SINKING RIVERS QUALITY - THE PIVKA CASE STUDY

KVALITETA PONIKALNIC - PRIMER REKE PIVKE

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Izvleček UDK 551.448(497.4)

Janja Kogovšek: Kvaliteta ponikalnic - primer reke Pivke

Prispevek obravnava kvaliteto ponikalnice Pivke na ponoru v Postojnsko jamo. Pivka sprejema odpadne komunalne in industrijske vode naselij, od katerih čistijo le odpadne vode Postojne. Z različnimi pristopi pri vzorčevanju so skušali zajeti čim več značilnosti Pivke. Občasna opazovanja so podala nihanja posameznih parametrov in opozorila na kritične situacije, ki nastopajo v zimski in poletni suši zaradi nizkega vodostaja Pivke že v zgornjem delu struge. Kritičnost se odraža v nizki vsebnosti raztopljenega kisika ter prisotnosti organskega onesnaženja. Podrobnejša sistematična opazovanja tekom 24 ur so podala značilnosti kvalitete ob nizkih zimskih in poletnih vodah ter ob naraščanju in upadanju pretoka.

Ključne besede: krasoslovje, ponikalnice, kvaliteta vode, hidrološki dogodki, reka Pivka, Slovenija

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The paper deals with the quality of the Pivka sinking stream at the Postojnska jama swallow-hole. In its superficial flow the Pivka receives waste communal and industrial waters from the villages; only the waste waters of Postojna itself are treated. By various methods of sampling the author tried to estimate properties of the Pivka quality. Periodical observations provided the variations of single parameters during the observations and pointed out critical situations occurring during winter and summer drought. During drought the water level is low and the Pivka sinks in upstream parts of the riverbed already. Specially critical is the low level of dissolved oxygen and the presence of organic pollution. Detailed systematic observations during 24 hours provided properties of water quality at low winter and summer levels and also at increase, or decrease of discharge.

Key words: karstology, sinking stream, water quality, hydrological events, the Pivka river, Slovenia

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INTRODUCTION

Sinking rivers are exposed during their superficial flow to pollution by waste municipal and industrial waters and also due to agriculture and various waste disposal sites. When sinking in the poljes they transport this pollution underground and it reappears at the resurgences. It means that "the same water" and "the same pollution" reappears again at the resurgences; in the case of the Ljubljanica this repeats five times. Thus pollution of the upstream part of a sinking flow means the pollution of the entire flow and of all the resurgences. This fact dictates the need for care for quality at the first swallow-hole already, the treatment of waste waters flowing underground and control over its quality.

PIVKA SINKING RIVER

The Pivka sinking river flows 15 km on the surface before disappearing into Postojnska jama. Along its flow there are several settlements where people are engaged in agriculture or employed in the wood industry (Fig. 1). More or less untreated waste waters flow into the Pivka. Since 1987 only the town of Postojna has had treatment for the major part of the municipal waters. After sinking into Postojnska jama the Pivka receives tributaries: we are aware of the polluted Črni potok but it is possible that the stream and waste waters of Studeno village flow into it too. The Pivka reappears in Planinska jama where, underground, it is joined by the Rak river; the water flowing out of the cave is called the Unica.

In the past the sinking Pivka river has been studied several times. In 1974 hydrologists from Sarajevo studied the processes of self-purification capacity in its underground flow (Preka & Preka-Lipold 1976). The Pivka pollution problem was studied by Sket and Velkavrh (1981). In the years 1984 and 1985 analyses of the Pivka quality along its flow and the quality of its tributaries were carried out (Gospodarič 1989). At the same time detailed observations of the Pivka quality were made at the swallow-hole to Postojnska jama, along its underground flow in Pivka jama and in Planinska jama (Kogovšek 1991).

During dry periods in summer and autumn the Pivka low waters disappear in the riverbed upstream; this means that the water at the swallow-hole is mainly that of its tributary - the Nanoščica. During high water level the Pivka is diluted by springs at Žeje and Trnje and by the superficial stream of the

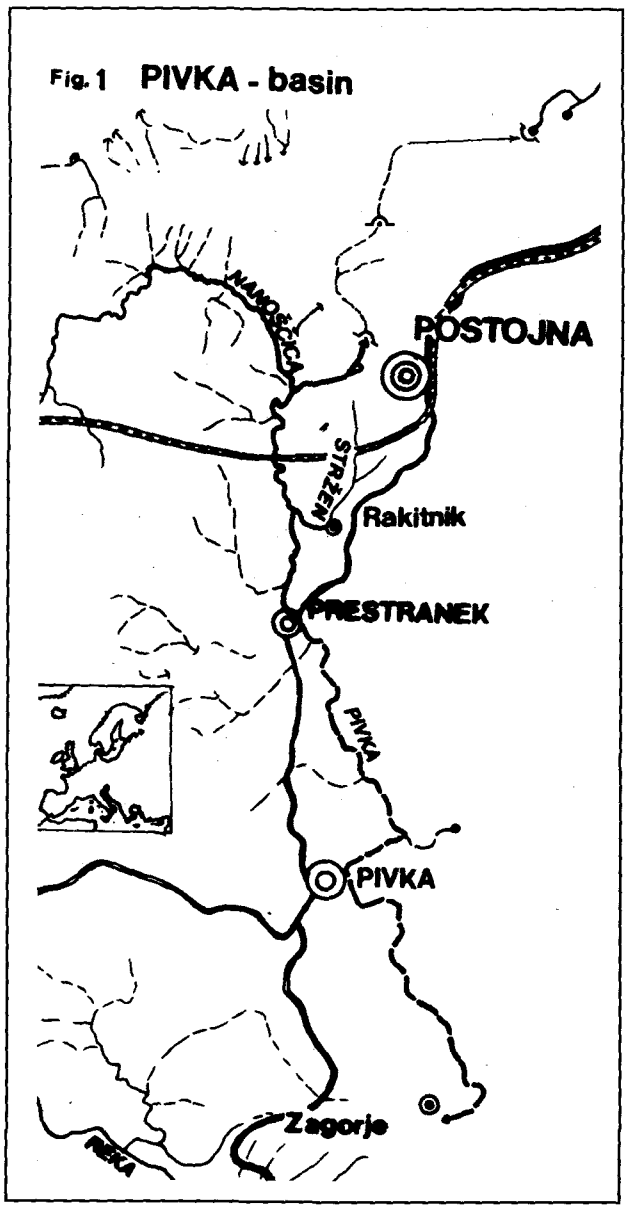

Fig. 1: The Pivka sinking river appears near Zagorje and in its superficial flow up to the swallow-hole at the entrance to Postojnska Jama receives waste communal and industrial waters from the villages
Sl. 1: Ponikalnica Pivka izvira pri Zagorju in na poti do ponora v Postojnsko jamo sprejema vodo pritokov kot tudi odpadne vode naselij

Slavenski potok (Gospodarič & Habič, 1985). Thus the waters of Pivka are of various discharges and quality at the Postojnska jama swallow-hole where the river starts its underground way towards Planinska jama (air distance 7.3 km); at low waters it requires 5 days and at high water 7 hours only (Sket & Velkavrh 1981).

PIVKA QUALITY - SEASONAL OBSERVATIONS IN THE YEARS 1984-1985

The Pivka quality at its ponor into Postojnska jama was observed at first seasonally and later in more detail. The increased concentrations of all the studied parameters, except for dissolved oxygen, indicated the deterioration of the quality.

Seasonal observations mostly assessed critical situations of the Pivka quality connected with low water level in summer and autumn months, August, September and October. In that time the level of o-phosphate and chloride, the level of chemical (COD) and biochemical (BOD) oxygen demand and specific electric conductivity (SEC) increase were observed and at the same time the decrease of dissolved oxygen concentrations (Kogovšek 1991).

Due to efficient Postojna waste water treatment at the water works which started in 1987, the concentrations of the above-mentioned parameters decreased considerably. COD decreased by one third, BOD_5 by 3 times, chlorides by 2 times and o-phosphates by 5 times.

Poor Pivka quality occurs during winter drought at low discharges and temperatures. A part of water freezes and the pollution concentrates in the remaining water. We have measured even bigger COD values than in summer drought due to slower decomposition, and lower self-purification effect at low temperatures.

During rains the waste waters are joined by meteoric waters and the quantity augments so much that the water treatment plant is able to treat one part only, the remaining water flows into Pivka directly. But, the dilution is so effective that the water quality is even better than during the efficient treatment of all the waste waters when the water level is low.

DETAILED OBSERVATIONS OF PIVKA QUALITY WERE MADE DURING LOW STABLE WATER LEVEL IN AUGUST 1985, JULY 1991 AND FEBRUARY 1993.

The observations show that the levels of chloride and o-phosphate variations are small, yet COD, BOD, nitrate and oxygen levels vary much more.

In February 1993 at temperatures below 2°C the COD during 24 hours did not change essentially. In August 1985 at temperatures between 18 and 20°C the first maximum was noted about noon and a little lower second maximum about 8 p.m. In July 1991 at approximately the same conditions we measured a compatible increase of COD at midday. But at that time the water

treatment plant was already in action; thus the COD increase probably reflects the general pollution increase in the last years.

Comparing the nitrate levels of February 1993 with August 1985, the first were considerably higher (Fig. 2). Even during periodical measurements after the water treatment plant started to operate, the nitrates, unlike other parameters, increased.

O-phosphates were considerably lower in winter 1993 and summer 1991 than in August 1985, reflecting the efficient phosphate treatment by the water treatment plant (Fig. 3).

In July 1991 the chlorides were substantially lower than in August 1985, but in February 1993 they were high again, probably due to road salting during the winter (Fig. 4).

These detailed observations have shown that it is very important at which time of the day the sinking stream is sampled because COD, BOD_5 and dissolved oxygen levels vary substantially during a day.

DETAILED OBSERVATIONS OF THE PIVKA QUALITY AT INCREASE AND DECREASE OF DISCHARGE

In March 1992 we observed a water pulse at water temperatures between 6 and 8°C when the Pivka discharge greatly increased, and later decreased

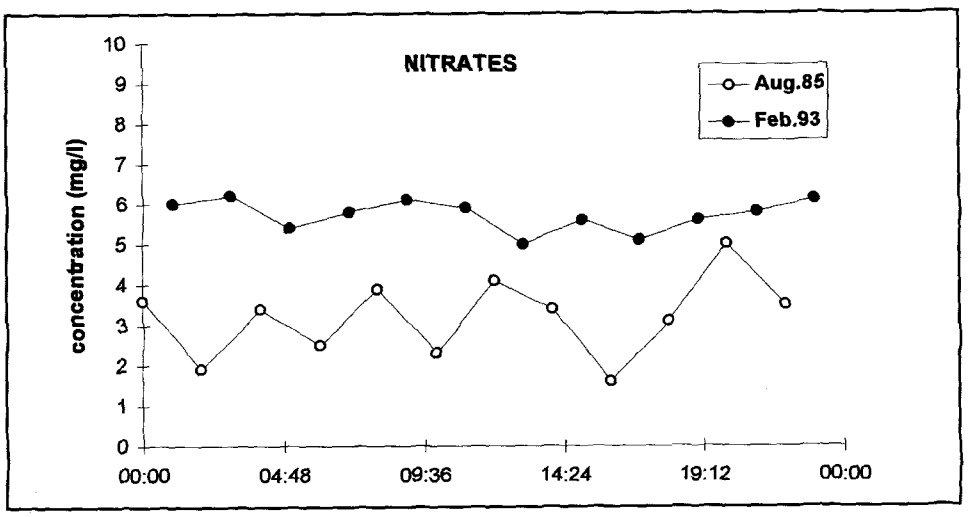

Fig. 2: A detailed study of nitrate levels in the Pivka at the swallow-hole to Postojnska Jama at low water level in winter, February 1993 and in summer, August 1985

Sl. 2: Podrobno spremljanje nitratov Pivke na ponoru v Postojnsko jamo ob nizkem vodostaju pozimi februarja 1993 in poleti avgusta 1985

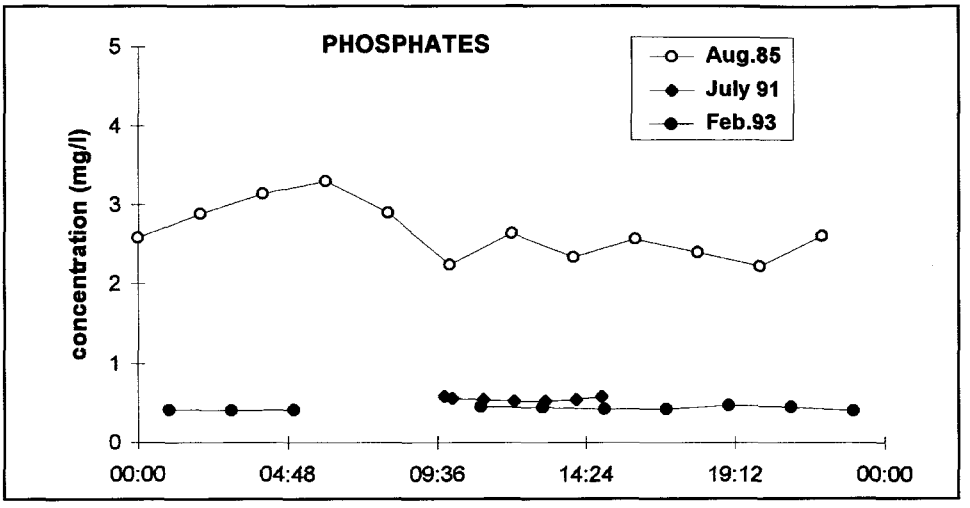

Fig. 3: A detailed study of phosphate levels in the Pivka at the swallow-hole to Postojnska Jama at low water level in winter, February 1993 and in summer, August 1985 and July 1991
Sl. 3: Podrobno spremljanje vsebnosti fosfatov Pivke na ponoru v Postojnsko jamo ob nizkem vodostaju pozimi (februarja 1993) in poleti (avgusta 1985 in julija 1991)

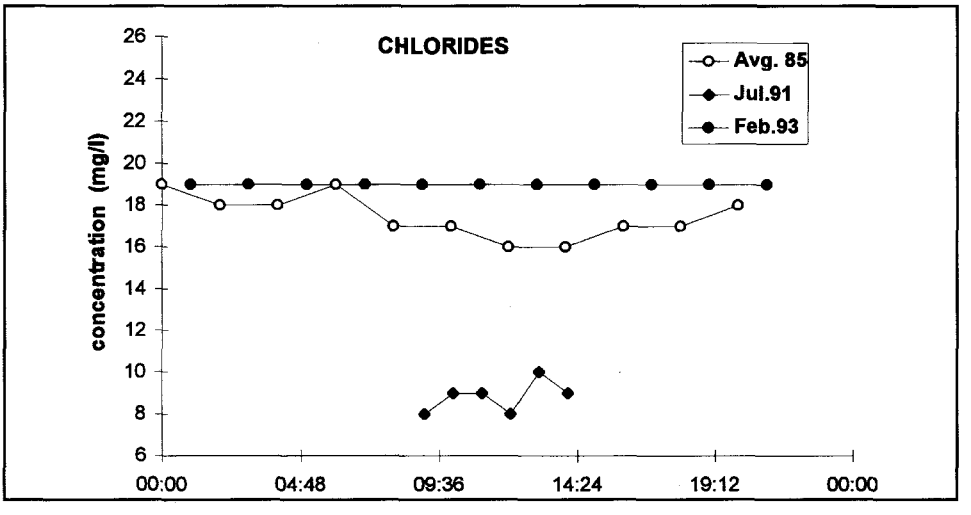

Fig. 4: A detailed study of chloride levels in the Pivka at the swallow-hole to Postojnska Jama at low water level in winter, February 1993 and in summer, August 1985 and July 1991
Sl. 4: Podrobno spremljanje vsebnosti kloridov Pivke na ponoru v Postojnsko jamo ob nizkem vodostaju pozimi (februarja 1993) in poleti (avgusta 1985 in julija 1991)

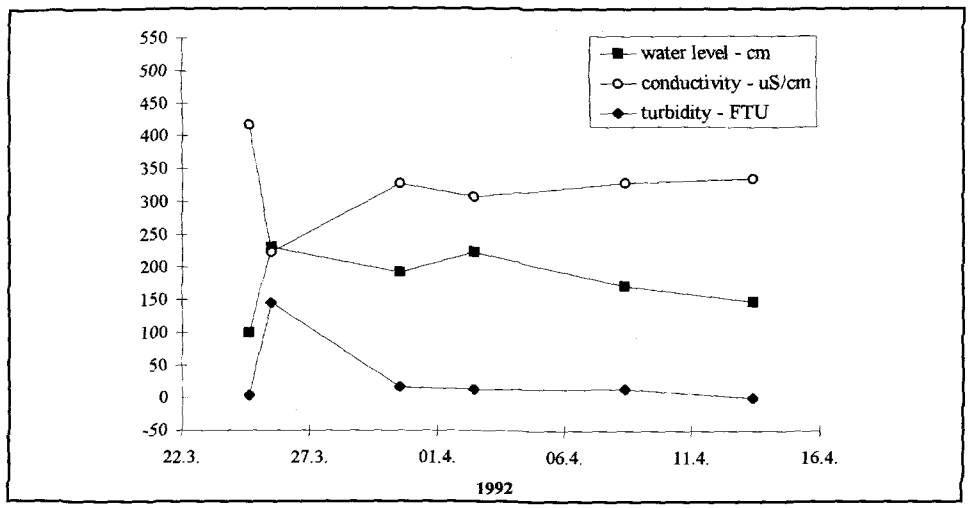

Fig. 5: Water pulse of the Pivka at the swallow-hole in Postojnska Jama in March 1992: measurements of water level, specific electric conductivity and turbidity
Sl. 5: Vodni val Pivke na ponoru v Postojnsko jamo marca 1992: meritve vodostaja, specifične električne prevodnosti in kalnosti

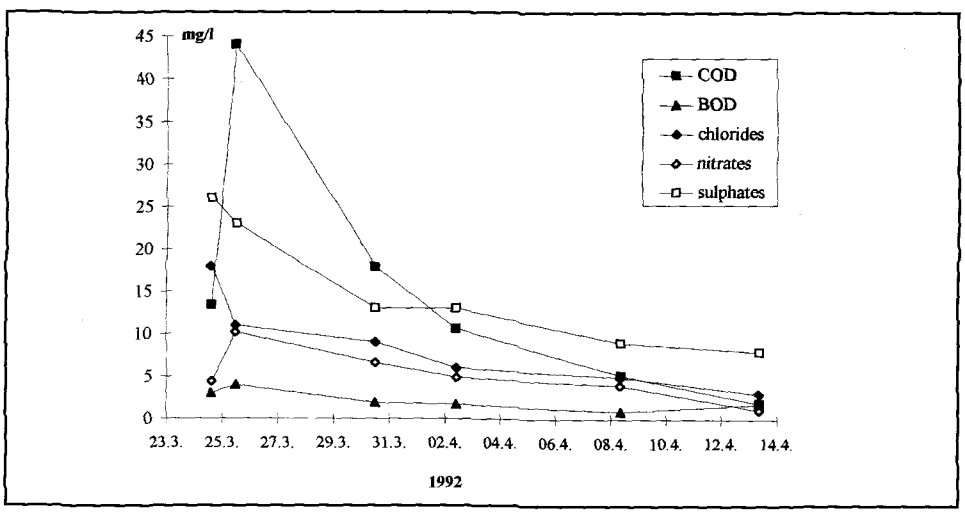

Fig. 6: Water pulse of the Pivka at the swallow-hole in Postojnska Jama in March 1992: measurements of chemical (COD) and biochemical (BOD) oxygen demand and chloride, sulphate and nitrate levels
Sl. 6: Vodni val Pivke na ponoru v Postojnsko jamo marca 1992: meritve kemijske (COD) in biokemijske (BOD) potrebe po kisiku, vsebnosti kloridov, sulfatov in nitratov

slowly. When the discharge increased, the turbidity increased also yet SEC decreased (Fig. 5). Referring to other measured parameters, COD increased the most (maximum level 44 mg O_2 l^{-1}) while BOD_5 and nitrate much less due to riverbed outwash after a long dry period. At maximum discharge maximum values of COD, BOD, and nitrate levels were registered. Regarding chloride and sulphate levels the dilution effect was noticed and continuous steady decrease of their concentrations (Fig. 6). High output of chloride levels is due to winter road salting.

A similar water pulse or increase of the Pivka discharge was observed during May 1994 (Fig. 7). By sampling we mostly got the initial part of the discharge increase. We sampled in Pivka jama. At first the water level increased slowly and on May 22 much more.

Slow discharge increase after the first days was followed by contemporaneous slow increase in concentrations of the chloride and nitrate levels and conspicuous increase in COD which reached its maximum value of 28 mg O_2 l^{-1} even before the discharge of the Pivka level considerably increased. This high increase in discharge caused higher dilution and thus COD started to decrease in the same manner as it increased previously. The decrease of the sulphate and chloride level was less dramatic.

Nitrates were relatively low and gradually increasing even when higher dilution occurred due to discharge increase.

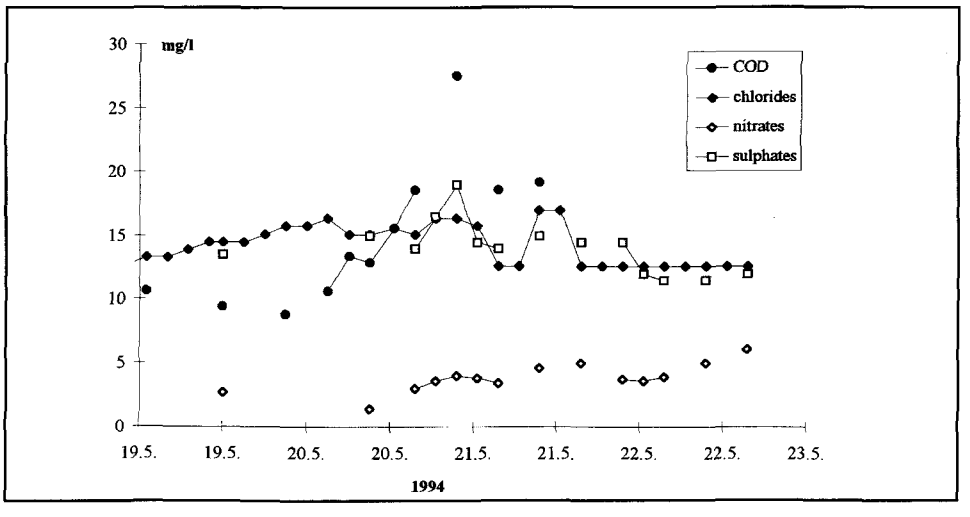

Fig. 7: Measurements of chemical oxygen demand (COD) and levels of chloride, sulphate and nitrate during the Pivka level increase at the swallow-hole to Postojnska Jama in May 1994
Sl. 7: Meritve kemijske potrebe po kisiku (COD), vsebnosti kloridov, sulfatov in nitratov ob naraščanju Pivke na ponoru v Postojnsko jamo maja 1994

THE COMPARISON OF BOTH WATER PULSES OF THE PIVKA

Almost four months before the observed water pulse in March 1992 there was no serious rainfall (altogether slightly less than 100 mm had fallen as gentle rain). Abundant rainfall occurring in March 23 and 25 and slightly less intensive at the beginning of April caused a high water pulse of the Pivka; we observed it at the swallow-hole to Postojnska jama where the water level increased for 1.30 m and decreased very slowly. Intensive showers washed the riverbeds of the tributaries and of the Pivka and in spite of high dilution effect a very high turbidity and increased organic pollution and increased nitrate level occurred. The initial state of the measured parameters existing before this water pulse were not restored in less than a week; considering the quantity of water this indicates that serious pollution was washed underground. High dilution was reflected in a conspicuous decrease of SEC due to dilution of most of the dissolved components, in particular chloride, sulphate and phosphate levels.

The water pulse in May 1994 occurred after a relatively wet April and after the rainfall at the beginning of May when the pollution was every time washed away. The amount of rainfall in May 18 and 20 was smaller than that of March 1992 and created a less distinctive water pulse. Again a prominent increase in organic pollution was recorded yet it was considerably smaller than in the observed water pulse in March 1992; the pollution appeared in the initial part of the water pulse, it lasted for two days but later discharge increase already exhibited a dilution effect.

CONCLUSION

We inferred that critical situations of the Pivka quality at the swallow-hole occur at low waters in summer and in autumn, and also in winter. The Pivka pollution varies over a day, the worsening of its quality in the last years means that water treatment for the villages which now drain directly into the Pivka and treatment of all the waste waters of Postojna, is urgent. The water treatment plant in Postojna now treats only a part of Postojna waste waters.

Water pulses, the increase of the stream discharge after a longer time without rainfall results in flushing of the riverbeds and other tributaries and the transport of this pollution underground. When the water quantity increases this pollution pulse is followed by strong dilution and a better situation is restored.

The quality in Planinska jama depends on the quality at the swallow-hole. Until 1989 good quality of the Pivka was registered in Planinska jama due to favourable self-purification processes in the underground. The deterioration was registered in 1990 and 1991. Later, in 1993 and 1995 we did not record the deterioration of the Pivka quality in Planinska jama at low water level. We infer that it was a case of periodic, short-lasting major pollutions; however, a

true state of the Pivka quality at its resurgence might be shown by regular monitoring of its waters only.

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KVALITETA PONIKALNIC - PRIMER REKE PIVKE

Povzetek

Ponikalnica Pivka na svoji 15 km dolgi poti po površju do ponora teče ob naseljih, kjer se ljudje ukvarjajo s kmetijstvom ali pa so zaposleni v lesni industriji. Odpadne vode boj ali manj direktno odtekajo neočiščene v Pivko, saj ima čiščenje odpadnih voda od leta 1987 le Postojna. Po ponikanju v Postojnsko jamo dobi še pritoke, onesnažen Črni potok, zelo verjetno tudi potok pri Studenem, v katerega se izlivajo odpadne vode tega naselja, verjetno pa tudi nam neznane pritoke. Pivka se nato ponovno pojavi v Planinski jami. Za svojo 7.3 km dolgo podzemno pot (zračna razdalja) potrebuje ob visokih vodah 7 ur (B. Sket & F. Velkavrh 1981), ob nizki vodi pa pet dni.

Z različnimi pristopi pri raziskovanju kvalitete Pivke, predvsem pri vzorčevanju smo skušali zajeti čim več značilnosti njene kvalitete. Občasna opazovanja Pivke smo dopolnili s podrobnejšimi sistematičnimi opazovanji ob nizkih vodah v poletni in zimski suši tekom 24 ur, ter s pogostimi opazovanji ob naraščanju in upadanju njenega pretoka po izdatnejših padavinah.

Ugotovili smo, da kritične situacije kvalitete Pivke na ponoru v Postojnsko jamo nastopajo ob njenem nizkem vodostaju kasno poleti in jeseni, pa tudi pozimi. Onesnaženje Pivke niha že preko dneva, občasna poslabšanja njene kvalitete v zadnjih letih pa kažejo, da je nujno čiščenje odpadnih voda naselij ob Pivki, kot tudi celotnih odpadnih voda Postojne.

Vodni valovi, naraščanje pretoka Pivke po izdatnejših padavinah, ko dalj časa ni bilo dežja, pomenijo spiranje odloženega onesnaženja iz struge Pivke

in njenih pritokov ter prenos tega onesnaženja v kraško podzemlje. Temu povečanju onesnaženosti v začetku vodnega vala sledi močna razredčitev in tako vzpostavitev boljše kvalitete Pivke.

Kvaliteta Pivke v Planinski jami zavisi od njene kvalitete na ponoru v Postojnsko jamo, od razredčevalnih ali onesnaževalnih učinkov pritokov ter od poteka samočistilnih procesov v podzemlju. Do leta 1989 je bila zabeležena dobra kvaliteta Pivke v Planinski jami. Kasnejše občasne meritve pa so pokazale na njeno poslabšanje. Sklepamo, da gre le za krajša poslabšanja, ki nastopajo po daljših sušnih obdobjih, ko prve padavine dobro sperejo akumulirano onesnaženje iz strug Pivke in pritokov in jih v vodnem valu hitro prenesejo do ponovnega izvira v Planinski jami. Pri krajšem zadrževalnem času potečejo samočistilni procesi v podzemlju v znatno manjši meri, kar rezultira v slabši kvaliteti Pivke v Planinski jami. Podrobno sliko kvalitete Pivke bi dala le redna opazovanja njene kvalitete.