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MONITORING THE MALENŠČICA WATER PULSE BY SEVERAL PARAMETERS IN NOVEMBER 1997

VEČPARAMETERSKO SPREMLJANJE VODNEGA VALA MALENŠČICE NOVEMBRA 1997

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Janja Kogovšek: Večparametersko spremljanje vodnega vala Malenščice novembra 1997

Podani so rezultati opazovanj vodnega vala Malenščice pri Planini po prvih intenzivnih in izdatnih jesenskih padavinah novembra 1997. V času, ko se je pretok z minimalnega letnega pretoka povečal do maksimalnega letnega pretoka 10 m^3/s so bili v črpalnem zajetju na izviru z dataloggerjem merjeni nivo vode, temperatura in spec. el. prevodnost. Vzporedno je bila vzorčevana voda za pogoste določitve vsebnosti karbonatov, kalcija, magnezija, nitratov, kloridov, sulfatov in o-fosfatov, spremljano pa je bilo tudi iztekanje zastalega uranina po njegovem injiciranju junija 1997 na Počku. Rezultati kažejo, da v Malenščico najprej doteka stara voda iz prepustnejšega dela zaledja Javornikov, ki se mu kasneje pridruži še iztekanje iz slabše prepustnega dela in iztekanje infiltriranih padavin. Temu dotoku se pridružuje dotok sekundarnih dotokov, ki v začetnem delu pomeni pomemben prenos onesnaženja ob spiranju korit vodotokov. Kasneje pomeni dotok akumulirane vode s Cerkniškega polja oz. jezera pomemben stalen dotok Malenščice, ki ga do konca novembra lepo nakazuje temperatura Malenščice.
Ključne besede: krasoslovje, kraški izvir, vodni val, sledenje z naravnimi in umetnimi sledili, Slovenija.

Abstract UDC: 556.3(497.4)

Janja Kogovšek: Monitoring the Malenščica water pulse by several parameters in November 1997

The results of single event observations of the Malenščica near Planina after the first intensive and abundant autumn rain in November 1997 are given. In the time when the discharge from minimal annual value increased to maximal annual discharge of 10 m^3/s the water level, temperature and specific electric conductivity were measured in pumping reservoir at the spring by datalogger. At the same time the water was sampled to define carbonate, calcium, magnesium, nitrate, chloride, sulphate and o-phosphate levels as well as measurements of Uranin which remained at its injection in June 1997 of water tracing at Poček. The results show that the old water from the more permeable part of the Javorniki recharge area reach the Malenščica first followed later by water from the less permeable part and by infiltrated rain. This inflow is complemented by secondary inflow which in the initial part means an important pollution transport when the riverbeds are rinsed. Later the accumulated water from Cerkniško jezero represents an important, rather permanent inflow to the Malenščica which is indicated by the Malenščica temperature up to the end of November.
Key words: karstology, karst spring, water pulse, water tracing by natural and artificial tracers, Slovenia.

INTRODUCTION

Water tracing in Velika Karlovica in April 1964 (Gams 1965) when Uranin was injected, showed that waters from Cerkniško polje flow towards the Malenščica also. The swallow-holes at Jamski zaliv (The Cave's Bay) in the NW part of Cerkniško polje are reached by waters of the Cerkniščica and during high water level by Stržen also; in dry conditions in winter and summer the last one disappears through the floor swallow-holes in the central part of the polje. The waste waters of Cerknica flow into the Cerkniščica; these waters were more or less treated by a smaller water treatment plant near Dolenja vas. This plant was restored in 1998. The lowest water of the Cerkniščica and Stržen, if they reach Jamski zaliv, disappear in Svinjska jama cave and in nearby lateral swallow-holes. When inflow increases these swallow-holes are no more capable swallowing up all the water and the water level rises to disappear through higher-lying Mala Karlovica and later through Velika Karlovica. These waters, supplemented in Rakov Škocjan by waters from the Javorniki Mt. flow towards Planinsko polje.

The water tracing in August 1988, when Uranin was injected into swallow-hole in the Pivka riverbed near Trnje, showed that waters from this area, when they reach the swallow-hole, flow towards the Malenščica also (Habič 1989). Waste waters from Pivka flowing into the Pivka disappear in the riverbed before reaching the swallow-hole when the riverbed is dry in summer months.

Thus the Malenščica receives during the low water level polluted water from Cerkniščica, flowing from Cerkniško polje through Rakov Škocjan and from the Pivka valley the waste water of the Pivka town and from scarcely inhabited area of Javorniki Mt. the infiltrated rain water (Kogovšek 1999). After an abundant rain from these directions considerably larger amounts of water start to flow by different dynamics; when discharge starts to increase it rinses the superficial riverbed of sinking streams and their underground conduits. In such conditions I expected the increase of pollution indicators such as nitrate, chloride, sulphate and other substances levels. Until now in the Malenščica we recorded at the discharge increase just the increase of turbidity.

According to present knowledge the primary feeding of the Malenščica is infiltrated rain from the Javorniki Mt. karst recharge area. To this amount are added waters from non-karstic areas, the inflow from flysch border near Pivka and sinking streams from Cerkniško polje which disappear into Javorniki Mt. These inflows are secondary feeders of the Malenščica. The Malenščica discharge line (Gospodarič & Habič 1976) shows stability, and relatively small discharge variations over one year (Kogovšek 1999) due to complexity of its recharge area.

Kiraly et al. (1995) state that an important amount of old water may be stored in epikarstic and vadose zone, in well permeable network of conduits and in channels below the karst spring level. Also Jeannin and Grasso (1995) write that rain infiltrates into epikarst; one part flows quickly towards karst conduits and one part is stored in less permeable part of an aquifer. Petrič (2000) reports that fast percolation of water through the epikarstic zone in the Vipava recharge area is reflected by fast discharge increase occurring the same day. A relatively high share of old water is probably due to storage during previous events, from the time before the arrival of fast feeding in water pulse.

By measuring temperature, specific electric conductivity, pH, turbidity, Uranin presence due to water tracing test, carbonate, calcium, magnesium, chloride, nitrate and sulphate levels, I wanted to establish the dynamics of water inflow from various parts of the aquifer and also the water composition after the first rinsing after a long dry period. In continuation I give the results of a detailed observation of such water pulse formed after a long dry summer occurring after first autumn rain at the beginning of November 1997.

ANALYTICAL METHODS

Temperature and specific electric conductivity (SEC 20 °C) measurements and water level surveys in the pumping well were done by datalogger Gealog S every hour. The water level was recorded by sound fixed in the well. At the same time staff of the drinking water treatment plant of Postojna water supply - KOVOD manually sampled the water for fluorescence with different frequency, at first every 2 and every 4 hours, and at the end of observation two times per day. They gave us the turbidity measurements measured by HACH instrument Turbidimeter 1720 C at the inflow of raw water.

Water samples for Uranin level were taken into dark glass bottles and fluorescence was defined by luminescence spectrometer LS 30, Perkin Elmer (E_{ex}=492 nm, E_{em}=515 nm). Due to higher turbidity of the Malenščica differences occurred in results of measurements done directly after sampling or in decanted samples. Therefore the samples were centrifuged (frequency 6000/s, 15 minutes).

The samples for chemical analyses were taken into polyethylene bottles to be later simultaneously analysed in our laboratory based at that time in Planina. Carbonate, calcium and magnesium levels were defined by standard titrimetric methods, chloride levels by titrimetric method with mercury chloride, sulphate levels by turbidymetric method, o-phosphates by standard method with tin chloride (Standard Methods for the Examination of Water and Wastewater 1992), and nitrate levels by method with sodium salicilat. By determining the sulphate levels we foresee inconveniences at samples with higher turbidity. Decanted and centrifuged samples showed rather lower sulphate levels (up to 1 mg/l) than original samples.

PRECIPITATION AND HYDROLOGICAL CONDITIONS

After soft rain in the area of Javorniki Mt. (precipitation station Jurišče, data by Hydrometeorological Institute RS) in August (101 mm), September (32,9 mm) and October (39,4 mm) the autumn rain started in 1997 on November 5 only when there were some mm of rain. Next day, on November 6 there were 29 mm, on November 8 it started to rain in the morning, the rain was more intensive in the afternoon and in first hours of the following day. In 24 hours there were more than 100 mm of rain. It rained the following six days to reach 250 mm altogether. The rain quantity at the Postojna meteorological station was same at this time only the distribution varied slightly (Fig. 2).

On November 6 at 15.00 a smaller increase in the Malenščica discharge was recorded lasting up to 21.00 when discharge started to rapidly escalate and reached the maximal value on November 8 at 7.00. Until 15.00, when Hidrometeorološki zavod RS measured discharge of 10 m^3/s it decreased slightly. The following week discharge remained at the value of 9,9 m^3/s and than slowly decreased to the end of December to 9,11 m^3/s.

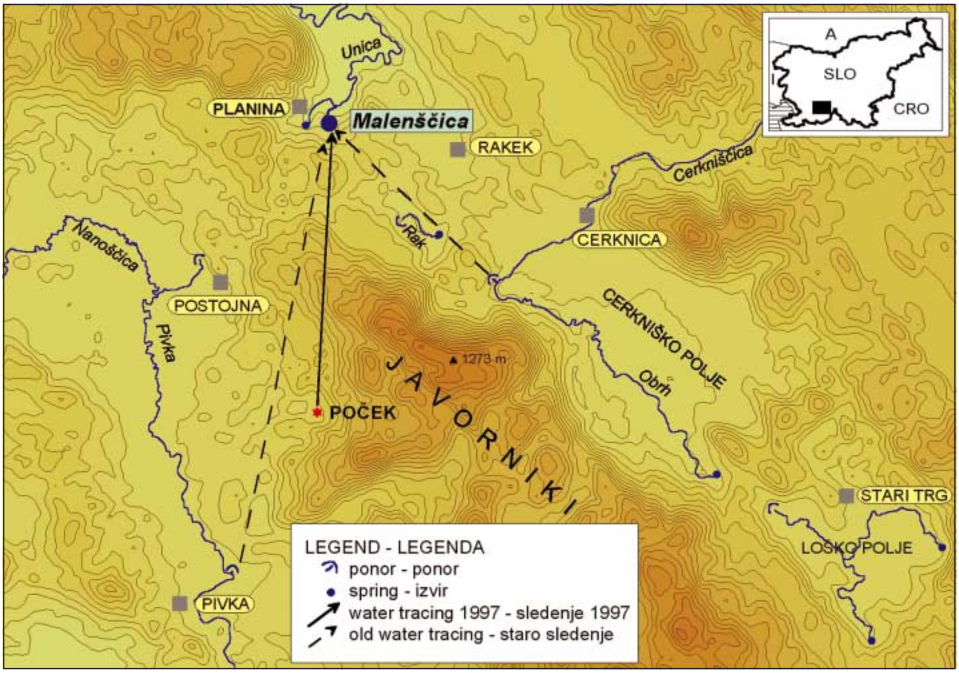

Fig. 1: The Malenščica resurgence at Planinsko polje and its recharge area.
Sl. 1: Izvir Malenščice na Planinskem polju in njeno zaledje.

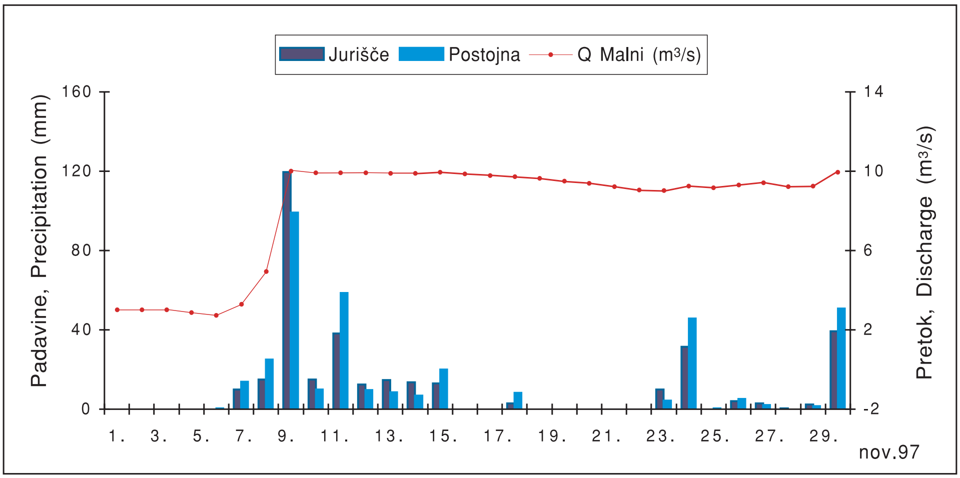

Fig.2: Precipitation at meteorological stations Jurišče and Postojna and the Malenščica discharge in November 1997.
Sl. 2: Padavine na meteoroloških postajah Jurišče in Postojna ter pretok Malenščice v novembru 1997.

RESULTS

As the values of temperature and turbidity (Fig. 4-A, Fig. 5), SEC, water level in pumping well and Uranin level (Fig. 4-B, Fig. 5), pH, carbonate, calcium, magnesium and Ca/Mg relation levels (Fig. 4-C) as well as chloride, nitrate, sulphate (Fig. 4-D) levels vary I tried to explain the water pulse consecutively and I divided it into several time intervals.

Time before the November rain started

Since mid August 1997 the Malenščica discharge trended to decrease. In mid September only 33 mm of rain in the area of Javorniki (Jurišče) caused an increase in the pumping reservoir at the spring for some two days. Temperature and SEC reacted by 24-hour delay and after one day delay the traces of Uranin appeared (up to 0,01 ppb) which remained in the Javorniki underground after the injection in June 1997 at Poček (Fig. 3). Temperature rose from 8,6 to 9,6 °C, SEC from 312 to 317 μS/cm. I think that this was old infiltrated water remained in Javorniki runoff due to slightly increased of secondary inflow related to sinking streams. HMZ RS measurements did not record any changes in the Malenščica discharge in this time.

After almost three dry weeks a storm broke out on the afternoon of October 8 at Postojna and nearby with 104 mm of rain; yet the storm did not affect the central part of Javorniki Mt., at Jurišče only 16 mm of rain being recorded. The Malenščica discharge, which remained at mini-

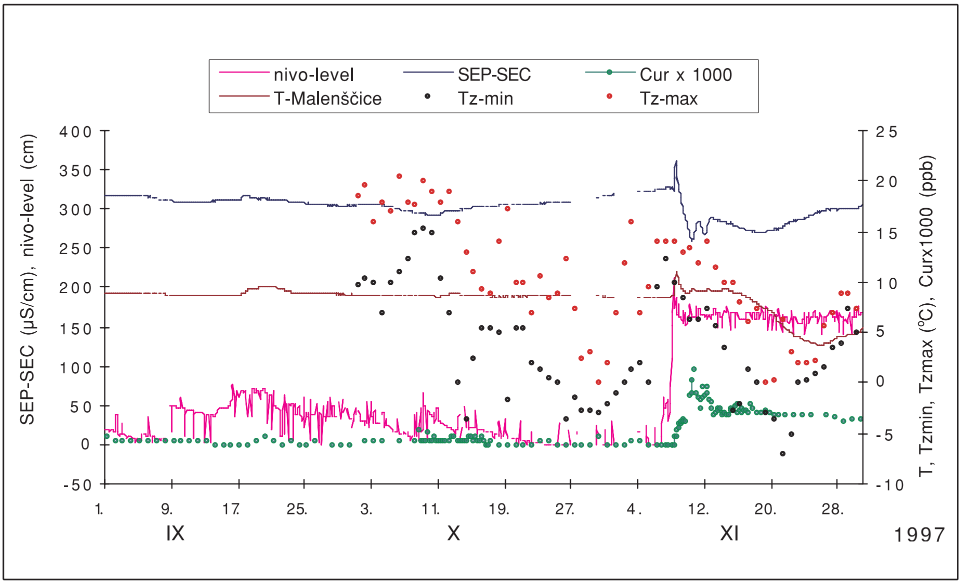

Fig. 3: Temperature, SEC, Uranin level in the Malenščica, maximal (Tz_{max}) and minimal (Tz_{min}) air temperature at Postojna in autumn 1997.
Sl. 3: Temperatura, SEC, nivo in vsebnost uranina v Malenščici, maksimalna (Tz_{max}) in minimalna (Tz_{min}) temperatura zraka v Postojni jeseni 1997.

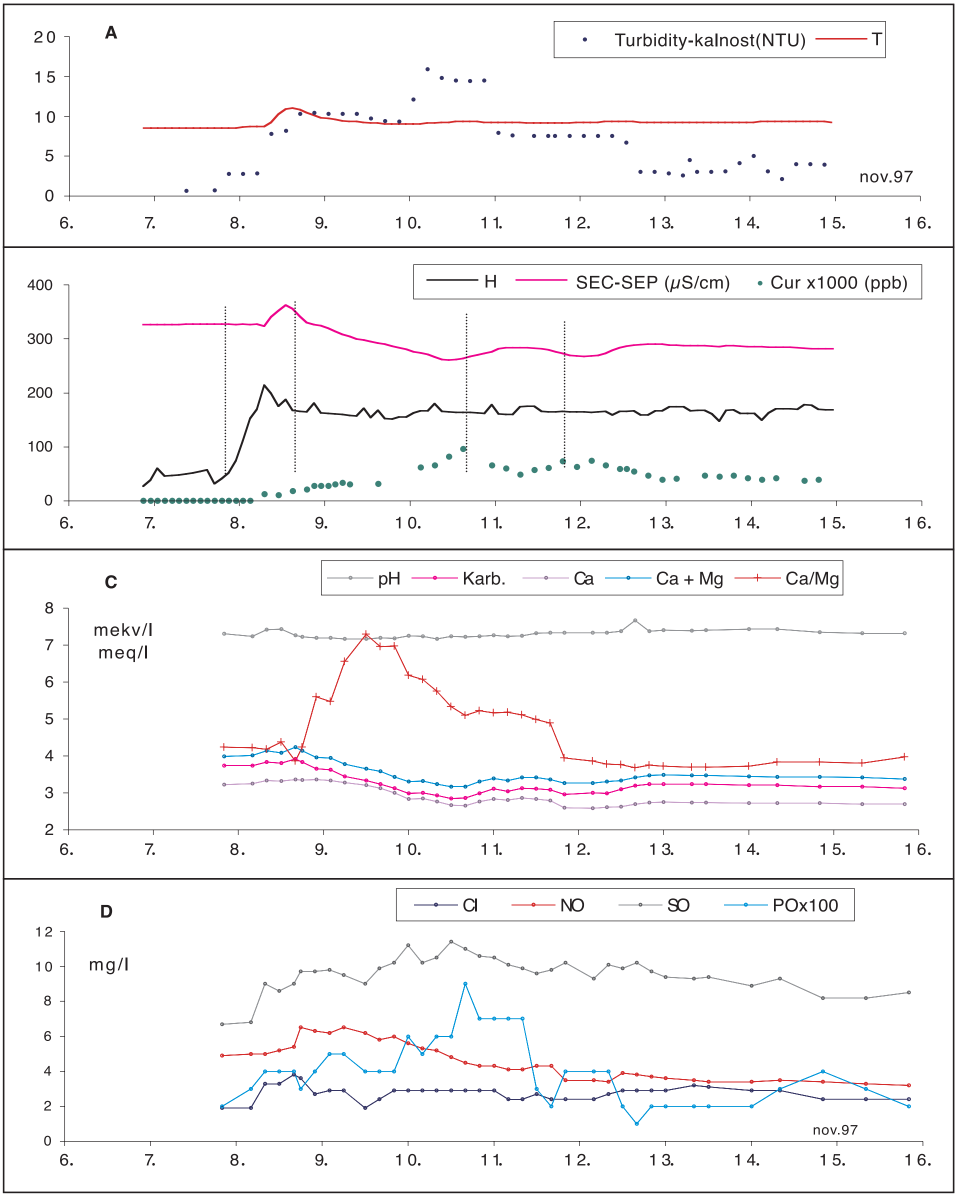

Fig. 4: The Malenščica water pulse in November 1997: A - temperature and turbidity measurements, B - level, SEC and Uranin concentration, C - carbonate and calcium levels, total hardness, pH and Ca/Mg rate, D - Chloride (Cl), nitrate (NO), sulphate (SO) and o-phosphate (PO) levels.
Sl. 4: Vodni val Malenščice novembra 1997: A - Meritve temperature in kalnosti, B - Nivo, SEP in vsebnost uranina, C - vsebnost karbonatov in kalcija, celokupna trdota, pH in razmerje Ca/Mg, D - vsebnost kloridov (Cl), nitratov (NO), sulfatov (SO) in o-fosfatov (PO).

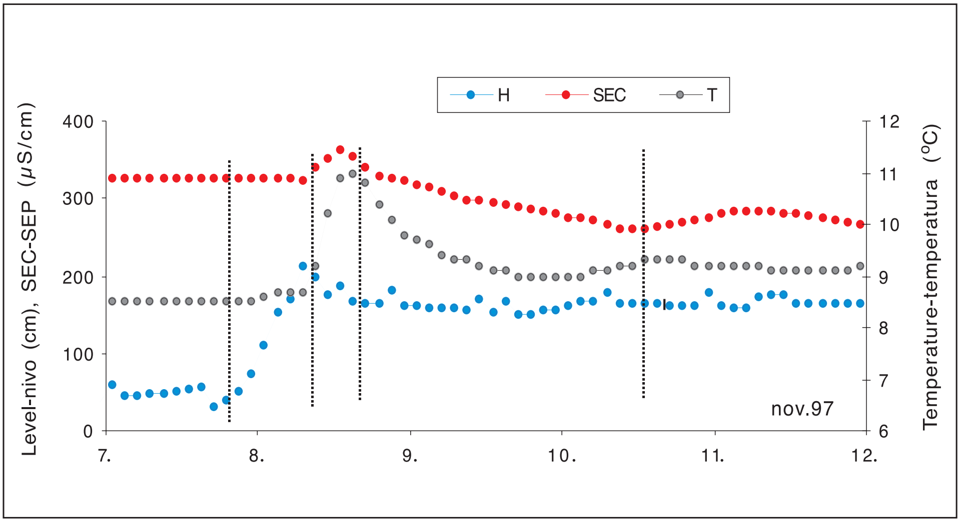

Fig. 5: Mesurements of temperature, water level and conductivity (SEC) were done by datalogger Gealog S every two hours.
Sl. 5: Meritve temperature, nivoja vode in SEP so potekale z dataloggerjem Gealog S, vsaki dve uri.

mal values of 2,87 m^3/s for two previous weeks, rapidly increased and on October 9 reached the maximal value of 3,98 m^3/s (momentary daily values by HMZ RS). In the pumping reservoir we recorded a slightly greater increase of the level than was the case after the rain in September. At the same time we recorded a smaller increase of the Uranin concentration (up to 0.02 ppb). The first discharge increase could thus be attributed to old water outflow from Javorniki Mt. Then SEC was in decrease and it only rose after almost 3 days delay for 8 μS/cm. Temperature changed minimally around 8,6 °C although the air and consequently rain temperature was rather high. As at minimal SEC in the Malenščica sample from October 10 at 23.00 we recorded substantially higher Ca/Mg rate, which was 8,4 and lower carbonate level we may conclude that the October's discharge increase of the Malenščica is due to an important inflow from the Pivka valley. Nevertheless lower nitrate and o-phosphate levels and calcium and magnesium compared to sample from October 7, 1997 indicate more probable inflow from the Javorniki region.

Later the Malenščica temperature decreased from 8,7 °C to be at the end of October and the first week in November permanent, 8,5 °C. At the same time SEC evenly increased from 300 to 327 μS/cm and during permanent discharge decrease towards its minimal annual value of 2,74 m^3/s. Considerable variations in air temperature reflected in the water temperature of secondary inflow were not recorded in the Malenščica temperature (Fig. 3). I infer that this is related to a slow outflow of old infiltrated water. Modest inflow of secondary feeding, when Cerkniško jezero contributes the Cerkniščica only and from the Pivka valley only wastewater flow did not influence upon the Malenščica temperature.

Thus I conclude that the temperature of old infiltrated water flowing from the Javorniki Mt. is very close to the mentioned value of the Malenščica, which is 8,5 °C.

Time interval from November 6 to 7 at 17.00

After reaching the minimal annual discharge of 2,74 m^3/s of the Malenščica on November 5 very little rain on November 6 caused a small discharge increase. We recorded an increase of the water level in the pumping well. On November 6 HMZ RS recorded daily momentary discharge of the Malenščica to be 3,28 m^3/s, on November 7 it was 4,93 m^3/s. At this time we did not record any changes in temperature which remained at 8,5 °C nor in SEC, which was 327 μS/cm nor water turbidity which remained below 1 NTU (Fig. 4).

I state that in this time equal water flowed through the Malenščica spring as before the discharge increase. The first rain caused a somewhat accelerated outflow of old water from the more permeable recharge area of Javorniki without changing substantially the minimal inflow from Cerkniško polje and the Pivka valley, or in other words, the share of this inflow was all the time relatively small and did not influence the Malenščica. According to estimation in the period of 40 hours, 110 000 m^3 more water flowed than at supposed stable low discharge. On average every hour 2800 m^3 more of old water flowed through the Malenščica.

Time interval between November 7 at 17.00 and November 8 at 7.00

More intensive rain that followed on November 7 and 8 caused the Malenščica discharge to increase strongly in the evening of November 7 (Fig. 4B). Maximal value was reached on November 8 at 7.00 and later it slowly decreased. HMZ RS recorded on that day the maximal value of 10 m^3/s (momentary daily value). During the discharge increase SEC did not change, only at maximal discharge we recorded less than two-hours decrease of SEC from 327 to 323 μS/cm. Turbidity rose from 0,7 to 2,8 NTU. The Malenščica temperature remained stable up to November 8 at 1.00 when it started to increase slowly and up to 7.00 rose for 0,2 °C to 8,7 °C. In the Malenščica inflow up to this time were recorded no traces of Uranin which remained in the Javorniki underground since its injection of June 10 at Poček. No changes were recorded in chloride, sulphate, nitrate, calcium, magnesium, Ca/Mg and pH levels (samples: November 7 at 20.00 and November 8 at 4.00).

In this interval we recorded 3, 73 meq/l carbonate, 3,25 meq/l calcium, 0.75 mg/l magnesium, 1,9 mg/l chloride, 5 mg/l nitrate, 6,8 mg/l sulphate and 0,03 mg/l o-phosphate levels; Ca/Mg rate was 4,2.

I think that in this time interval an accelerated outflow of old water from the Javorniki Mt. was concerned driven out by rainfall that rapidly infiltrated through the most permeable parts of the aquifer. In this time we did not record any changes in SEC, hardness, Ca/Mg, nitrate, sulphate, o-phosphate and chloride levels. The Malenščica temperature increased from 0.2 °C only probably reflecting the inflow of a smaller amount of warmer superficial water as the air temperature, after two rather cold days on November 6 and 7, 1997, was relatively high (Fig. 3). In favour of a superficial inflow speaks also turbidity increase just before the maximal discharge was reached. An increased inflow through permeable conduits from Cerkniško polje would be possible. Stronger inflow must be reflected in lowered value of Ca/Mg rate as in such conditions in Jamski zaliv into Svinjska jama disappears only the Cerkniščica with Ca/Mg rate about 1. Also Kotliči in Rakov Škocjan have a small value of Ca/Mg rate in such circumstances. The possibility of increased outflow from the Pivka valley through the swallow hole near Trnje seems less plausible although Pivka was again active from November 8 after more than 6 months of dry riverbed and the discharge at Žeje was 200 l/s (estimated) and similar discharge was observed at the Žejski izviri.

Obviously in this time the infiltrated water from less permeable part of the Javorniki (Poček) aquifer did not yet occur, at least not in such a quantity that Uranin would be noticeable; we recorded it after this time only. The remaining Uranin stayed stored after the injection on June 10 in a less permeable part of the aquifer.

After rough estimation in this time interval, 14 hours, more than 130 000 m^3 additional water was drained which means that every hour more than 9000 m^3 more of old water drained than at the supposed stable low discharge.

Time interval November 8 between 7.00 and 15.00

In the time of November 8 from 7.00 to 15.00, when water table in pumping well decreased a little, the temperature increased from 8.7 to 11 °C, while SEC increased up to 13.00 (from 323 to 362 µS/cm) and later decreased (Fig. 4). In this time interval I recorded the pH increase from 7,2 to 7,4, the increase of chloride from 1,9 to 3,3 mg Cl^-/l, sulphate from 6,8 to 9 mg SO_4^{2-}/l, o-phosphate from 0,02 to 0,04 mg PO_4^{2-}/l levels and increase of turbidity from 2,8 to 8,1 NTU as well as minor increase of nitrate level. Also calcium, magnesium and carbonate levels increased (up 0,2 mekv/l), while Ca/Mg rate slightly decreased at the end of the interval. We recorded the first traces of Uranin from Javorniki Mt., from the Poček area.

Besides replacing of old water with rapidly infiltrated rainfall the Malenščica temperature shows the possibility of increasing inflow from the surface, mostly this first superficial inflow that rinsed the river beds. The air temperature on November 6 and 7 was between 9,6 and 14 °C and superficial flows were warmed up. We also recorded pollution, turbidity and pH increase. As the Ca/Mg rate did not change substantially, at the end of the interval it even decreased, it seems possible that the inflow from Cerkniško polje increased, these are those first, little augmented waters, when Cerkniščica is joined by Stržen in Jamski zaliv. At low water level Rak at the spring, Kotliči and Rak in front of swallow holes at Veliki naravni most (The great Natural Arch) have low Ca/Mg rate (1,5, 2,7 and 2,2), as they receive mostly waters from dolomite from Cerkniško polje and its vicinity. Only bigger inflow of Javorniki Mt. with higher Ca/Mg into Kotliči and joining of Stržen in the swallow holes in Jamski zaliv influence upon raised Ca/Mg rate of the Rak at swallow hole.

The appearance of the first Uranin traces from the Javorniki region means that rainfall which slowly infiltrated into the less permeable part of the aquifer started to drive out the old water containing retarded Uranin from the injection in June 1997. In favour of this inflow speaks the carbonate, calcium and magnesium levels increase. Also SEC increased for 40 µS/cm which I explain by carbonate, calcium and magnesium levels increase as well as by increase of chloride and sulphate levels. By water tracing it was stated (Doerflinger & Zwahlen 1995) that drainage though less permeable block delays for one day after the one through karst conduit. The measurements of Uranin in our case show that slow infiltration is delayed after rapid infiltration for less than one day.

Time interval between November 8 at 15.00 and November 10 at 16.00

In the initial part of the time interval between November 8 at 15.00 and November 9 at 19.00 the water level in the pumping well decreased steadily, the annual discharge value was on November 9 and 10 (HMZ RS) 9,9 m^3/s. In this time the Ca/Mg rate increased substantially from 3,9 to 7,3 and at the same time SEC decreased from 355 to 295 µS/cm (Fig. 4B). The Uranin concentration in the Malenščica increased gradually while turbidity after the initial small increase to

10,3 NTU remained at this value, similar as it was recorded at nitrate levels which increased from 5,2 to 6,5 mg NO_3^-/l. Meanwhile the chloride concentration level slightly decreased, sulphate and o-phosphate increased during these variation. O-phosphates reached the maximal value of 0,09 mg PO_4^{3-}/l.

In the evening of November 9 Ca/Mg rate reached the maximal value and when discharge started to increase again Ca/Mg decreased as well as nitrate levels yet chloride level did not change; sulphate levels reached maximum in this water pulse. During Ca/Mg decrease turbidity at first increased up to 14,8 NTU and later remained at 14,5 NTU. At the same time the Uranin concentration increased faster and on November 10 at 15.00 reached the maximum of 0,095 ppb in the autumn water pulse.

During the whole time interval we recorded a steady decrease of carbonate, calcium and magnesium levels. At the same time SEC decreased also. Drop in temperature was gradual and stabilised at 9 °C, pH was low all the time around 7,2, the lowest in the whole observed pulse.

Rise in Uranin concentration shows increase of slow infiltration impact of rainfall, or replacing old water from less permeable part of the Javorniki aquifer. Rise in Ca/Mg rate with simultaneous drop in SEC and carbonate, calcium and in particular magnesium levels can also reflect the impact increase of the fast flowing freshly infiltrated water with substantial calcium dissolution compared to magnesium.

The initial rise in nitrate level and their later very slow decrease as well as high turbidity indicate the inflow of secondary feeding with initial intensive rinsing of riverbeds. According to rise in Ca/Mg rate we would infer about an important inflow from the swallow holes near Pivka. Yet, much more probable seems a strong inflow from Cerkniško polje, probably waters accumulating in limestone border as they have higher Ca/Mg rate. At the same time the sulphate level increased.

The drop in Ca/Mg rate and nitrate level followed with simultaneous rise in Uranin concentration showing the increased inflow of slow infiltration from the Javorniki Mt compared to other inflows. However, high turbidity is surprising as this may be the impact of increased inflow from flysch area where is located the swallow hole near Trnje. At the same time we recorded the rise in temperature for 0.3 °C only which may imply a more important inflow of superficial water as air temperature a day before was between 8.4 to 13 °C. A fast rise in turbidity may be explained also by intensive washing off the accumulated particles together with increasing discharge from underground conduits leading to the Malenščica from the Pivka valley. A mineralogical analysis of particles would probably provide a more accurate answer.

Time between November 10 at 16.00 and November 11 at 20.00

Relatively stable Ca/Mg relation (5,2 to 4,9) is typical of this period. The variations in carbonate (2,98 to 3,08 mekv/l) and total hardness (3,3 to 3,30 mekv/l) levels were minimal also. Nitrate levels slightly decreased similar as sulphate while chloride levels varied only a bit. The o-phosphate levels severely decreased to the end of interval from its maximal value of 0,09 mg PO_4^{3-}/l. The Uranin concentration decreased to 0,045 ppb at higher initial discharge on November 11 (dilution effect) to remain at 0,075 ppb. At first turbidity rapidly decreased to persevere later at 7,5 NTU. Temperature decreased from 9,3 to 9,1 °C, and SEC increased from 267 to 283 µS/cm and later, together with Ca/Mg decreased a little pH steadily increased reflecting the rising inflow of superficial water.

I think that in this time the prevailing influence of water accumulated in Javorniki recharge area with an important share of slow infiltration is felt which is additionally confirmed by higher carbonate, calcium and magnesium levels and lower Ca/Mg rate. Also important is a permanent inflow from Cerkniško polje reflected in temperature, pH and turbidity and in smaller extent the inflow from the Pivka valley.

Time after November 11 at 20.00

In this period at relatively steady high discharge the inflow from Javorniki continued which is indicated by permanent Uranin presence as after three days is dropped to 0,040 ppb (Fig. 4B) only. Until 19 November SEC decreased and then up to the end of the month increased when it reached 300 µS/cm. Also Ca/Mg at first dropped from 4,9 to 3,9, to stay steady up to November 14 when it started to increase slowly. At the beginning chloride and nitrate levels increased a little. We recorded a rise in pH to 7,4; temperature ranged between 9.2 and 9.3 °C. Maximal daily air temperature was in the first days between 11 and 14 °C; after November 14 it dropped so much that it influenced the accumulated water in Cerkniško polje and after one day the drop was reflected in the Malenščica temperature. From November 12 at 9.00 the turbidity persisted at 7,5 NTU, later it rapidly decreased and for some time persevered at about 3 NTU.

Low Ca/Mg levels show not only the inflow of infiltrated water from the Javorniki region but also an important inflow from Cerkniško polje, reflected also by a higher pH. It seems that in the second half of November the Malenščica received not only maximised inflow from Cerkniško polje and important part of waters from Javorniki as Ca/Mg rate steadily increased. After November 7 and 8 the rainfall continued less intensively up to November 14 every day. The inflow from the polje after the water accumulation when solid particles brought by tributaries to Cerkniško polje are being deposited contained less solid particles as also lower nitrate and sulphate levels.

CONCLUSIONS

Simultaneous monitoring of numerous parameters of the Malenščica resurgence water in the autumn water pulse after abundant autumn rain partly indicated the dynamics of water inflow from a wider recharge area but at the same time opened a lot of questions which could be explained by additional researches.

In the initial time of rapid rise in the Malenščica discharge (54 hours) about 250 000 m^3 more water drained through the resurgence than it would be at supposed stable low discharge. The water quality was identical to that before the discharge increase. This is why I think that after an intensive rain the first to drain is the old water, in particular this in the more permeable part of the aquifer from the Javorniki region although the secondary feeding was minimal. This is followed by squeezing old water out of the less permeable part of the aquifer, consecutively a rise in rapidly infiltrated rainfall and a rise in secondary feeding by initial washing of the pollution out of riverbeds and underground channels. I could not determine the inflows from Cerkniško polje and the Pivka valley but there is a possibility in mineralogical analyses of solid particles transported by the Malenščica. The first discharge increase of secondary feeding after a longer dry period washes a great quantity of pollution from superficial riverbeds and underground leading to quality deterioration of the Malenščica. Our measurements included nitrate, sulphate, o-phosphate and chloride levels only but due to strong dilution they are no more evidenced by increase in their concentration. More dangerous are eventual toxic and carcinogen substances which may be harmful in very low concentrations already.

After four days the situation calmed down, the Malenščica received an important share of the Javorniki and Cerkniško polje, where an accumulation lake was formed. In the lake the solid particles deposited. The share of drainage from Javorniki and Cekniško polje was later influenced by rain which caused the drainage increase from the Javorniki region.

Turbidity, nitrate, o-phosphate and sulphate levels showed to be an important tracer of the superficial inflow within the multiparameter monitoring of resurgence water. The accumulated water coming from Cerkniško polje was mostly proved by temperature and pH. In future it would be easier to distinguish the superficial water coming from the Pivka and this, coming from Cerkniško polje by analysing solid particles and by isotopic analyses of water. Replacement of old water from the less permeable part of the Javorniki aquifer was shown by Uranin concentration measurements and from the more permeable part a sum of all the parameters which did not change at that time.

Anyway in the Malenščica case it is a complex activity, different drainage dynamics well shown in water composition. This was just the first attempt to explain the water inflow into this resurgence from different recharge areas and to find out when pollution from inhabited recharge areas impacts on water.

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VEČPARAMETERSKO SPREMLJANJE VODNEGA VALA MALENŠČICE NOVEMBRA 1997

Povzetek

Zaledje izvira Malenščice pri Planini je zelo obsežno in zajema tako dotok infiltracijke vode z območja Javornikov, ki predstavlja primarno napajanje, kot dotok površinskih voda s Cerkniškega polja in iz doline Pivke, ki pomenita sekundarno napajanje. To so pokazala sledenja podzemnih voda v preteklosti. Občasno (do 6-krat letno) se opravljajo tudi manj ali bolj obsežne kemične in biološke analize Malenščice, ki jih opravlja Hidrometeorološki zavod RS, saj je njena voda zajeta za oskrbo prebivalstva s pitno vodo. Tokrat smo podrobneje spremljali sestavo vode v času vodnega vala po izdatnih padavinah.

Sočasno smo spremljali temperaturo, SEP, pH in nivo vode v črpalnem zajetju na izviru in zajemali vzorce vode za analizo na vsebnost kloridov, nitratov, o-fosfatov in sulfatov v času vodnega vala po prvih izdatnejših jesenskih padavinah. Do določene mere smo spoznali dinamiko dotoka vode iz širšega zaledja, vendar pa so se hkrati nakazala številna vprašanja, ki jih bodo lahko razjasnile le nadaljnje raziskave.

V času začetnega naraščanja pretoka Malenščice do maksimalne vrednosti (54 ur), ko je steklo skozi izvir okoli 250 000 m^3 več vode, kot ob domnevnem stabilnem nizkem pretoku, je voda Malenščice ostajala enake sestave kot pred naraščanjem pretoka. Zato sklepam, da gre po intenzivnih padavinah najprej za iztiskanje stare vode z območja Javornikov, predvsem tiste iz bolj prepustnega dela vodonosnika ob sicer minimalnih dotokih sekundarnega napajanja. Šele nato sledi iztiskanje tudi stare vode iz manj prepustnega dela vodonosnika, naraščanje sekundarnega napajanja z začetnim spiranjem onesnaženja iz strug in naraščanje prispevka hitro infiltriranih padavin z območja Javornikov. Dotokov sekundarnega napajanja s Cerkniškega polja in doline Pivke nisem uspela ločiti, vendar vidim možnost v mineraloški analizi trdnih delcev. Prvo naraščanje pretokov sekundarnega napajanja spira po daljšem sušnem obdobju veliko količino onesnaženja iz površinskih strug in podzemlja, ki pomeni poslabšanje kakovosti Malenščice. Naše meritve so zajele le nitrate, sulfate, o-fosfate in kloride, ki pa se zaradi močnih razredčitev ne odrazijo v večjih povečanjih njihove koncentracije. Bolj nevarne so morebitne strupene in karcenogene snovi, ki kvarno vplivajo že v zelo nizkih koncentracijah.

Po štirih dneh se je dogajanje umirilo, ko je v Malenščico dotekal pomemben delež voda z Javornikov in s Cerkniškega polja, kjer je prišlo do zastajanja dotekajoče vode in se je oblikovalo jezero. V akumulaciji je prišlo do predhodnega usedanja trdnih delcev. Na razmerje dotokov z Javornikov in iz Cerkniškega jezera so kasneje vplivale padavine, ki so vsakokrat povečevale dotok voda z območja Javornikov.

V okviru multiparameterskega spremljanja izvirne vode so se izkazala kot pomembna sledila površinskega dotoka kalnost, vsebnost nitratov, o-fosfatov in sulfatov. Dotok akumulirane vode s Cerkniškega jezera sta odražala predvsem temperatura in pH. Pri ločitvi dotoka površinske vode iz doline Pivke oz. s Cerkniškega polja bi si v prihodnosti verjetno lahko pomagali z analizo trdnih delcev in izotopskimi analizami vode. Izpodrivanje stare vode iz slabo prepustnega dela vodonosnika Javornikov nam je pokazalo spremljanje koncentracije uranina, izpodrivanje stare vode iz prepustnejšega dela pa skupek vseh parametrov, ki se tedaj niso spreminjali. Ostaja še

odprto vprašanje v časovnem intervalu z visokim razmerjem Ca/Mg, ko gre za različen in spreminjajoč dotok iz različnih delov vodonosnika. Predvidevam, da je visoko razmerje Ca/Mg verjetno lahko posledica tudi pretežnega vpliva hitro infiltriranih padavin.

Vsekakor pa gre v primeru Malenščice za kompleksno dogajanje, za različno dinamiko dotokov, kar se odrazi v sestavi Malenščice. To je bil le prvi poskus, da bi razložila dotekanje vode v ta izvir iz različnih delov zaledja, oz. kdaj doteka v izvir onesnaženje s poseljenega dela zaledja izvira.