ACTA CARSOLOGICA	31/2	2	61-73	LJUBLJANA 2002

COBISS: 1.01

MULTIPARAMETER OBSERVATIONS OF THE REKA FLOOD PULSE IN MARCH 2000

VEČPARAMETERSKO SPREMLJANJE POPLAVNEGA VALA REKE MARCA 2000

JANJA KOGOVŠEK[1]

[1] Karst Research Institute ZRC SAZU, Titov trg 2, SI-6230 POSTOJNA, SLOVENIA
e-mail: kogovsek@zrc-sazu.si

Prejeto / received: 26. 7. 2002

Izvleček UDK: 556.166:550.4(497.4)

Janja Kogovšek: Večparametersko spremljanje poplavnega vala Reke marca 2000

Podani so rezultati meritev temperature, pH, specifične el. prevodnosti in raztopljenega kisika ter analiz vsebnosti nitratov, o-fosfatov, kloridov, biokemijske in kemijske potrebe po kisiku v poplavnem valu konec marca 2000, ko je pretok Reke pri Cerkvenikovem mlinu porasel s 13,2 na 112 m^3/s. Napravljena je ocena prenosa onesnaženja po merjenih komponentah in primerjava z manjšim poplavnim valom maja 1999.
Ključne besede: hidrokemija, večparameterske meritve, kraška ponikalnica, onesnaževanje, Reka, Slovenija.

Abstract UDC: 556.166:550.4(497.4)

Janja Kogovšek: Multiparameter Observations of the Reka flood pulse in March 2000

This article aims to offer the results of temperature, pH, specific electric conductivity and dissolved oxygen measurements as well as analyses of nitrate, o-phosphate and chloride levels and biochemical and chemical oxygen demand in a flood pulse at the end of March 2000 when the Reka discharge at Cerkvenikov mlin increased from 13.2 to 112 m^3/s. An estimation of pollution transport according to measured components and comparison with a smaller flood pulse in May 1999 are given.
Key words: hydrochemistry, multiparameter measurements, sinking karst stream, pollution, the Reka, Slovenia.

INTRODUCTION

The Reka drains water from a wider inhabited flysch recharge area (Rojšek 1987). Part of water is contributed by karst springs, in particular the Bistrica and Podstenjšek, giving fresh clean water. Rainfall, depending on quantity and intensity, rinses the river-bed of tributaries in the inhabited areas and transports pollution into the main flow of the Reka which later disappears into Škocjanske jame.

In times past the Reka was a clean and rich river. Yet pollution increased to such a degree that in 1966 the Reka catchment for Divača water supply has been suppressed (Mejač et al. 1983). Detailed researches of the »dead« river in 1969-1979 and in 1981-1982 showed that each intensive rain rinses unmitigated pollution from the Reka riverbed and transports it into Škocjanske jame. In spite of dilution a huge increase in COD and BOD_5 were recorded in the Reka. In autumn 1990 the quality of water improved as Factory of Organic Acids in Ilirska Bistrica, the greatest pollutant, was shut down (Kogovšek 1994; Kogovšek & Kranjc 1999). Yet, even today the Reka is polluted by ever-reducing smaller pollutants.

In May 1999 we studied the water pulse of the Reka near Draga waterworks near Dolenje Vreme when the discharge increased from an initial 3.7 m^3/s to its maximal value of 19.3 m^3/s (Kogovšek 2001). Repeated detailed study of flood pulse of the Reka was done in March 2000, when discharge was steadily increasing from an initial value of 13.2 m^3/s to reach the peak of the pulse at a discharge of 112 m^3/s. In situ we measured temperature, specific electric conductivity, pH and dissolved oxygen and in the laboratory of the Karst Research Institute we made additional chemical analyses of samples.

The observations of the Reka flood pulse was done within the UNESCO IHP programme. We also checked the function of the automatic sampler by datalogger (ISCO-B) which was purchased within this programme. Observations of the flood pulse included also velocity measurements by different devices performed by co-operators of the Chair of Hydrology and Hydraulic Engineering of the Faculty of Civil and Geodetic Engineering led by Prof.M.Brily.

THE REKA DISCHARGE DURING THE FLOOD PULSE OBSERVATIONS

After a dry February a substantial rainfall in the first days of March was followed by a longer period without any rain worth mentioning. In the last week of March discharge increased with increasing precipitation. In the days from March 28 to 29 the Reka discharge at Cerkvenikov mlin varied around 13.2 m^3/s until the morning of March 29 when it started to increase, at first slowly and later faster. At two p.m. discharge reached almost 24 m^3/s, and it continued to increase for the next three hours to reach 47 m^3/s. In the following 6 hours the discharge rose to its maximal value of 112 m^3/s. Later discharge diminished relatively evenly and without any substantial fluctuations (Figs. 1, 2 and 3).

DYNAMICS OF SAMPLING, MEASUREMENTS AND USED METHODS

Discharge measurements were performed in the same way as when studying the flood pulse in 1999 at hydrological station Cerkvenikov mlin. Discharge values were calculated by measur-

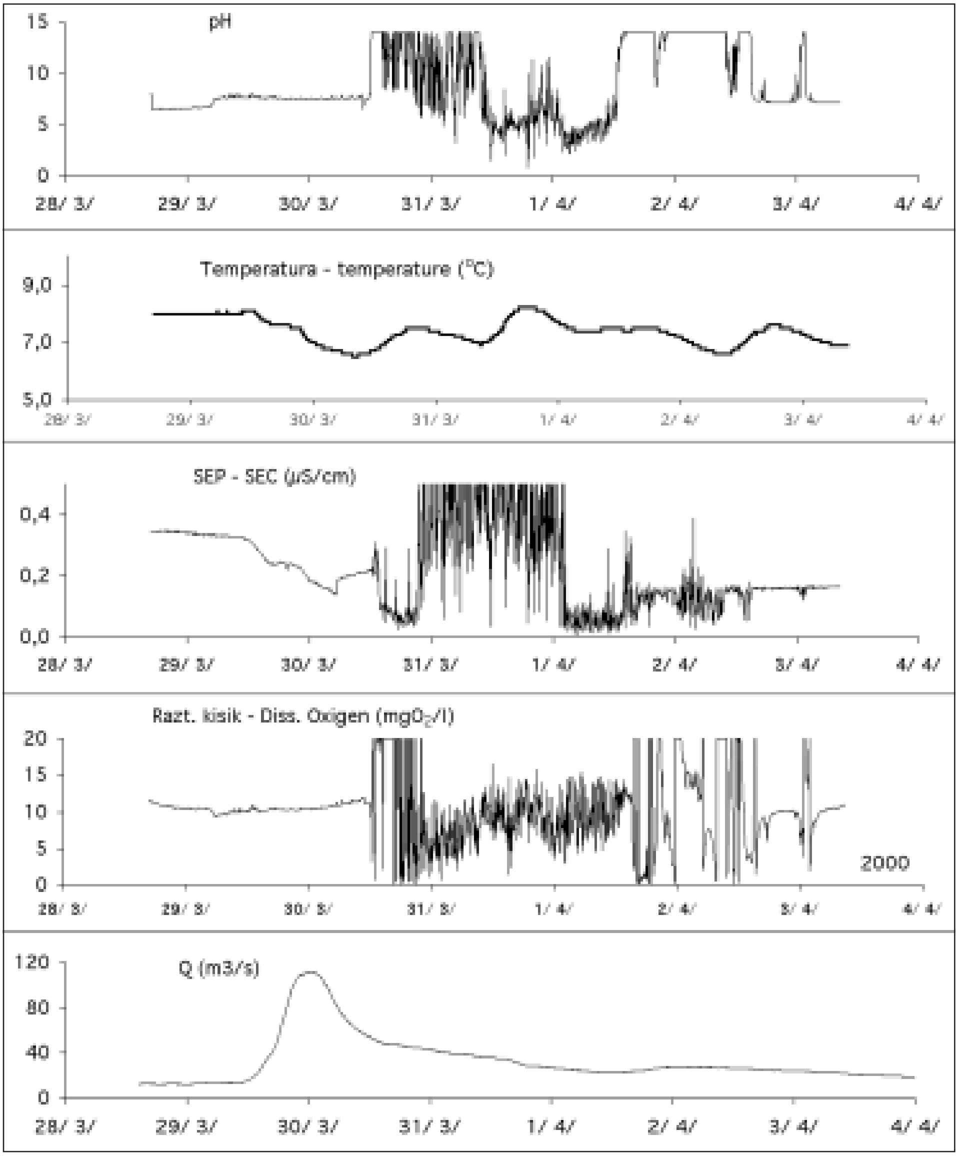

Fig. l: The Reka flood pulse - March 2000: measurements of pH, conductivity and dissolved oxygen by known discharge.

Sl. 1: Poplavni val Reke - marec 2000: Meritve pH, temperature, specifične električne prevodnosti in raztopljenega kisika ob znanem poteku pretoka.

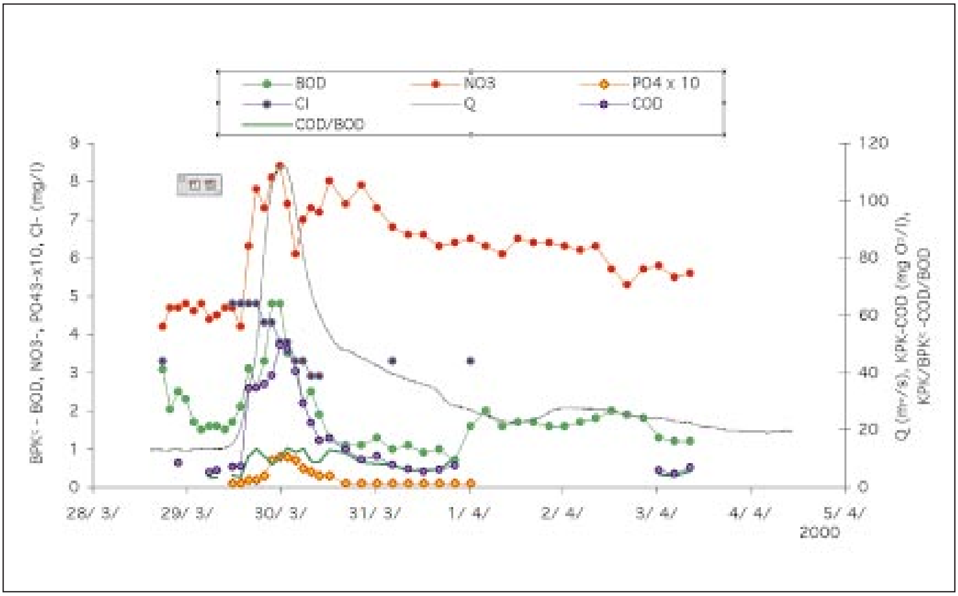

Fig. 2: The Reka flood pulse - March 2000: discharge, nitrate, chloride, o-phosphate, COD and BOD_5 *levels.*
Sl. 2: Poplavni val Reke - marec 2000: pretok, koncentracije nitratov, kloridov, o-fosfatov, KPK in BPK_5*.*

ing the level height each 5 minutes, done by co-operators of the Chair of Hydrology and Hydraulic Engineering of the Faculty of Civil and Geodetic Engineering and curve, done by the Agency of the Republic of Slovenia for Environment. Physical measurements and sampling for chemical analyses were done at the same place as in 1999, near the waterworks of Karst Water-Supply at Vreme.

Temperature, specific electric conductivity (SEC), pH and dissolved oxygen levels were measured every 5 minutes by a combined probe YSI 600. Data were saved on ISCO 6700 - B datalogger with automatic sampler. By March 30 at noon, when the flood pulse had already decreased, the measurements of all the parameters went with a swing. Later difficulties occurred with measuring SEC, pH and dissolved oxygen level. I suppose that measurements were troubled by accumulated alluvial deposits near the probe casing. Temperature measurements got under way without any problems.

Parallel periodical measurements with field thermometer and conductometer LF 597, WTW in comparison with YSI probe showed temperature values lower by 0.3 °C, and measurements of SEC on March 28 and 29 deviated by 2%.

The measurements of pH in the initial stage of observations seem questionable, as pH persisted for 12 hours at values about 6.6 and later, gradually in an hour and a half increased to 7.5. Also a sudden increase in SEC from 140 to 190 µS/cm on March 30 in the morning is surprising. These questions need to be cleared in future in such a way that YSI probe would be comple-

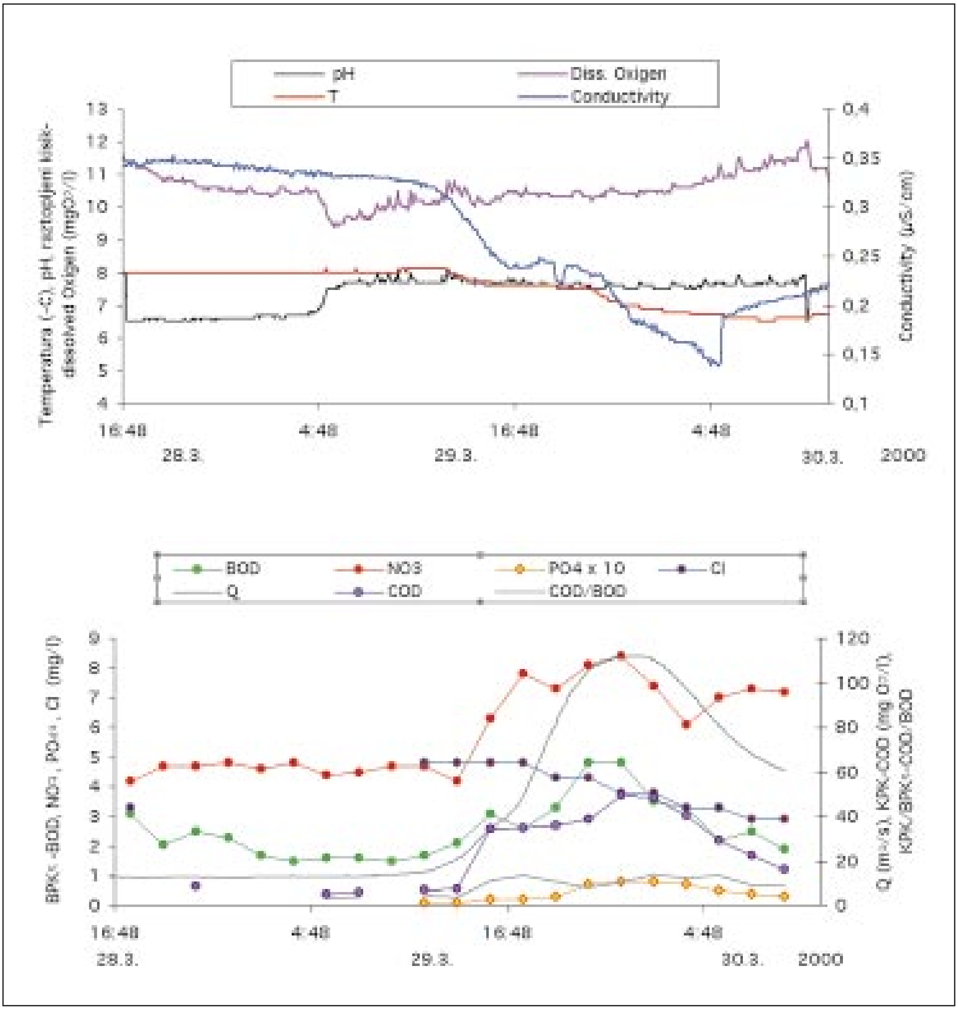

Fig. 3: The Reka flood pulse - March 2000: measurements of temperature pH, conductivity and dissolved oxygen by YSI 600 Sound and chemical analyses of water sampled by ISCO 6700 auto-sampler.

Sl. 3: Poplavni val Reke - marec 2000: meritve temperature, pH, specifične električne prevodnosti in raztopljenega kisika s sondo YSI 600 in kemične analize vodnih vzorcev, ki smo jih zajeli z avtomatskim zajemalnikom ISCO 6700.

mented by parallel measurements. The most reasonable would be additionally to measure SEC and pH of samples by portable devices.

Sampling for chemical analyses did not cause any troubles and all the planned analyses were made. Automatic sampler ISCO 6700 was uniform time paced. Based on the experiences from

May 1999 when we sampled instantaneous samples I decided to sample average or composite samples in the space of two hours. Each sample was composed of four samplings, meaning that sampling took place every half hour. Such was the way of sampling in the central part of the flood pulse, after March 30 samplings were more rare, each hour and four samplings composed one sample. Such mode persisted to the end of sampling on April 3.Altogether 45 samples were taken.

In water samples chloride, nitrate, o-phosphate levels and biochemical (BOD_5) and chemical (COD) oxygen demand were determined; altogether more than 130 chemical analyses were made in the Karst Research Institute laboratory. We started the analyses immediately after the sampling and by suitable choice both of parameters and samples, the most typical of the flood pulse, we succeeded in analysing chosen samples in good time without problems. COD analyses and nitrate levels were determined immediately after transport of samples into the lab (March 30 and April 3); the samples for other analyses were stored in a cool place at about 15 °C. This is why the quality of chemical analyses is this time better than it was for flood pulse in 1999.

We used standard methods (Standard Methods for the Examination of Water and Wastewater 1992). Chloride levels were determined titrimetrically by $Hg(NO_3)_2$, nitrate and o-phosphate spectrophotometrically by sodium salicylat or stannous chloride method. Oxygen level and BOD_5 in original samples was measured by WTW oxymeter Oxi 196, COD was determined from original samples by method with $K_2Cr_2O_7$ in strong acid environment.

RESULTS

Temperature, SEC, pH and dissolved oxygen level measurements

At the beginning of the flood pulse on March 29 the Reka water temperature was 8.0 °C. About noon, when discharge started to increase slowly, it rose for about half an hour to 8.1 °C, and later at discharge decrease the temperature lowered to morning of the next day to reach 6.5 °C (Figs. 1 and 3). In the following days when the flood pulse was in decrease the daily fluctuations were between 6.5 and 8.8 °C.

pH measurements showed a distinctive decrease after the first 15 minutes from 8.0 to 6.6. pH persisted at low values for 12 hours before the flood pulse was entirely formed. I suppose that some disturbances occurred at measurements as other measurements do not show any changes. After 2 hours pH reached 7.7. Smaller fluctuations in pH up to 8.0 followed. During maximal discharge pH decreased to 7.5 and later increased again. As I already mentioned we remained without useful data after March 30.

At the beginning of measurements on March 28 specific electric conductivity (SEC) reached 348 µS/cm and decreased slowly up to March 29 at noon to 318 µS/cm. When discharge was increasing SEC distinctly decreased and at the peak of the flood pulse reached 170 µS/cm. SEC decreased for further three hours to 140 µS/cm and then instantaneously increased to 190 µS/cm. Such a fast and great change cannot be explained by changes in other parameters. As we recorded the minimal SEC value in the 1999 flood pulse at its peak I suppose that measurements in temporal intervals when we recorded the decrease of SEC value from 170 to 140 µS/cm is probably due to thin particles of floating material in the measurement cell and that, in fact, the minimal value of 170 µS/cm was reached in the peak of the pulse. I convinced myself about such a possibility by an experiment in the laboratory.

Up to the morning of March 29 the dissolved oxygen level in the Reka slowly decreased to 10.3 mg O_2/l and then sharply declined to 9.5 mg O_2/l at otherwise steady discharge and temperature. At the same time we recorded the already mentioned well-defined increase in pH. The increase continued up to 11 mg O_2/l, during fluctuations to 0.5 mg O_2/l. During the first distinctive discharge increase the oxygen level declined up to 10.2 mg O_2/l, during the following increase it varied around 10.4 mg O_2/l. In the decrease part of the flood pulse the dissolved oxygen level increased and after 5 hours reached the value 11.8 mg O_2/l, which is more than before the flood pulse.

Transport of nitrates, chlorides and o-phosphates in the flood pulse

Samples were also analysed for nitrate, chloride and o-phosphate levels (Figs. 2 and 3, Table 1). The nitrate level varied between 4.2 and 4.8 mg NO_3^-/l before the flood pulse discharge started to slowly increase. At the same that the discharge increased the nitrate level increased also to reach its highest value of 8.4 mg NO_3^-/l during the maximal discharge. The transport of nitrates lasted much longer than the transport of other substances, like I had found in a flood pulse in May 1999 (Kogovšek 2001). When the discharge was in a substantial decrease, the nitrate level still fluctuated up to 8 mg NO_3^-/l. Only after 30 hours did the nitrate level decrease below 7 mg NO_3^-/l to stay later at a concentration about 6.4 mg NO_3^-/l for more than two days. Only after five days of intensive rinsing by a flood pulse, when discharge reached 23 m^3/s it reached the value of 5.6 mg NO_3^-/l which is still higher than the initial value.

Before the flood pulse the o-phosphate levels were at 0.01 PO_4^{3-}/l. Together with discharge rise the phosphate level rises also; in the middle part of the flood pulse for some 12 hours the value was above 0.05 PO_4^{3-}/l. The maximum recorded value was 0.08 PO_4^{3-}/l. The transition of o-phosphates or their increased concentration was measured for 24 hours in the middle part of the flood pulse.

Chloride levels increased from the first 3.3 mg Cl^-/l at the first discharge increase to 4.8 mg Cl^-/l; when the discharge reached 50 m^3/s it started to decrease slowly and after 12 hours reached the initial value.

The transport of organic pollution, measurements of COD and BOD_5 in a flood pulse

Just before the discharge started to rise the measurements of BOD_5 (Figs. 2 and 3) showed the values below 2 mg O_2/l. At the same time as the discharge increased, BOD_5 increased also and reached the highest value of 4.8 mg O_2/l together the highest values of COD, nitrate, o-phosphate levels when the discharge reached the peak of the pulse. Gradual decrease of values followed when BOD_5 reached in 12 hours 1.3 mg O_2/l and later it fluctuated more than 30 hours around 1 mg O_2/l. In the two following days when discharge decreased below 28 m^3/s this value increased slightly and remained at values slightly below 2 mg O_2/l and then decreased to 1.2 mg O_2/l. I found out that after intensive rinsing of the Reka river-bed and its tributaries a smaller improvement of the Reka occurred in the flood pulse in terms of organic pollution which can be measured by BOD_5 in comparison with the situation before the flood pulse.

A similar picture of organic pollution transport showed in recording of COD. Values of measurements at starting point were below 6 mg O_2/l. After the first fast discharge increase in the afternoon hours of March 29 the COD value suddenly increased to 35 mg O_2/l. Later it increased gently and the highest value (50 mg O_2/l) was reached in the peak of the flood pulse. Steady decrease together with discharge decrease followed. After two days the initial value was reached at the Reka discharge of 36 m^3/s. At the end of observations, on the sixth days of the flood pulse, the value remained unchanged (Table 1).

Ratio COD/BOD_5 shows the ratio of barely degradable organic pollution in comparison with biochemical degradable pollution. Before the flood pulse the COD/BOD_5 values fluctuated around 3.5 mg O_2/l. During the first discharge increase there were no substantial changes, but when the Reka discharge increased more, the rate augmented faster and at the discharge of 50 m^3/s reached the value of 13.4. During the further discharge increase the rate fluctuated slightly and reached in the peak of the flood pulse its highest value of 13.8. When discharge decreased this value decreased only slowly and reached after two days the values about 6.0 and after additional two days the COD/BOD_5 values reached the initial value recorded before the flood pulse.

The rinsing of organic pollution until the initial state was re-established took five days. The curve COD/BOD_5 reflects different dynamics of degradable and barely degradable organic pollution from different parts of the Reka recharge area.

Quantitative transport of pollution components

In 24 hours the major organic pollution occurred in the medium part of the flood pulse, measured by COD/BOD_5 and o-phosphate and nitrate levels (Fig. 4). The calculation of single substances was done from known discharges and measured concentrations for a given time interval. As in May 1999, this time also the nitrate transport lasted substantially longer than the trans-

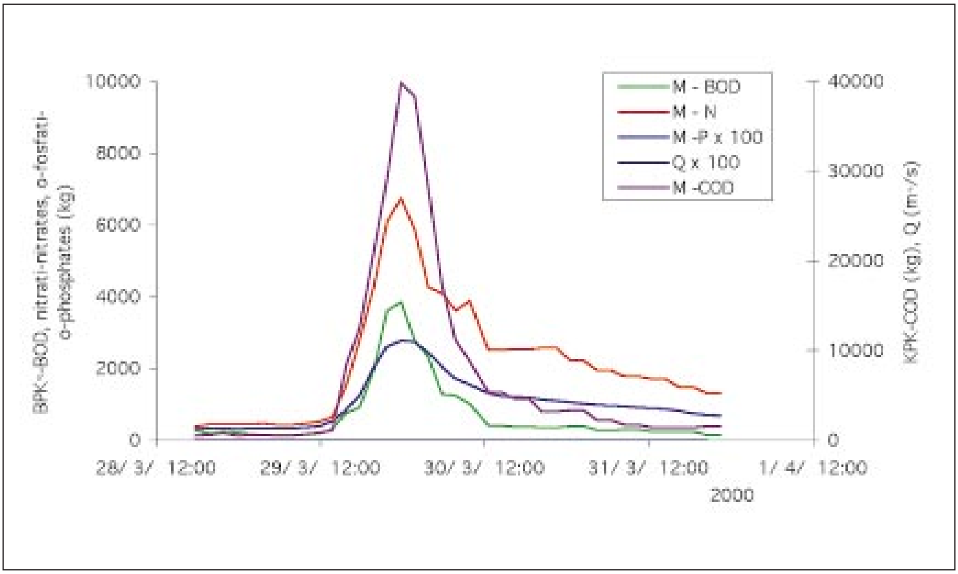

Fig. 4: The Reka flood pulse - March 2000: quantity transport (2-hours amount) of nitrate, o-phosphate, biochemical degradable (BOD_5) and chemical degradable (COD) pollution.
Sl. 4: Poplavni val Reke marca 2000: količinski prenos (2-urne količine) nitratov, o-fosfatov, biokemijsko razgradljivega (BPK_5) in kemijsko razgradljivega (KPK) onesnaženja.

port of other substances. After the fifth day of the flood pulse we still recorded elevated values of nitrate levels while o-phosphate, COD and BOD_5 already reached the initial or even lower values.

Before the flood pulse at the discharge of 13.2 m^3/s the Reka transported underground in one hour about 220 kg of nitrate (NO_3^-), 0.5 kg o-phosphate (PO_4^{3-}), biochemical degradable organic pollution (BOD_5) was an equivalent of 70 kg O_2, while barely degradable organic pollution (COD) equivalent of 280 kg O_2. In the peak of the flood pulse these values were essentially higher: there were 17 times more nitrates, 64 times more o-phosphates, 27 times more (BOD_5) biochemical degradable organic pollution and 70 times more barely degradable (COD) organic pollution. Particularly distinctive was augmented transport of barely degradable organic pollution which needs for its decay underground much more time and thus can be transported for longer distances.

In the peak of the flood pulse we recorded decline in nitrate level concentration probably due to high dilution and not to possibility that rain effectively dewatered nitrates from the recharge area; at the end of the observations the nitrate level still did not return to initial value as did other observed parameters.

In two days the flood pulse rinsed and transported underground additional 28 t of nitrates and 280 kg o-phosphates. The quantity of hardly degradable organic pollution (referring to COD measurements) reached 200 t O_2, the quantity of biochemical degradable pollution (referring to BOD_5) was 7 t O_2. In the flood pulse in May 1999 these values were perceivably lower, 5.7 t nitrates and about 40 kg o-phosphates.

Statements - comparison with the flood pulse in May 1999

Abundant and intensive rainfall at the end of March 2000 caused a maximal discharge 9 times its initial value. This is why the rinsing in the entire Reka recharge area was still more intensive and formation of the flood pulse was much more distinctive than in May 1999 when discharge augmented 5 times only.

Compared to the smaller flood pulse in May 1999 when in 3 days 3.3 10^6 m^3 of water flowed through the observation point at the Reka, in March 2000 in two days and a half 4 times more water (12. 10^6 m^3) flowed through the flood pulse.

Compared to the flood pulse in May 1999 we recorded in March 2000 higher maximum values at single parameters showing a more thorough dewatering of the recharge area. Nitrate levels reached the concentration of 8.3 mg NO_3^-/l, in May 1999 only 6.9 mg NO_3^-/l; o-phosphates 0.08 mg PO_4^{3-}/l, in May 1999 0.05 mg PO_4^{3-}/l; but, the initial value of o-phosphates in May 1999 was 0.06 mg PO_4^{3-}/l. COD values augmented in March 2000 to 50 mg O_2/l, slightly lower values, up to 46 mg O_2/l were recorded in May 1999 (Table 1).

Before the flood pulse in May 1999 the Reka transported underground every hour 50 kg of nitrate and 0.8 kg of o-phosphate, while in March 2000 220 kg of nitrate and 0.5 kg of o-phosphate. In the peak of the flood pulse these values were substantially higher: in May 1999 8 times more nitrates and 7 times more o-phosphates; in March 2000 17 times more nitrates and 64 times more o-phosphates.

The March 2000 flood pulse transported underground an additional 28 t of nitrates, which is 5 times more than in May 1999. I found out that the substances transport is proportional to water quantity, in other words, the more intensive and abundant the rainfall the more thorough is the rinsing of the polluted Reka recharge area, depending also on hydrological circumstances before the flood pulse which influence the accumulation of pollution in the Reka river-bed in longer periods of low water. The dilution effects probably occur at extremely high discharge only, or during a high flood pulse following several previous pulses.

Table 1: Minimal and maximal concentrations of measured parameters of flood pulses in May 1999 and March 2000.
Tabela 1: Minimalne oz. izhodne in maksimalne koncentracije merjenih parametrov v poplavnih valovih marca 1999 in maja 2000.

	Q	nitrati nitrates	o-fosfati o-phosphates	KPK COD	BPK_5 BOD	KPK/BPK_5 COD/BOD
Water pulse 5/99 - Val 5/99	m^3/s	mg/l	mg/l	mg/l	mg/l	
Min. values - izhodne vrednosti	3.7	3.9	0.06	5	1.5	
Max. values - največje vrednosti	19.3	6.9	0.05	46	3.2	
Water pulse 3/00 - Val 3/00						
Min. values - izhodne vrednosti	13.2	4.5	0.01	6	1.7	3.5
Max. values - največje vrednosti	112	8.4	0.08	50	4.8	13.8

CONCLUSIONS

Measurements and analyses of the Reka water during a major flood pulse when the discharge from initial 13.2 m^3/s increased to maximal value of 112 m^3/s showed a stronger transport of substances than was the case in a smaller flood pulse in May 1999. The pollution transport depends also on accumulated pollution in a recharge area which depends on hydrologic condition before a flood pulse. In our case abundant rainfall occurred three weeks before the observed flood pulse and later there were no substantial rain. In the year 1981 when the Reka, referring to previous researches, was polluted at the major daily degree (Ilirska Bistrica), 95% on account of Lesonit and Organic Acids Factory, this pollution was from 30 to 36 t/day of COD and from 17 to 22 t/day of BOD_5 (Mejač et al. 1983). Before the flood pulse in March 2000 on average 7 t of COD and 1.7 t of BOD_5 per day flowed underground. Yet we measured substantially higher substances transport in the central part of the flood pulse, in time of 24 hours, which later continued intensively for one day and a half. The estimation of daily transport of COD in the flood pulse of March 2000 is in average 80 t and BOD_5 2.8 t.

Maximal measured concentration of nitrate levels in the flood pulse of March 2000 was 8.4 mg NO_3^-/l, and 0.08 mg PO_4^{3-}/l; these values are higher than the ones in the flood pulse of May 1999. The maximum value of BOD_5 was 4.8 mg O_2/l and COD 50 mg O_2/l. The flood pulse rinsed and transported underground an additional 28 t of nitrates, 280 kg o-phosphates and the quantity of hardly degradable organic pollution (according to COD measurements) reached 200 t O_2 and the quantity of biochemical degradable pollution (according to BOD_5) was 7 t O_2.

Obviously a complete rinsing of pollution in the wider Reka recharge area occurs after abundant and intensive rain. In spite of high discharges of the Reka the dilution effect did not find expression only slightly at nitrate levels. Maybe we can expect dilution effects at the highest Reka discharge which could be shown by suitable measurements only. After only five days, when discharge decreased to 23 m^3/s the o-phosphate level and COD and BOD_5 reached the initial or even lower values, with exception of nitrate levels where increased concentrations were recorded, similar as in the May 1999 flood pulse.

REFERENCES

Kogovšek, 1994: Impact of human activity on Škocjanske jame. Acta carsologica, 23, 73-80, Ljubljana.

Kogovšek, J., 2001: Opazovanje poplavnega vala Reke maja 1999. Acta carsologica, 30, 55-68, Ljubljana.

Kogovšek J. & A. Kranjc, 1999: Pollution by surface water: The Reka River: v Drew, D. (ed) & H. Hötzl (ed.) Karst Hydrogeology and Human Activities, Impacts, Consequences and Implications. 148-153, Rotterdam.

Mejač, B., Roš, M., Dular, M., Rejic, M. & Ponikvar-Zorko, P., 1983: Onesnaževanje Notranjske Reke. Med. simp. »Zaščita Krasa ob 160-letnici tur. raz. Škocjanskih jam«, 48-51, Sežana.

Rojšek, D., 1987: Fizičnogeografske značilnosti in naravne znamenitosti porečja Notranjske Reke. Varstvo narave, 13, 5-24, Ljubljana.

Hidrološki letopis Slovenije, 1998, 9, 61, Hidrometeorološki zavod Slovenije, Ljubljana.

Standard Methods for the Examination of Water and Wastewater, 1992, 18th Edition, American Public Health Association.

VEČPARAMETERSKO SPREMLJANJE POPLAVNEGA VALA REKE MARCA 2000

Povzetek

Zaledje Reke obsega 442 km^2 ozemlja (Rojšek 1987), ki ga grade flišne kamnine in pomeni površinske dotoke ter dva pomembnejša dotoka z bližnjega kraškega sveta, Bistrico in Podstenjšek. Srednji pretok Reke je v letu 1998 znašal 5,9 m^3/s, minimalni 0,895 m^3/s in maksimalni 161 m^3/s (Hidrološki letopis Slovenije 2000). Reka ponika v Škocjanske jame in se ponovno pojavi po 41 km podzemne poti na izvirih Timava. Na kakovost Reke vplivajo dotoki onesnažene komunalne in industrijske odpadne vode Ilirske Bistrice in drugih naselij.

Maja 1999 (Kogovšek 2001) in nato še v v času od 28. marca do 3. aprila 2000 smo z meritvami in kemičnimi analizami Reke v poplavnem valu po izdatnejših padavinah preučevali sestavo njene vode in prenos onesnaženja v kraško podzemlje. Poleg meritev temperature, specifične električne prevodnosti, pH in raztopljenega kisika, ki smo jih merili »in situ«, smo zajemali tudi vzorce za kemične analize in jih analizirali v laboratoriju Inštituta za raziskovanje krasa.

V osrednjem delu poplavnega vala marca 2000 je steklo kar 4-krat več vode kakor osrednjem delu poplavnega vala maja 1999.

Upadanje SEP (Sl. 1) in naraščanje vrednosti nitratov, o-fosfatov, KPK in BPK_5 ob naraščanju pretoka Reke kaže na naraščujoč dotok predvsem površinskih dotokov, ki spirajo onesnaženje iz

zaledja. Podobno kot se je oblikoval poplavni val, so se oblikovale tudi krivulje prenosa nitratov, o-fosfatov, KPK in BPK_5, ki so maksimalne vrednosti dosegle v vrhu poplavnega vala. Maksimalna izmerjena koncentracija nitratov je bila 8,6 mg NO_3^-/l, o-fosfatov 0,08 mg PO_4^{3-}/l, BPK_5 4,8 mg O_2/l in KPK 50 mg O_2/l (Tabela 1, Sl. 2, 3).

Reka je pred začetkom poplavnega vala ob pretoku 13,2 m^3/s odnašala v eni uri v podzemlje okoli 220 kg nitratov (NO_3^-), 0,5 kg o-fosfatov (PO_4^{3-}), biokemijsko razgradljivega organskega onesnaženja (BPK_5) ekvivalentno 70 kg O_2, teže razgradljivega organskega onesnaženja (KPK) pa je bilo ekvivalentno 280 kg O_2. V vrhu poplavnega vala pa so bile te vrednosti opazno višje: nitratov je prenašala 17-krat več, o-fosfatov 64-krat več, biokemijsko (BPK_5) razgradljivega organskega onesnaženja 27-krat več in teže razgradljivega organskega (KPK) onesnaženja kar 70-krat več (Sl. 4). Predvsem izstopa povečan prenos teže razgradljivega organskega onesnaženja, ki se pri svojem nadaljnjem podzemnem toku le počasi razgrajuje do mineralnih komponent in se tako lahko prenaša na večje razdalje.

Poplavni val marca 2000 je v kraško podzemlje odnesel dodatnih 28 t nitratov, kar je 5-krat več kot maja 1999. Ugotavljam, da je prenos snovi sorazmeren količini vode, oz. da intenzivnejše in izdatnejše padavine popolneje spirajo onesnaženo zaledje Reke, ki je odvisno tudi od hidroloških razmer pred oblikovanjem poplavnega vala, ko se v strugi lahko akumulira različna količina onesnaženja. Verjetno razredčevalni učinki nastopijo šele pri ekstremno visokih pretokih oz. velikih poplavnih valovih.

Šele po petih dneh intenzivnega spiranja v poplavnem valu, ko je pretok upadel na 23 m^3/s, so se vrednosti merjenih parametrov vrnile na izhodne ali celo nižje vrednosti, razen nitratov, za katere smo že maja 1999 ugotavljali dalj časa trajajoči prenos.