zbirkami ali pa naj se razvoja lotimo z uporabo lastnega znanja in znanja, dostopnega na tržišču. Zaradi tehnoloških in organizacijskih posebnosti ter večdesetletne tradicije naše službe, o kateri priča tudi obsežen arhiv podatkov, ki ga je bilo treba prepisati v novo podatkovno zbirko, smo ocenili, da je lasten razvoj boljša rešitev.

HIDROLOG (Hydrologist) – NEW INFORMATION SYSTEM OF THE NATIONAL HYDROLOGY SERVICE

Marjan Bat, Msc, Jože Miklavčič

Most of the data derived from the measurements within the national hydrology network, which we publish in the 2008 Hydrology Yearbook, were processed in HIDROLOG, the new information system of the Hydrology and State of Environment Office (Office), Environmental Agency of the Republic of Slovenia (EARS). The system is the result of several years of work performed by the company Monolit informacijski sistemi d. o. o. side by side with Office colleagues. In the information sense HIDROLOG combined the subsystems of the national network for monitoring groundwater, springs, surface water and the sea. Up until now the two have had the comprehensive information support of surface water and groundwater monitoring. The former, from the late 1980s, used **BHP** (Hydrology Database), a system using Fortran-associated programs on the VAX computer, while the latter used the **SSPGD** (**S**ystem of **S**aving and **P**rocessing **G**roundwater **D**ata) database developed around 1995 in the program FOXPRO, which already took the relational model of data into account. The separate program packages enabled the entry, control, processing, saving and capturing of data. Annual blocks of daily values were verified in both. The programs had no graphical support. Sea and springs observation data were processed with different programs and saved separately on personal computers.

By the end of the 1990s, operating under the then known Hydrology Sector of the Hydrometeorological Institute of the Republic of Slovenia, we felt the need for a modern and unified information system based on the relational model of data. It was then that the Institute began, in terms of data processing, to introduce the ORACLE RDBMS and so the decision regarding on which basis the system shall operate was thus inevitable. We deliberated whether it would be wise to buy an already developed instrument to meet our needs for hydrological database processing or to develop our own instruments using our knowledge and the knowledge available on the market. Due to technological and organisational particularities and more than 60-year tradition of our service, demonstrated also by our extensive data archives which had to be

Značilnosti HIDROLOGA

Sistem HIDROLOG sestavljata spletna aplikacija v tehnologiji J2EE in podatkovna zbirka v ORACLU. Spletna aplikacija z relacijskim modelom povezuje številne HIDROLOGOVE interne in zunanje podatkovne tabele. Skrbniki zunanjih tabel so različne službe ARSO, interne tabele pa so v pristojnosti Urada.

V podatkovno zbirko HIDROLOGA se zapisujejo le podatki, ki jih je mogoče povezati z vodomernimi postajami državne hidrološke službe. Te predstavljajo osnovni podatkovni gradnik celotnega sistema. Vodomerne postaje so le ena od podmnožic merilnih mest ARSO, ki so enotno popisana v **I**nformacijskem **S**istemu **M**erilnih **M**rež. **ISMM** hrani med drugim podatke o imenih postaj, njihovih lokacijah (koordinate merilnega mesta), merilni opremi (seznam merilnikov, historiat, tipi…), organizacijski pripadnosti oziroma vrsti merilnega mesta (na primer meteorološka, hidrološka postaja, merilno mesto za določanje kakovosti vode …). Podatki oziroma tabela(-e) ISMM so za HIDROLOGA ena od zunanjih tabel. V njih je zapisan del informacij o vodomernih postajah, potrebnih za pravilno interpretacijo hidroloških podatkov. Podatki o lastnostih, ki so posebnost vodomernih postaj (na primer površina vodozbirnega zaledja, oddaljenost merilnega mesta od izliva reke, nadmorska višina kote »0«), so zapisani v internih hidrologovih tabelah.

Med zunanjimi podatkovnimi tabelami, ki so operativne neodvisno od delovanja sistema HIDROLOG in niso obvezno v pristojnosti Urada, so poleg omenjenih tabel ISMM trenutno še:
– tabele podatkovne zbirke avtomatskih merilnih postaj (AMP) ARSO, vključno s tabelami sistema za kontrolo in popravljanje podatkov AMP (Kolomon);
– podatkovna zbirka hidrometričnih meritev z akustičnimi merilniki (HidFlow – glej Podatkovna zbirka rezultatov meritev pretoka kot orodje za podporo odločanju, Hidrološki letopis 2006).

V interne tabele se zapisujejo podatki meritev v mreži državnega hidrološkega monitoringa in rezultati obdelav teh podatkov. V ta sklop tabel sodijo na primer tabele vrednosti (verificirane oziroma arhivske ter urne in dnevne delovne vrednosti hidroloških veličin – vodostajev, pretokov, …) in ekstremov (dnevni, mesečni minimumi in maksimumi hidroloških veličin), tabele pretočnih krivulj, tabele povzetkov rezultatov hidrometričnih meritev, opazovalcev, podatkovnih tipov ter opomb. Hidrološke veličine, ki jih lahko merimo na vodomernih postajah, so: višina gladin

copied to the new database, we deemed that our own development would be the better solution.

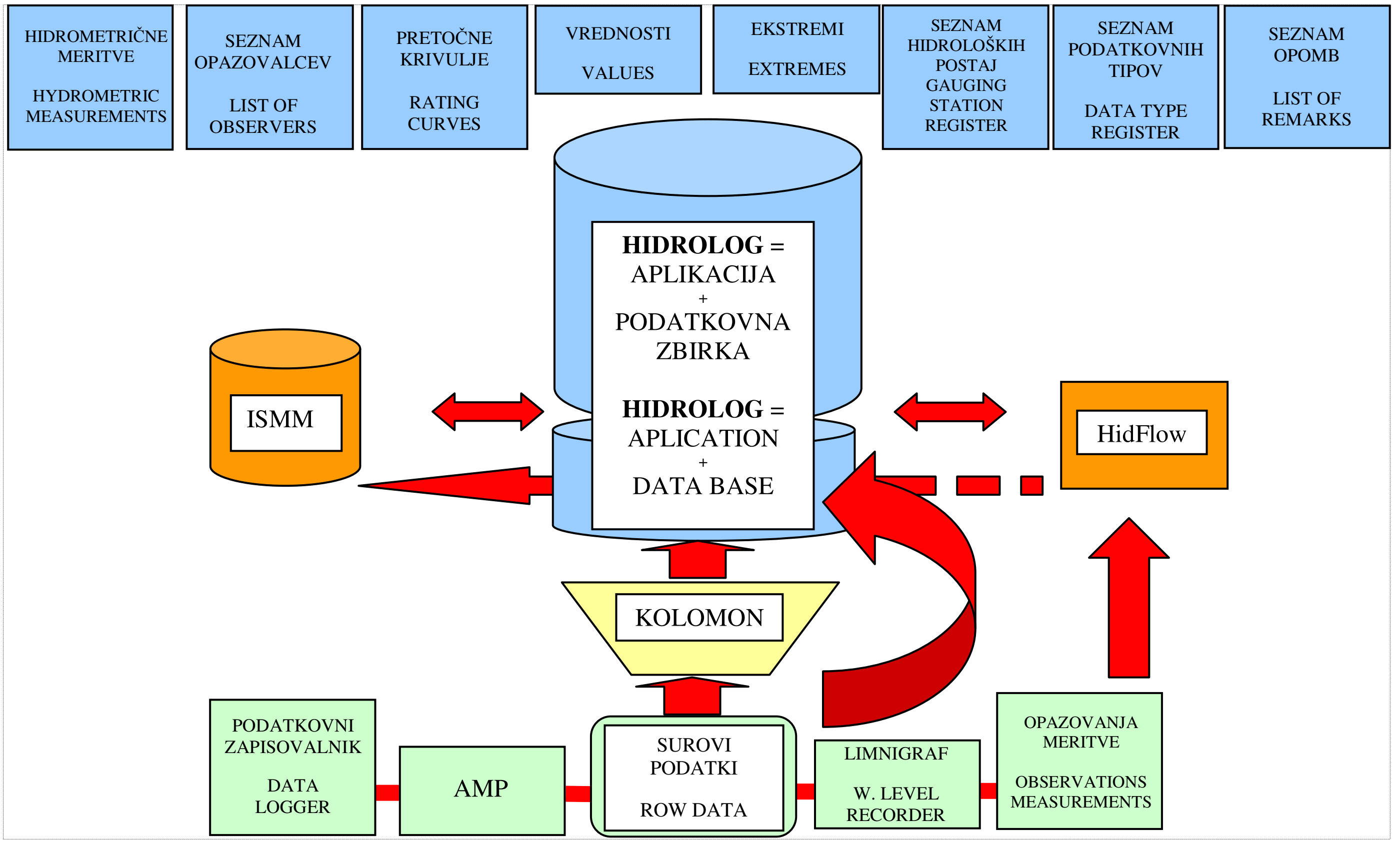
HIDROLOG characteristics

The HIDROLOG system comprises a web application using the J2EE technology and the ORACLE database. The web application with the relational model of data combines several HIDROLOG internal and external database tables. Various EARS services are administrators of the external tables, while the Office is responsible for the internal tables.

Only data which can be associated with the water gauging stations of the national hydrology service are registered in the HIDROLOG database. This represents the basic data element of the entire system. Water gauging stations are merely one of the subgroups of EARS gauging sites, which are recorded in a uniform manner in the **I**nformation **S**ystem of **M**easuring **N**etworks. The **ISMN** also, among other data, keeps data on the names of the stations, their location (coordinates of the monitoring site), gauging equipment (list of measuring devices and their state, types, etc.), organisational affiliation or type of the monitoring site (such as meteorological, hydrological station, monitoring site for determining water quality, etc.). Data on the ISMN table(s) are treated as external tables by HIDROLOG. These tables record part of the information on water gauging stations required for correct interpretation of hydrological data. Data on the characteristics representing a particularity of water gauging stations (for example the area of the drainage basin, distance of the water gauging site from the river's outfall, datum point altitude) are recorded in internal hydrological tables.
Among the external data tables which are operatively independent of the functioning of HIDROLOG and are not necessarily under the authority of the Office, you will currently find the following in addition to the ISMN tables:
– tables from the EARS automatic gauging stations (AGS) database, including the tables within the system for control and correction of AGS data (Kolomon);
– the database of hydrometric measurements with acoustic gauges (HidFlow – see the Database of discharge measurement results as a tool for decision-making support, 2006 Hydrological Yearbook).

Data on measurements within the national hydrology monitoring network and processing results of this data are recorded in internal tables. This set of tables includes for instance value tables (verified or archived and hourly or daily vode – vodostaj, temperatura vode, vsebnost suspendiranega materiala, specifična električna prevodnost.

work values of hyrdological quantities – water levels, discharges, etc.) and extremes (daily, monthly minimums and maximums of hydrological quantities), rating curve tables, tables demonstrating the summarised results of hydrometric measurements, observers, data types and notes.



Slika 1: Shema podatkovnega modela informacijskega sistema HIDROLOG
Figure 1: Data model scheme of the HIDROLOG information system

Vrednosti odčitajo opazovalci s poljubnega merilnika (na primer merilne letve ali vodnega termometra), lahko jih zabeležijo merilne naprave z merilniki (avtomatske merilne postaje ali podatkovni zapisovalniki, opremljeni z merilniki za vodostaj, temperaturo …, limnigrafi), lahko se določijo z laboratorijsko analizo zajetih vzorcev. Z vsemi temi podatki polnimo zbirko »**surovih« vrednosti**:
– podatke, ki jih vsakodnevno ali enkrat mesečno pošiljajo opazovalci, vnesemo v zbirko surovih podatkov s tipkovnico (nekaj podobnega velja tudi za rezultate laboratorijskih analiz);
– v predpisano digitalno obliko prevedene (digitalizirane) analogne zapise z limnigrafskih trakov prepišemo v zbirko surovih podatkov s posebnim vmesnikom;
– podatke podatkovnih zapisovalnikov v določenih časovnih intervalih zajamemo na merilnih mestih in nato prepišemo v zbirko surovih podatkov s posebnim vmesnikom;
– podatki avtomatskih postaj prihajajo v zbirko

The following hydrological quantities can be measured at water gauging stations: water table levels – water level, water temperature, suspended material concentration, specific electrical conductivity. Values are read by observers using any type of meter (for example staff gauge or water thermometer). They can also be recorded by measuring devices with gauges (automatic gauging stations or data loggers equipped with water level, temperature, gauges, water-level recorders (limnigraph), etc.), or can be determined through laboratory analysis of gathered samples. With all this data we complete the database of **"raw" values:**
– data sent once daily or monthly by observers is entered by hand (keyboard) into the database of raw data (something similar also applies to the results of laboratory analyses);
- the analogue recordings from water-level recorder strips translated (digitalised) into the prescribed digital format are copied into the raw data database with a special interface;

neposredno s prenosi z merilnih mest (zapisujejo se v zunanjih tabelah podatkovne zbirke AMP).

Vse surove vrednosti so časovno in prostorsko določene (s povezavami v podatkovnem modelu) ter do določene mere kontrolirane in pripravljene za nadaljnje obdelave s programom HIDROLOG. Ta omogoča tabelarične in grafične preglede surovih podatkov, na osnovi katerih se obdelovalec odloča, katere surove podatke bo uporabil za pripravo **urnih delovnih podatkov** na **delovni ravni**. Na nekaterih merilnih mestih namreč vodostaj zaradi večje zanesljivosti in neposredne kontrole lahko merimo z več različnimi merilniki hkrati – na primer z radarjem in tlačno sondo – in imamo za isto veličino več serij surovih podatkov. **Urne delovne vrednosti** predstavljajo naslednjo stopnjo v podatkovnem toku, ki se začenja s **surovimi** in zaključi z **verificiranimi podatki**. Podatke, ki so na merilnih mestih zabeleženi v različnih časovnih intervalih (enkratdnevna opazovanja, petminutne meritve digitalnih merilnikov), posebni algoritmi časovno poenotijo, sočasno pa določijo tudi dnevne minimume in maksimume ter jih zapišejo v tabeli vrednosti in ekstremov. Na delovni ravni operater tudi **pretvori vodostaj v pretok** (H/Q). Pretvorba upošteva veljavno pretočno krivuljo, ki je umerjena s hidrometričnimi meritvami, katerih rezultati so zapisani v zunanjih in internih tabelah.

Po kontroli, usklajevanju in korekciji urnih vrednosti sledi **pretvorba urnih vrednosti v dnevne**. V nasprotju s prejšnjim sistemom, ki je srednje dnevne pretoke določil s pretvorbo H/Q iz dnevnih vodostajev, se v HIDROLOGU srednji dnevni pretoki izračunajo iz urnih pretokov.

Vse podatke ter pretočne krivulje in rezultate izvrednotenih hidrometričnih meritev lahko operater pregleduje v tabelarični ali grafični obliki. Z ustreznimi pravicami, ki mu jih dodeli skrbnik sistema, lahko s posebnimi orodji serije ali posamezne urne in dnevne podatke tudi popravlja. Popravljeni podatki so v podatkovni zbirki posebej označeni, lahko pa jim operater doda tudi tekstovno opombo.

Po zaključenih usklajevanjih se vrednosti in ekstremi v podatkovni zbirki **verificirajo** in jih ni mogoče brisati ali kako drugače spreminjati. Podatke lahko deverificira le skrbnik podatkovne zbirke. V letu 2008 smo verificirali le dnevne vrednosti, postopoma pa bomo vpeljali usklajevanje in verifikacijo na ravni urnih vrednosti, kjer bodo podatki to dopuščali. Verifikacija urnih vrednosti bo sočasno pomenila tudi verifikacijo izvedenih dnevnih vrednosti.

– data from the data loggers are collected in certain time intervals at gauging sites and then copied into the raw data database with a special interface;
– automatic gauging station data enters the database directly through transmission from gauging sites (recorded in external tables of the AGS database).

All raw values are defined in time and space (with links in the data model) and to a certain point controlled and prepared for further processing through the HIDROLOG program. This enables tabular and graphic reviews of raw data, based on which the processor decides which raw data will be used for preparing **hourly operational data at the work level**. At some gauging sites, due to greater reliability and direct control, the water level can be measured with various gauges simultaneously – for example with the radar and pressure probe – thus obtaining several sets of raw data for the same quantity. **Hourly work values** represent the next stage in the data flow starting with **raw** and ending with **verified data**. Data recorded at gauging sites in various time intervals (once daily observations, five-minute measurements using digital gauges) is unified, time-wise, by special algorithms simultaneously defining the daily minimum and maximum values and entering them in the table of values and extremes. At the work level, the operator also converts the water level into discharge (H-Q, stage-discharge). The conversion takes into account the applicable rating curve calibrated with hydrometric measurements, the results of which are recorded in external and internal tables.

The control, harmonisation and correction of hourly values is followed by the **conversion of hourly values to daily values**. Contrary to the previous system, which determined mean daily discharges through the H/Q conversion from daily water levels, HIDROLOG calculates the mean daily discharges from hourly discharges.

All data, rating curves and results of hydrometrical measurements can be reviewed by the operator in tabular or graphic form. With the appropriate rights assigned by the system’s administrator, the operator can also correct datasets or certain hourly and daily data through the application of special instruments. The corrected data is specially marked in the database. A text comment may also be added to the marking by the operator.

Upon completing harmonisation, the values and extremes in the database are verified, meaning they cannot be erased or otherwise altered. Data

Iz verificiranih dnevnih vrednosti lahko zaenkrat v HIDROLOGU izračunamo srednje in značilne letne ter obdobne vrednosti (na primer obdobni srednji letni pretok – sQs), iz verificiranih dnevnih pretokov pa krivuljo trajanja. Vse podatke, ki jih HIDROLOG prikaže v tabelah, lahko tudi izvozimo v formatih xls, pdf ali csv.

Prednosti in nadaljnji razvoj

Tehnologija in trenutna zasnova sistema ponujata številne možnosti za nadaljnji razvoj. V doslej zaključenih fazah smo želeli predvsem prestaviti osnovne delovne operacije Urada, povezane z meritvami v državni hidrološki mreži, v novo programsko okolje. Ne glede na to pa sistem že sedaj prinaša številne novosti delavcem Urada kot tudi uporabnikom hidroloških podatkov. Časovni zamik med meritvami in verifikacijo oziroma objavo podatkov (spletne strani, Hidrološki letopis) se skrajšuje. Tudi verifikacija urnih vrednosti in izračun srednjih dnevnih pretokov iz urnih sta novosti, ki jih prinaša novi sistem, in pomenita kakovostnejše in uporabnejše podatke. Obe izboljšavi sta nekako pričakovani glede na to, da bomo v prihodnjih letih vsaj v podsistemu površinskih voda na vseh vodomernih postajah enkratdnevna opazovanja nadomestili z neprekinjenimi meritvami in vsaj polurnim vzorčenjem. Krajši časovni zamik med izmerjenimi vrednostmi in verificiranimi podatki ter grafična podpora obdelavi podatkov prav tako prispevata k večji kakovosti. Ponujajo pa se nam številne možnosti za nadaljnji razvoj modulov za analizo, zajem in grafične prikaze podatkov.

Oraclov sistem kontroliranih dostopov omogoča varno delo s podatki številnim uporabnikom spletne aplikacije HIDROLOG. V sistem se lahko prijavijo kot najavljeni uporabniki z natančno določenimi pravicami ali kot nenajavljeni gostje, ki podatkov ne morejo spreminjati. Hkrati lahko do podatkovne zbirke HIDROLOGA, v kolikor jim upravitelj zbirke dovoli, dostopajo tudi programi na strani klienta (na primer Access, Excel), pa tudi različne aplikacije, ki se izvajajo v spletnem okolju. Tako lahko verificirane dnevne vrednosti za vodostaje, pretoke, temperaturo vode, vsebnost in transport suspendiranega materiala, ki so shranjeni v HIDROLOGOVI podatkovni zbirki, uporabniki posredno pregledujejo na spletnih straneh ARSO (http://vode.arso.gov.si/hidarhiv/).

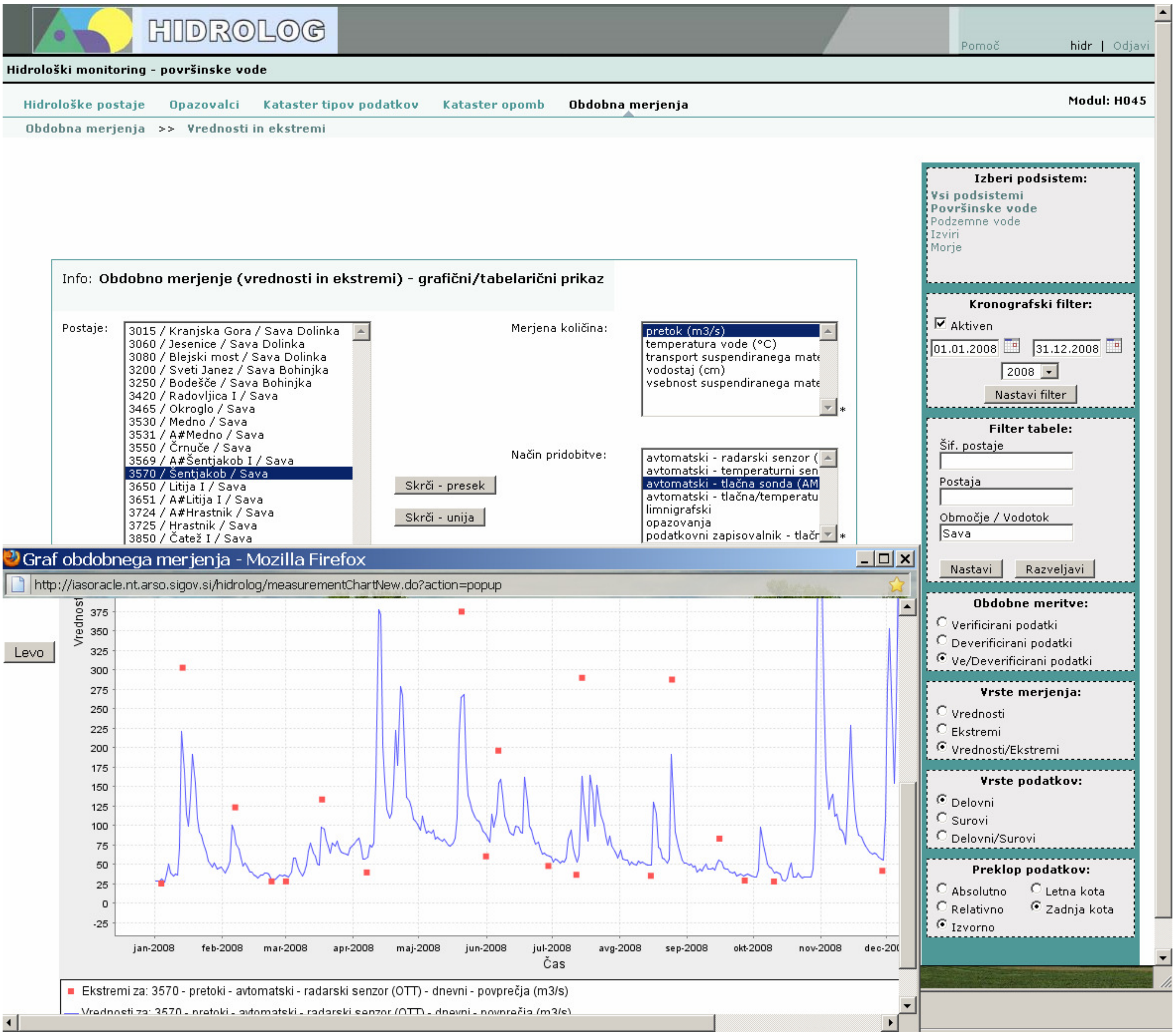
can only be unverified by the database administrator. In 2008 we only verified daily values but gradually we will introduce the harmonisation and verification at the level of hourly values wherever possible. At the same time the verification of hourly values shall also represent the verification of derived daily values.

For now, HIDROLOG enables the calculation of mean and characteristic annual and periodic values (e.g. periodic mean annual discharge – sQs, etc.) from verified daily values, while the duration curve is calculated from verified daily discharges. All the data demonstrated in the tables by HIDROLOG can be exported in .xls, .pdf or .csv format.

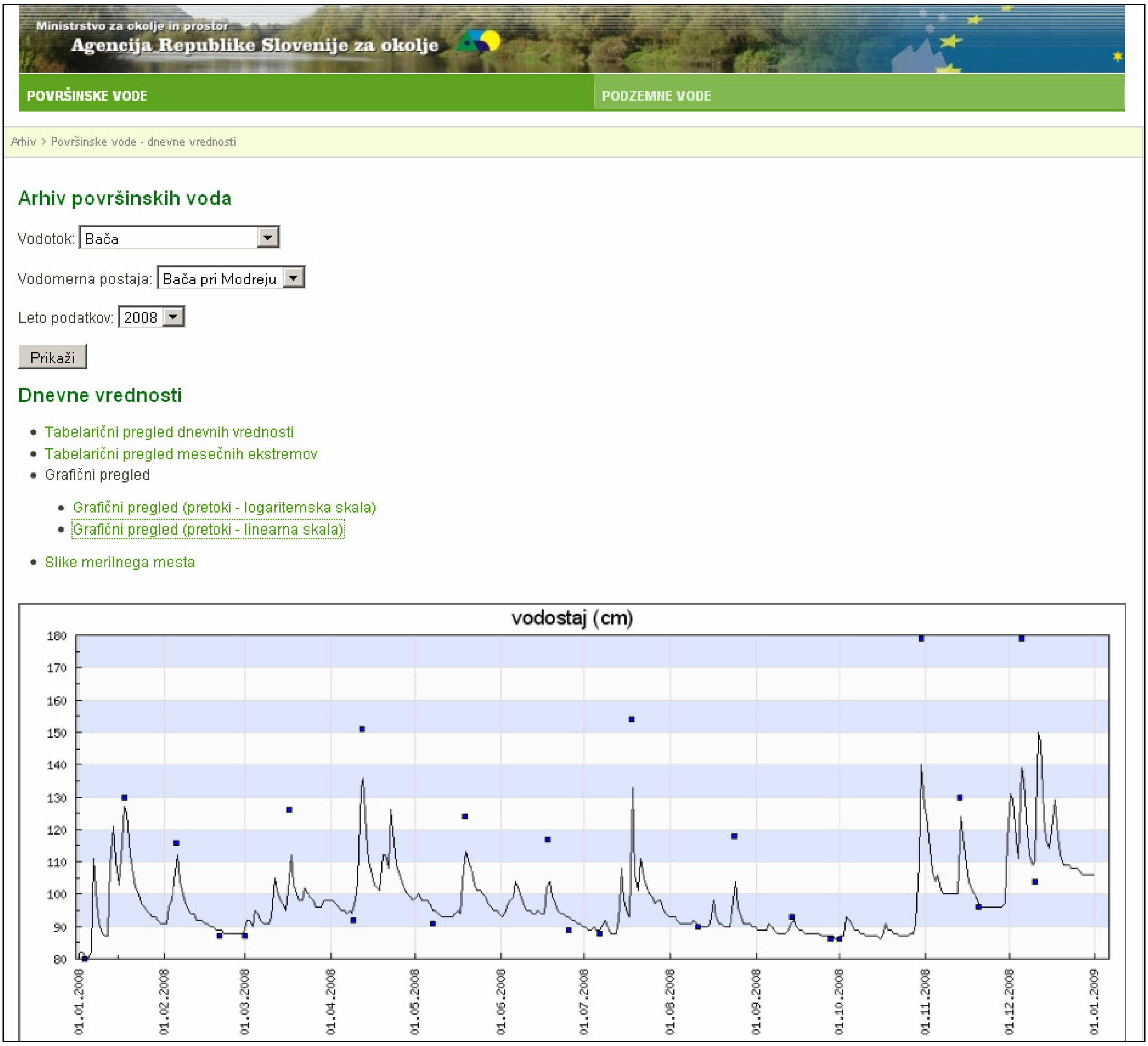
Advantages and further development

The technology and current concept of the system provide a number of opportunities for further development. In the phases completed to date, we mainly wanted to transfer the primary work operations of the Office associated with measurements within the national hydrology service to a new program environment. Regardless of this, the system has already contributed a number of innovations to Office employees as well as to the users of the hydrological data. The time delay between the measurements and the verification or data publication (websites, Hydrological Yearbook) is getting shorter. Also the verification of hourly values and the calculation of mean daily discharges from hourly values are innovations derived from the new system and imply increased quality and usefulness of data. Both improvements are more or less expected, considering that we will replace once-daily observations with continuous measurements and at least half-hour sampling in the next few years at least within the surface water subsystem at all water gauging stations. The shorter time delay between the measured values and verified data and graphic support for data processing also both contribute to greater quality. Several opportunities are arising for further development of modules for analysis, capturing and graphical demonstration of data.

The Oracle system of controlled access enables several users to work safely with data of the web application HIDROLOG. They can enter the system as registered users with precisely defined rights or as unregistered guests who cannot alter the data. At the same time the programs (software) on the client's side (e.g. Access, Excel, etc.) as well as various applications operating in the web environment may access the HIDROLOG database, if allowed access by the administrator. This enables users to indirectly view through the EARS website (http://vode.arso.gov.si/hidarhiv/) verified daily values for water levels, discharges, water temperatures, concentration and transport of suspended material stored in the HIDROLOG database.



Slika 2: Delo v HIDROLOGU
Figure 2: Working in HIDROLOG



Slika 3: Pregledovanje verificiranih dnevnih podatkov iz podatkovne zbirke HIDROLOG na spletnih straneh ARSO (http://vode.arso.gov.si/hidarhiv/)

Figure 3: Reviewing verified daily data from the HIDROLOG database through the EARS website (http://vode.arso.gov.si/hidarhiv/)

PREMEŠČANJE SUSPENDIRANIH SNOVI V SLOVENSKIH REKAH

Mag. Florjana Ulaga

Erozija kot eden od hudih problemov v pokrajini je v Sloveniji močno prisotna. Pod pojmom erozija razumemo spremembe v površinskem sloju zemeljskega površja, ki nastanejo zaradi delovanja padavin, temperaturnih razlik, vetra, naklona reliefa in tekočih voda. Prenos suspendiranega materiala je produkt tega procesa.

Dobra tretjina ozemlja Slovenije je sestavljena iz plazovitih, mehansko neodpornih in nestabilnih glinastih skrilavcev, glinenih usedlin in fliša. Na območju Julijskih Alp in Karavank lahko govorimo o močni hudourniški aktivnosti, na celotnemu območju Slovenije pa o klimatskih razmerah z velikimi temperaturnimi razlikami in pogostimi intenzivnimi padavinami. Poleg naravnih zakonitosti, ki pogojujejo veliko erozijsko ogroženost ozemlja, je ogroženost pogosto povečal tudi človek z nepremišljenim poseganjem v pokrajino. Tako je danes erozija eden najbolj kompleksnih problemov v pokrajini in v gospodarstvu, saj erozijski procesi postopoma uničujejo zemljišče, odnašajo hranilne snovi in spreminjajo vodni režim.

Da bi lažje spremljali potek erozije, ugotavljali njeno intenzivnost in razkrivali njene posledice, se seznanjamo tudi s premeščanjem materiala po rečnem koritu, njegovim zadrževanjem oziroma zastajanjem v strugi, akumuliranjem na večjih rečnih odsekih, ki so posledica tudi človekovega vpliva. S pravilnimi metodami dela, dobrimi laboratorijskimi analizami in premišljeno postavljeno mrežo merilnih postaj lahko ob pravilnem vrednotenju podatkov precej zanesljivo odkrivamo zakonitosti premeščanja plavin, s tem pa tudi vplivamo na lastnosti porečja.

Mreža postaj monitoringa premeščanja suspendiranih snovi v vodi

Začetek monitoringa premeščanja suspendiranih snovi sega, glede na arhivske podatke Agencije, v leto 1955. Najprej smo začeli vzorčiti in izračunavati premeščanje suspendiranih snovi na vodomernih postajah v Radečah in v Šentjakobu na Savi ter v Velikem Širju na Savinji. V naslednjem letu smo začeli izvajati monitoring tudi na Dravi na Ptuju in na Muri v Petanjcih. Temu so sledile uvedbe meritev na vseh večjih vodotokih,

TRANSPORTATION OF SUSPENDED MATERIAL IN SLOVENIAN RIVERS

Florjana Ulaga, MSc

Erosion is a serious issue in the region and is widespread across Slovenia. The term erosion implies changes to the surface layer of the earth's surface caused by rainfall, temperature differences, wind, terrain slopes and running water. The transportation of suspended material is a product of this process.

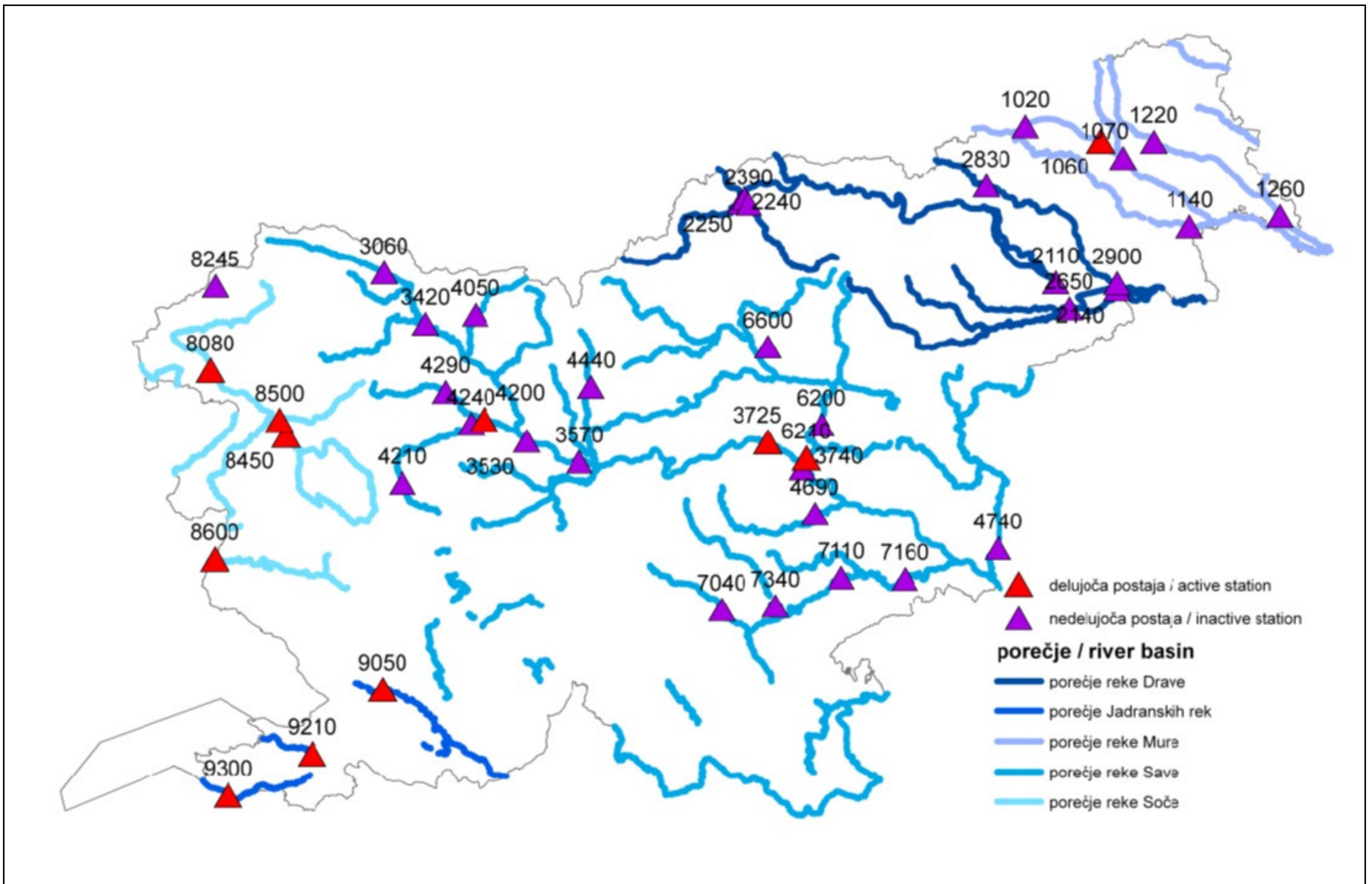
A good third of Slovenia is comprised of landslide, mechanically non-resistant and unstable clay slates, clay sediments (deposit) and flysch. In the region of the Julian Alps and Karavanke Mountain Range strong torrential activity is present, while climate conditions with great temperature amplitudes and frequent intense precipitation are prevalent across Slovenia's territory. In addition to the natural conditions which subject the region to the great threat of erosion, the hazard risk was often also increased by man with his reckless use of land. So erosion is currently a complex issue in the country and a threat to the economy, as erosion processes are gradually destroying land, sweeping away the nutritious substances and altering the water regime.

In order to better monitor the erosion process, identify its intensity and uncover its effects, we also observe the transportation of material through the river bed, its retention in the channel, accumulation on larger river sections, also as a result of human impact. With the correct work methods, good laboratory analyses and well-thought-out placement of the water gauging station network we can reliably identify the characteristics of sediment (debris) transportation upon correct valuation of data and as a result also influence the river basin features.

The network monitoring the transportation of suspended material in water

The beginning of monitoring the transportation of suspended material goes back to 1955 according to the data collected from the Agency's archives. We first began sampling and calculating the transportation of suspended material at the water gauging station in Radeče and Šentjakob on the Sava River, and in Veliko Širje on the Savinja River. The next year we started to perform monitoring also on the Drava River in Ptuj and on the Mura River in Petanjci. This was followed by krajše obdobje pa je odvzem vzorcev potekal tudi na manjših rekah, kot na primer Ložnica, Pesnica, Tržiška Bistrica. Najkasneje smo začeli vzorčiti na rekah jugozahodne Slovenije, na Reki leta 2001, na Dragonji in Rižani pa leta 2006. V 55-letnem nizu je bilo v monitoring skupno vključenih 44 vodomernih postaj. Najdaljši niz spremljanja premeščanja suspendiranih snovi ima Savinja, kjer na vodomerni postaji Veliko Širje izvajamo monitoring že 50 let (slika 2).

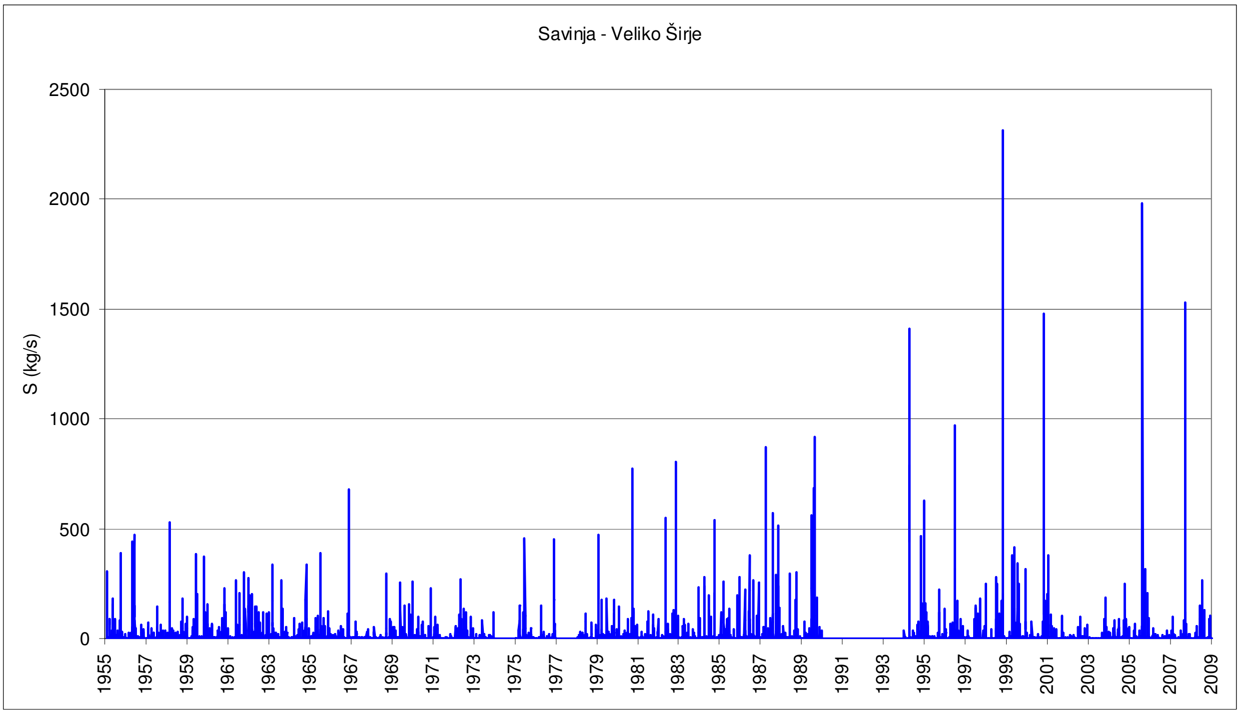
the introduction of measurements on all larger water courses (streams), although for a shorter period sampling also took place on the smaller rivers, e.g. Ložnica, Pesnica, Tržaška Bistrica, etc. We started sampling most recently in the south-western part of Slovenia, on the Reka River in 2001 and on the rivers Dragonja and Rižana in 2006. In the course of 55 consecutive years a total number of 44 water gauging stations were included in the monitoring. The longest period of continuously monitoring the transportation of suspended material was recorded on the Savinja River, where monitoring at the Veliko Širje gauging station has already been carried out for 50 years (Figure 2).



Slika 1: Ukinjene in delujoče postaje monitoringa suspendiranih snovi po porečjih
Figure 1: Terminated and operating stations of the monitoring of suspended material in river basins

Preglednica 1: Število delujočih postaj v petletnem obdobju
Table 1: Number of stations operating in the 5-year period

Obdobje/Period	1955-1959	1960-1964	1965-1969	1970-1974	1975-1979	1980-1984	1985-1989	1990-1994	1995-1999	2000-2004	2005-2008
Št.delujočih postaj/ No.of gauging stations	6	6	8	12	25	16	13	13	15	16	14



Slika 2: Premeščanje suspendiranih snovi v Savinji v Velikem Širju
Figure 2: Transportation of material in the Savinja River at Veliko Širje

Na nekaterih postajah monitoring ni potekal ves čas. Postaja je lahko delovala nekaj let, nato več let ni bilo odvzema vzorcev, kasneje pa so vzorce ponovno odvzemali. Dejansko število let z odvzemom vzorcev je prikazano na sliki 3.

Med postajami monitoringa suspendiranih snovi, ki so delovale v letu 2008, odvzem vzorcev najdlje poteka v Velikem Širju, Gornji Radgoni, Mirnu in Kobaridu.

Med ukinjenimi postajami monitoringa je opazovanje skoraj štiri desetletja potekalo na postajah Radeče in Šentjakob na Savi, vendar so z odvzemom vzorcev prenehali leta 1993 in 1994.

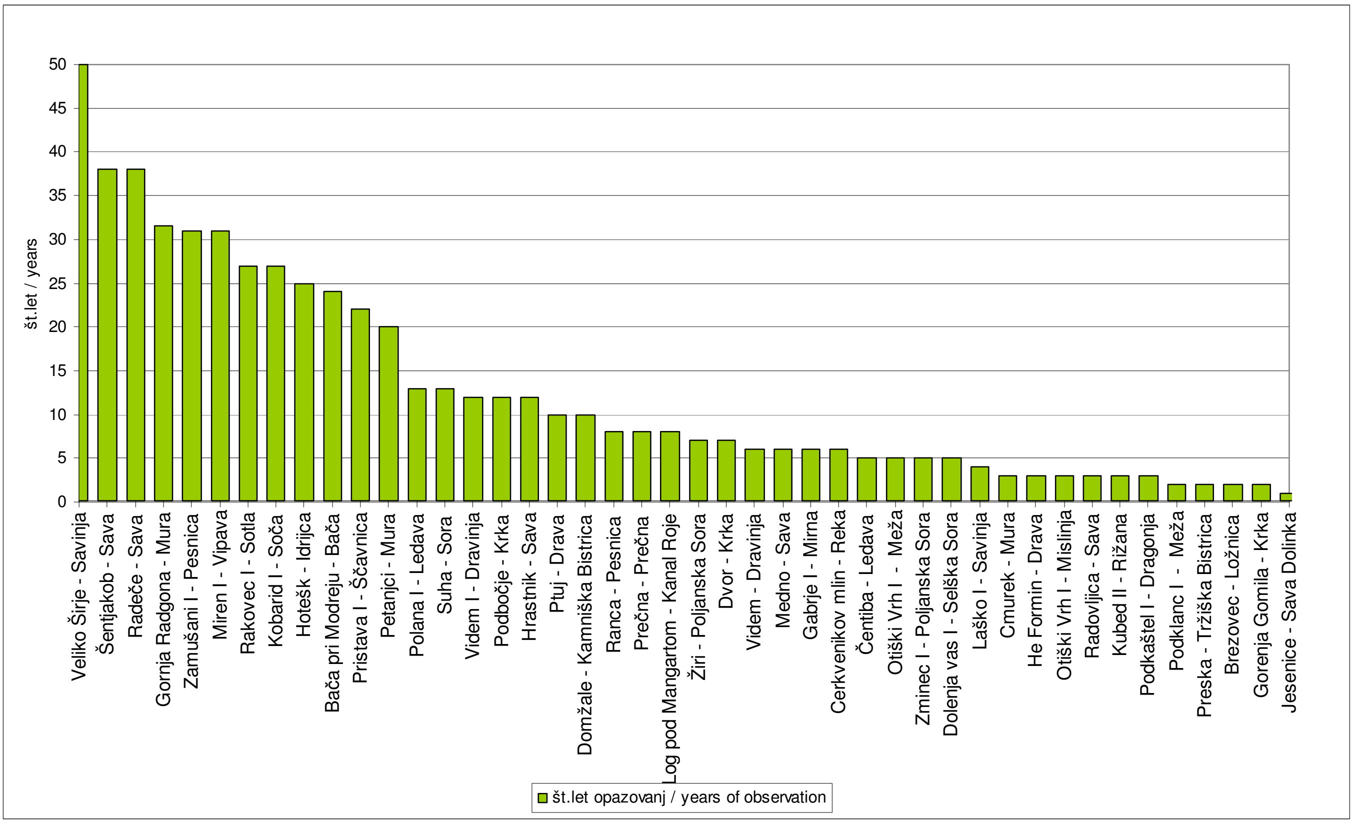
Tri desetletja je monitoring potekal v Zamušanih na Pesnici, 27 let na Sotli v Rakovcu, dobri dve desetletji pa na Ščavnici v Pristavi in v Petanjcih na Muri. Skupno več kot deset let, ponekod z vmesnimi prekinitvami, je monitoring potekal na postajah Polana na Ledavi, Videm na Dravinji in Podbočje na Krki. Na ostalih rekah je monitoring premeščanja suspendiranih snovi potekal le deset let ali manj.

At some stations monitoring was not carried out continuously. A station could have operated for a number of years then stopped sampling for a few years but later started sampling again. Actual number of years of sampling is demonstrated in Figure 3.

Among the stations monitoring suspended material, operating in 2008, sampling was carried out the longest in Veliko Širje, Gornja Radgona, Miren and Kobarid.

Among the terminated monitoring stations observation was carried out for almost four decades at the stations Radeče and Šentjakob on the Sava River; however, sampling ceased in 1993 and 1994.

Monitoring was also carried out for three decades at Zamušani on the Pesnica River, 27 years on the Sotla River in Rakovec, and a little over two decades on the Ščavnica River in Pristava and on the Mura River in Petanjci. Monitoring was carried out collectively for more than 10 years, in some places with intermediate stoppages, at the gauging stations Polana on the Ledava River, Videm on the Dravinja River and Pobočje on the Krka River. On the other rivers, the monitoring of suspended material transportation took place for only 10 years or less.



Slika 3: Število let opazovanj premeščanja suspendiranih snovi na vodomernih postajah
Figure 3: The number of years observing the transportation of suspended material at gauging stations

Preglednica 2: Monitoring suspendiranih snovi v letu 2008
Table 2: Monitoring suspended material in 2008

Šifra *Code*	Postaja *Station*	Začetek *First year*	Let opazovanj *Years of observation*	Prekinitev niza *Interruption of observation*
1060	Gornja Radgona - Mura	1977	32	NP
3725	Hrastnik - Sava	1997	12	NP
4200	Suha - Sora	1974	13	1980-2001
6210	Veliko Širje - Savinja	1955	50	1990-1993
8080	Kobarid I - Soča	1960	27	1977-1998
8450	Hotešk - Idrijca	1978	25	1980-1985
8500	Bača pri Modreju - Bača	1985	24	NP
8600	Miren I - Vipava	1978	31	NP
9050	Cerkvenikov mlin - Reka	2001	6	2004-2005
9210	Kubed II - Rižana	2006	3	NP
9300	Podkaštel I - Dragonja	2006	3	NP

NP - neprekinjen niz / uninterrupted

Preglednica 3: Vodomerne postaje na katerih se je izvajal monitoring suspendiranih snovi
Table 3: Water gauging stations at which monitoring of suspended material took place

Šifra *Code*	Postaja *Station*	Začetek *First year*	Konec *Last year*	Let opazovanj *Years of observation*	Prekinitev niza *Interruption of observation*
1020	Cmurek - Mura	1978	1980	3	NP
1070	Petanjci - Mura	1956	1976	20	1974
1140	Pristava I - Ščavnica	1979	2004	22	NP
1220	Polana I - Ledava	1963	1978	13	1974, 1976, 1977
1260	Čentiba - Ledava	1979	1995	5	1981-1985, 1988-1994
2110	Ptuj - Drava	1956	1965	10	NP
2140	He Formin - Drava	1979	1981	3	NP
2240	Podklanc I - Meža	1979	1980	2	NP
2250	Otiški Vrh I - Meža	1997	2001	5	NP
2390	Otiški Vrh I - Mislinja	1992	2000	3	1994-1999
2650	Videm I - Dravinja	1988	1999	12	NP
2652	Videm - Dravinja	2001	2006	6	NP
2830	Ranca - Pesnica	1967	1975	8	1974
2900	Zamušani I - Pesnica	1967	2004	31	1974,1977,1978,1988,2003
3060	Jesenice - Sava Dolinka	1980	1980	1	NP
3420	Radovljica - Sava	2004	2006	3	NP
3530	Medno - Sava	1997	2002	6	NP
3570	Šentjakob - Sava	1955	1994	38	1974, 1977
3740	Radeče - Sava	1955	1993	38	1974
4050	Preska - Tržiška Bistrica	1978	1979	2	NP
4210	Žiri - Poljanska Sora	1971	1978	7	1973
4240	Zminec I - Poljanska Sora	1974	1981	5	1975, 1976, 1979
4290	Dolenja vas I - Selška Sora	1973	1977	5	NP
4440	Domžale - Kamniška Bistrica	1978	1988	10	1983
4690	Gabrje I - Mirna	1977	1982	6	NP
4740	Rakovec I - Sotla	1978	2006	27	1985, 1996
6200	Laško I - Savinja	1990	1993	4	NP
6600	Brezovec - Ložnica	1958	1959	2	NP
7040	Dvor - Krka	1978	1984	7	NP
7110	Gorenja Gomila - Krka	1978	1979	2	NP
7160	Podbočje - Krka	1977	1987	12	NP
7340	Prečna - Prečna	1978	1985	8	NP
8245	Log pod Mangartom - Kanal Roje	1992	2000	8	1997

NP - neprekinjen niz / uninterrupted

Izvajanje meritev in rezultati analiz

Na Agenciji Republike Slovenije za okolje v okviru monitoringa površinskih voda izvajamo tudi monitoring premeščanja suspendiranega materiala v slovenskih rekah. Cilj spremljanja je izračun skupne količine materiala, ki se premesti prek izbranega mesta v vodotoku v določeni časovni enoti. Dinamiki gibanja plavin v vodi sledimo z merjenjem vsebnosti suspendiranega materiala, iz katere izračunamo premeščanje materiala kot produkt s pretokom vode. Največ materiala se v rekah premesti ob visokih vodah, zato se tudi monitoring izvaja najpogosteje v času visokih voda.

Performing measurements and results of analyses

The Environmental Agency of the Republic of Slovenia, within the monitoring of surface water, also performs the monitoring of suspended material transportation in Slovenian rivers. The objective of the monitoring is to calculate the total volume of material which is transported through the selected site in the water course within certain units of time. The sediment movement dynamic in the water is observed through measuring the concentration of the suspended material, from which we calculate the transportation of material as a product through the water discharge. The

Na podlagi analiz podatkov dolgoletnega niza smo ugotovili, da največja vsebnost suspenza v vodi nastopi pogosto nekoliko pred viškom visokovodnega vala. Zato je tudi predvidevanje količin suspenza zelo težavno. Upoštevati je treba, v katerem delu vodozbirnega zaledja so bile padavine, kakšna je geološka sestava tal na tem območju, predhodno namočenost zemljišča pa tudi čas od zadnjega visokovodnega vala.

Na podlagi poznavanja velikosti porečja lahko ocenimo zniževanje zemeljskega površja v zaledju posamezne postaje. Tako lahko ocenimo, da bi se ob podobnih hidroloških in erozijskih razmerah, kot smo jih zabeležili v 30-letnem obdobju, površje porečja Mure v tisočih letih v povprečju znižalo za 12 mm, Vipave za 16 mm, Savinje pa za 86 mm. Pri interpretaciji teh vrednosti pa ne smemo pozabiti na geološko pestrost zaledja, na selektivnost erozije, na korozijo na kraških območjih ter na kratek niz podatkov in dolgo dobo, ki je potrebna za večino geomorfoloških sprememb.

Največje količine suspendiranega materiala se skozi rečni profil premestijo ob visokovodnem stanju, zato je vzorčenje takrat najbolj pomembno. Pogostnost vzorčenja je torej odvisna od količine padavin oziroma od višine in pretoka vode, prepuščena pa je tudi presoji opazovalca. V izrednih hidroloških razmerah, ko je hitrost vode izjemna ali ko reka prestopi bregove, klasičen ročen odvzem vzorcev pogosto ni mogoč. Tako so največje vsebnosti in količine premeščenega rečnega materiala v resnici lahko še nekoliko večje, kot to lahko ugotovimo z našimi meritvami. Kljub temu so opazovalci v celotnem obdobju opazovanj v veliki večini primerov uspeli odvzeti vzorce vode tudi ob visokih vodah. Največja količina premeščenega suspendiranega materiala v reki je lahko odraz izrednega pretoka ali izredno povečane vsebnosti suspendiranega materiala.

V skladu z letnim Programom hidrološkega monitoringa Agencije in glede na hidrološke razmere smo v preteklosti mrežo monitoringa suspendiranih snovi delili v postaje primarne mreže, kjer se je izvajal dnevni odvzem vzorcev, na primer na Savi v Hrastniku (slika 4), in na postaje sekundarne mreže, kjer so bili vzorci odvzeti le ob izrednem hidrološkem stanju. Na vseh postajah smo večkrat letno sočasno z meritvami pretoka izvajali tudi profilne meritve vsebnosti suspendiranih snovi, ob katerih so bili vzorci odvzeti v več točkah štirih do sedmih vertikal rečnega profila. Na ta način smo dobili podrobnejše informacije o transportu suspendiranih snovi skozi profil vodomerne

greatest amount of material is transported at high-water (flood) levels; therefore monitoring is performed most frequently during high-water levels.

Based on the data analyses through a multi-annual period of time, we found that the highest concentration of suspended material in the water occurred often slightly before the peak of the high-water wave was reached. Thus the prediction of suspended material quantities is very difficult. We have to consider in which part of the drainage basin we would find precipitation, what is the geological structure of the terrain in this area, prior water-drenched land and also the time of the last flood wave.

Based on the knowledge of the volume of the river basin we can estimate the lowering of the land surface in the hinterland of a certain station. Therefore, we can make an assumption that in hydrological and erosion conditions similar to those recorded over the 30-year period, the surface of the Mura, Vipava and Savinja river basins would have been lower on average by 12 mm, 16 mm and 86 mm, respectively. In interpreting these values we cannot forget the geological diversity of the hinterland, erosion selectivity, corrosion on karst areas and the small volume of datasets and long period needed for the majority of the geomorphological changes to occur.

The largest volume of suspended material passing through the river profile is transported at high water levels, so sampling is most significant at that time. The sampling frequency is thus dependent on the precipitation volume or water height and discharge, also being left to the discretion of the observer. In extreme hydrological conditions, when the water velocity reaches extreme levels or when a river overflows its banks, classical manual sampling is often impossible. Thus the highest concentration and volume of transported river material is in fact slightly higher than recorded in our measurements. In spite of this, during the entire period of observation the observers managed to take water samples even at the high water level in most cases. The largest volume of transported suspended material in the river can reflect extreme discharge or an exceptional increase in the concentration of suspended material.

According to the Agency’s annual Program of hydrological monitoring and with regard to hydrological conditions we classified the network of monitoring suspended material in the past into postaje.

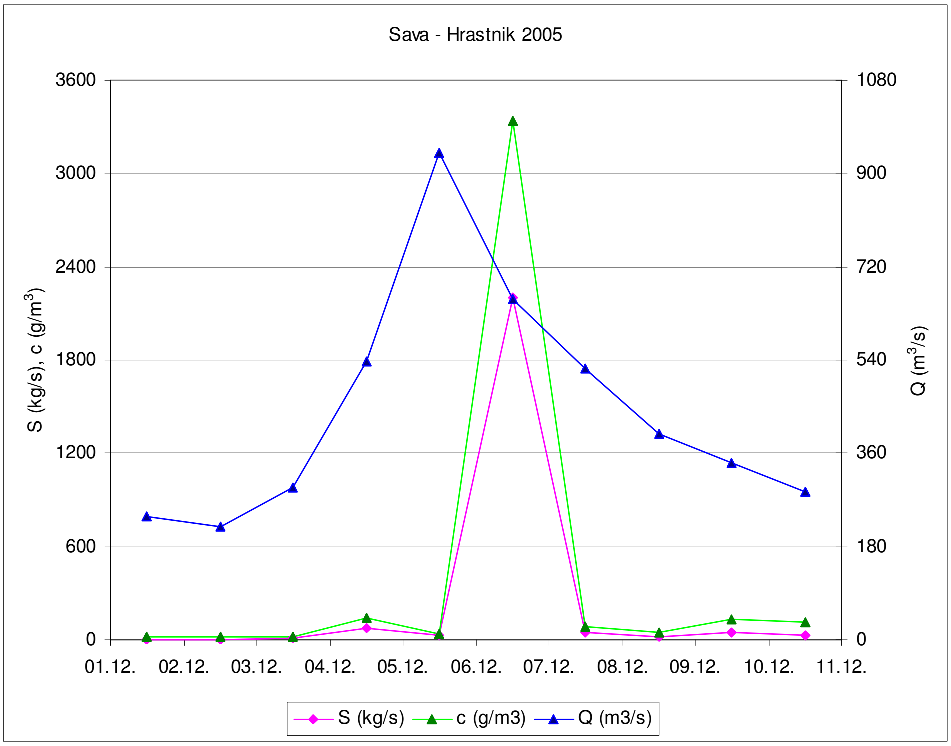
Najmanjše, srednje in največje izmerjene vrednosti v obdobju

Ob nizkovodnem stanju je vsebnost suspendiranih snovi v rekah zelo majhna. Rezultati laboratorijskih analiz odvzetih vzorcev vode izkazujejo, da se ob majhnem pretoku premosti skozi profil reke le 1 g/s. Zato vzorčenje ob nizkovodnem stanju za poznavanje rečnega transporta plavin ni najbolj smotrno. Največ suspendiranih snovi prenese reka ob visoki vodi, torej ob povečani hitrosti vode in seveda tudi večjem pretoku. Tako smo največje vrednosti premeščenega suspendiranega materiala v celotnem obdobju opazovanj izmerili leta 1958 v Muri v Petanjcih, kar 11.658 kg/s (slika 5). Sledijo Sava v Hrastniku, ko smo septembra 2007 v vzorcu izmerili dobrih 7500 kg/s, pa Drava v Ptuju septembra 1965, skoraj 5000 kg/s, Sava v Radečah 3290 kg/s (januarja 1979) in Savinja v Velikem Širju 2300 kg/s (novembra 1998).

primary network stations, where daily sampling was performed, for example in Hrastnik on the Sava River (Figure 4) and secondary network stations, where sampling was carried out only in extreme hydrological conditions. In addition to discharge measurements (stream gauging) several times annually at all stations we also simultaneously performed profile measurements of suspended material concentration where sampling was carried out at several points of the four to seven verticles of the river profile. As a result we obtained detailed information on the transport of suspended material through the profile of the water gauging station.

Minimum, mean and maximum recorded values during the reference period

At a low water level the concentration of suspended material in rivers is very low. The laboratory analyses results of water sampling indicate that at the low discharge only 1 g/s is transported through the river profile. So sampling at low water levels to assess the river transport of debris is not very practical.



Slika 4: Pretok (Q), vsebnost (c) in premeščanje (S) suspendiranega materiala v Hrastniku na Savi

Figure 4: Discharge (Q), concentration (c) and transportation (S) of the suspended material in Hrastnik on the Sava River in 2005

V vseh navedenih primerih je bil na dan zabeležene izredne količine premeščenega materiala močno povečan tudi pretok vode.

Kako izredne so količine prenesenih snovi po reki ob izrednih razmerah, je razvidno tudi iz preglednice 4.

The largest volume of suspended material is transported by the river at high water levels, meaning at the increased water velocity and also increased discharge. So the highest results of transported suspended material during the entire period of observation were

Na postajah z dolgim nizom vsakodnevnega vzorčenja nam izračunane srednje obdobne vrednosti služijo kot kazalnik razumevanja izrednih hidroloških stanj in nihanja parametrov vode.

Zaključek

Ob analizi podatkov več kot 50-letnega obdobja monitoringa premeščanja suspendiranih snovi v vodi smo prišli do zaključka, da se tudi v slovenskih vodotokih bistveni delež plavin premosti skozi rečni profil ob visokovodnih stanjih. S slike 6 je razvidno, da se je skozi profil Mure v Gornji Radgoni leta 2002 premostilo več kot 70 % suspendiranega materiala le v treh visokovodnih stanjih: 21.–26. marca 4 %, 11.–16. avgusta 55 % in 5.–9.decembra 13 %.

Poleg začasne prekinitve izvajanja monitoringa na nekaterih vodotokih, za katere je značilna manjša sposobnost premeščanja rečnih plavin, smo v skladu z ugotovitvami o značilnostih poteka premeščanja suspendiranih snovi zmanjšali tudi pogostnost vzorčenja le na odvzeme vzorcev ob izrednih hidroloških stanjih. S tem smo pripomogli k večji ekonomičnosti hidrološke službe, na podlagi dolgoletnega niza opazovanj in s tem poznavanja hidroloških razmer na vodomernih postajah pa je poročanje o stanju vseeno zadovoljivo. V okviru projekta modernizacije merilne mreže ARSO – *Nadgradnja sistema za spremljanje in analiziranje stanja vodnega okolja v Sloveniji,* se predvideva uvedba avtomatskih merilnikov, s pomočjo katerih bo mogoče stalno spremljanje hidroloških parametrov, med katere sodita tudi vsebnost in premeščanje suspendiranih snovi v vodi. S tem bo kakovost monitoringa večja, omogočen pa bo tudi nadzor nad trenutnim stanjem premeščanja suspendiranih snovi v rekah.

Odvzem vzorcev vode v Cerkvenikovem mlinu na Reki 12. decembra 2008 (foto: Arhiv ARSO)
Water sampling at Cerkvenikov mlin on the Reka River on 12 December 2008 (photo: EARS archives)

recorded in Petanjci on the Mura River in 1958, an incredible 11,658 kg/s (Figure 5). That result is followed by Hrastnik on the Sava River, where in September 2007 we measured slightly above 7,500 kg/s, then Ptuj on the Drava River in September 1965, reaching almost 5,000 kg/s, followed by Radeče on the Sava River at 3,290 kg/s (January 1979) and Veliko Širje on the Savinja River recording 2,300 kg/s (November 1998). In all these instances the water discharge increased significantly on the date of recording the extreme volume of transported material.

The extremity of the volume of the material transported down the river in extreme conditions is demonstrated in Table 4. At stations with a long series of daily sampling, the calculated mean periodical values serve as an indicator explaining the extreme hydrological conditions and oscillation of the water parameters.

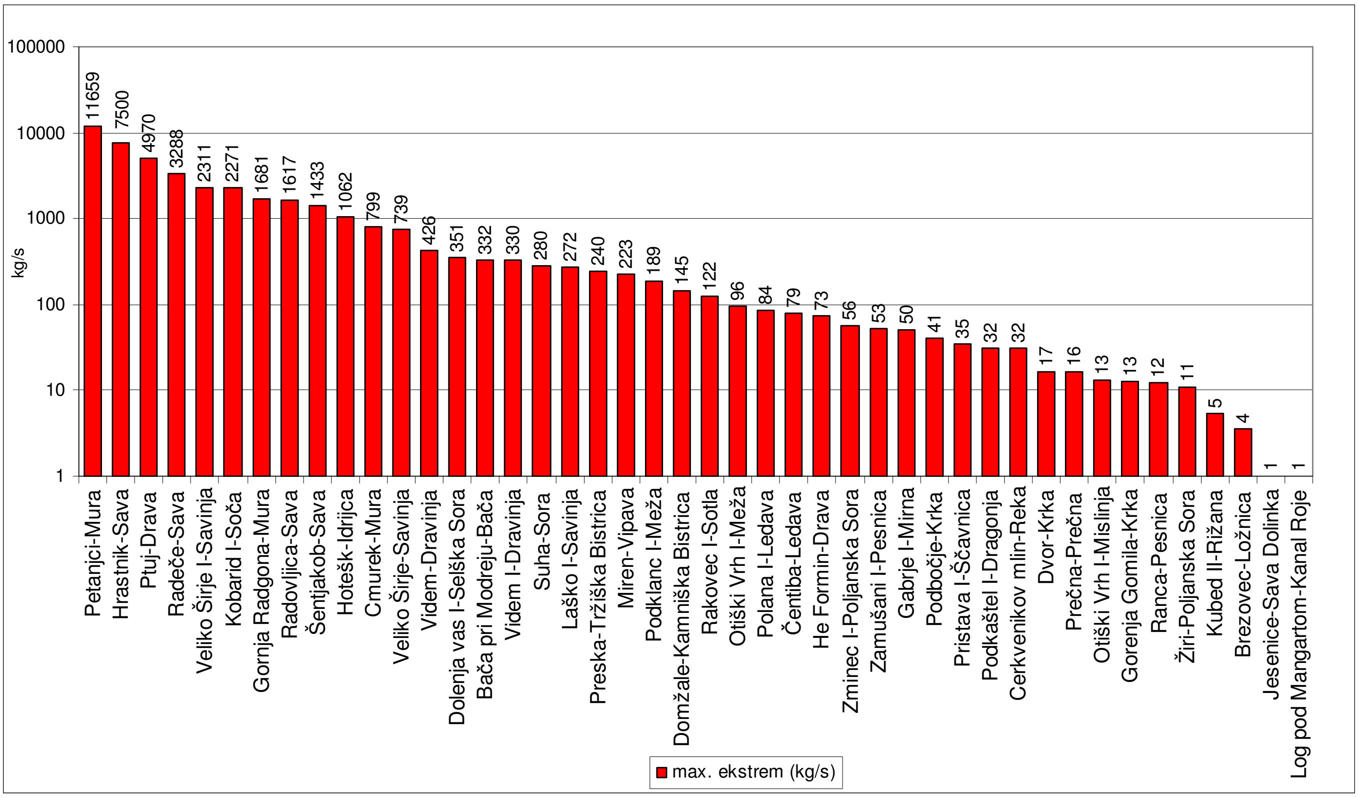
Conclusion

Upon analysing data capturing the transportation of suspended material in water over a monitoring period of over 50 years we concluded that the main portion of debris is transported through the river profile at high water levels in Slovenian watercourses too. Figure 6 clearly demonstrates that more than 70% of suspended material was transported through the profile of the Mura River in Gornja Radgona in 2002 in just three instances of high water conditions: between 21 and 26 March 4%, between 11 August and 16 August 55% and between 5 December and 9 December 13%.

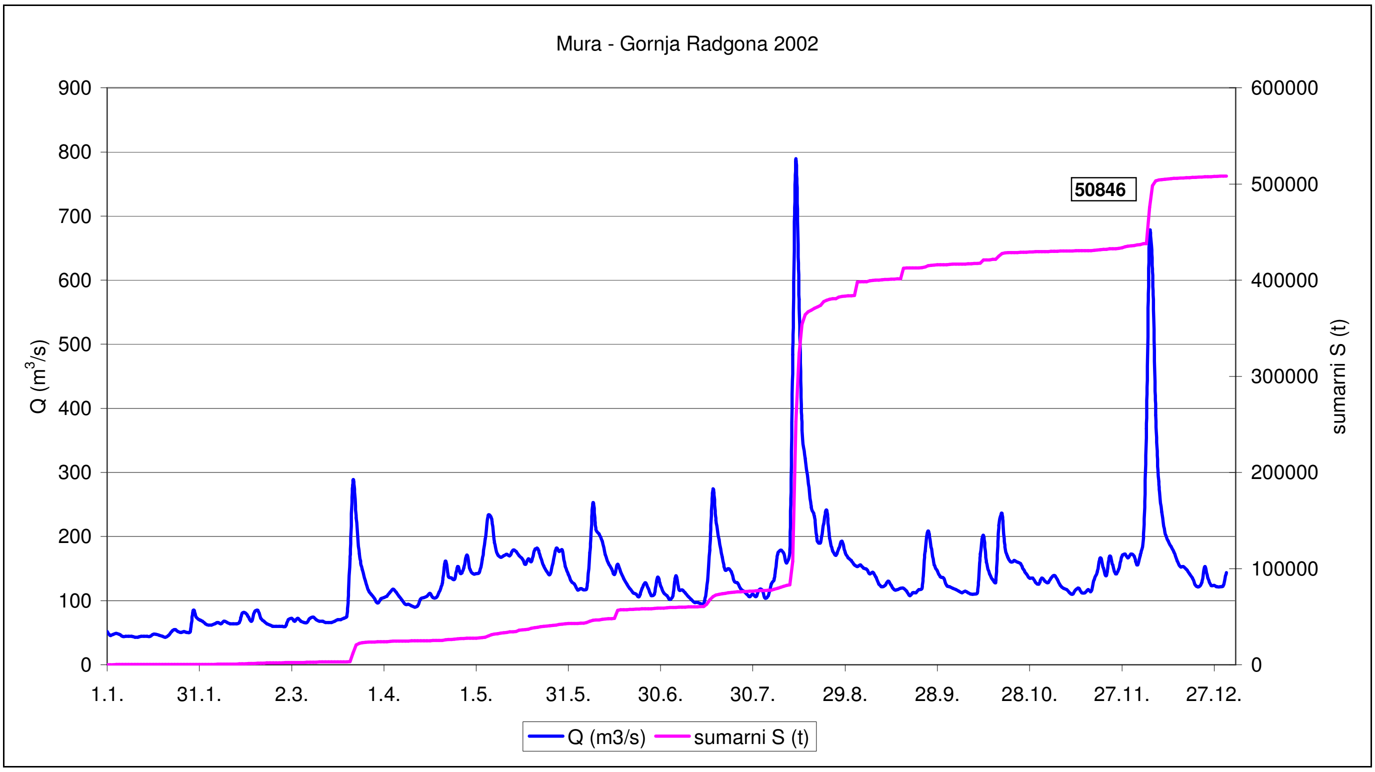
In addition to the temporary suspension of monitoring on some watercourses with a smaller capacity to transport suspended river debris, we also reduced the frequency of sampling to only taking samples in extreme hydrological conditions in line with findings relating to the characteristics of the process of transporting suspended material. By doing this we contributed to the greater economy of the hydrologic service and based on the multi-annual observation series and resulting knowledge of hydrological conditions we also maintained a satisfactory level with regard to reporting these conditions. Within the project modernising the EARS monitoring gauging site network – *Upgrading the system for monitoring and analysing the water environment status in Slovenia*, the introduction of automatic gauges is anticipated, with which the constant monitoring of hydrological parameters shall be possible, also including the concentration and transportation of suspended material in water. This increases the monitoring quality while also enabling supervision over the current conditions related to the transportation of suspended material in rivers.

Preglednica 4: Največje in srednje obdobne vrednosti premeščenega suspendiranega materiala
Table 4: The maximum and mean periodical values of transported suspended material

Vodotok *Stream*	Vodomerna postaja *Gauging station*	Največji letni transport 2008 (kg/s) *The highest annual transport (kg/s)*	Srednji obdobni transport (kg/s) *Mean transport in the period (kg/s)*
Mura	Gornja Radgona	1681	12
Sava	Hrastnik	7500	16
Savinja	Veliko Širje	2311	6



Slika 5: Ekstremne vrednosti premeščenega suspendiranega materiala v rekah
Figure 5: Extreme recorded values (results) of the transported suspended material in rivers



Slika 6: Premeščanje suspendiranih snovi v Gornji Radgoni na Muri v letu 2002
Figure 6: Suspended material transportation in Gornja Radgona on the Mura River in 2002

Otežen odvzem vzorcev vode zaradi naplavin na v.p. Suha na Sori (foto: Florjana Ulaga)
Aggravated sampling on w.g.s. Suha on the Sora River (photo: Florjana Ulaga)