# IMPACT OF HUMAN ACTIVITY ON ŠKOCJANSKE JAME

# ČLOVEKOV VPLIV NA ŠKOCJANSKE JAME

JANJA KOGOVŠEK

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**Kogovšek, Janja: Človekov vpliv na Škocjanske jame**

Prispevek podaja kvaliteto reke Reke, ki ponika v Škocjanske jame in sicer od prvih italijanskih meritev v začetku tega stoletja, sistematičnih meritev v letih 1969-79, ki jih je opravil Inštitut Boris Kidrič, Ljubljana, do analiz Inštituta za raziskovanje krasa ZRC SAZU iz Postojne. Podana je kvaliteta prenikajoče vode v Škocjanskih jamah, ki je, z izjemo curka v Tihi jami in močno onesnaženih curkov v Mahorčičevi in Mariničevi jami, vzdolž Tihe in Šumeče jame ter Hankejevega kanala, še čista.

Ključne besede: krasoslovje, hidrologija, človekov vpliv, kvaliteta vode

**Abstract** UDC 502.3 : 551.442(497.12 Škocjan)

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The article deals with the quality of the Reka river which sinks in Škocjanske jame from the first Italian measures at the beginning of the century to systematic observations in the years 1969-79 done by the Institute Boris Kidrič, Ljubljana and later measurements and analyses done by Karst Research Institute ZRC SAZU, Postojna. It treats the quality of the percolating water in the area of Škocjanske jame (measurements and analyses of the Karst Research Institute) and infers that with the exception of the trickle in Tiha jama, which has the increased values of nitrates contents and Mahorčičeva and Mariničeva jama with strongly polluted percolated water, the percolating water along Tiha and Šumeča jama and Hankejev kanal is still pure.

Key-words: karstology, hidrology, human impact, water quality

*Naslov - Address*
mag. Janja Kogovšek,
dipl.ing.chem.,razisk.svetnik
Inštitut za raziskovanje krasa ZRC SAZU
Titov trg 2,
SI-66230 Postojna, Slovenia

## INTRODUCTION

Wastes, thrown on the karst surface, in the dolines and pot holes are dissolved and the polluted water is washed into the karst underground. In addition to this pollution the sinking rivers contribute their amount of polluted water for in most cases the communal waste waters discharge directly into them. The occurrence of dark stains along the tourist walkways, where the polluted water percolates, smell resulting of decomposition of organic impurities, in particular in heavily polluted sinkstreams and various many-coloured packings transported by the sinking streams into the underground where it is deposited in some calm places does not speak in any case of well displayed karst cave.

The protection of natural heritage on the karst does not mean the protection of the underground only but also the surface above it as they are tightly connected ( the precipitations and the pollution within them could appear in a cave after half an hour already). If a sinking river flows through the cave the assurance of the water quality in the underground means that the quality must be safeguarded on the entire superficial flow.

Our researches in Škocjanske jame included the study of the quality of percolated water in various parts of the cave. Systematic researches lasted for several years in Tiha jama, seasonally in Hankejev kanal and in Tominčeva and Mahorčičeva jama. The quality of the Reka river was observed seasonally too.

## THE QUALITY OF THE PERCOLATED WATER

In percolated water in Tiha jama no pollution was registered. The chlorides, nitrates and o-phosphates contents were very low. On one point only the increased nitrates content (30 $mgNO_3^- l^{-1}$) was registered due to intensively cultivated field on the surface. Along Šumeča jama, in Tominčeva jama, in Svetinova dvorana and in Hankejev kanal no values indicating the pollution were registered (Kogovšek 1984).

Unfortunately the same cannot be said for Mahorčičeva and Mariničeva jama. On the surface above the cave a small village lies, inhabitants cultivate the land, sewage system does not exist, thus the waste waters discharge directly into the karst. The cave ceiling is from 50 to 80 m thick. In the year 1992 the percolated water was analysed several times in order to find out the actual state.

In August, during drought, we did not succeed to take the samples and we explain the fact by small amount of the waste water. After the rainfall in June and October the drops on some places developed into abundant trickles indicating that the waste waters were strongly diluted by the rainfall. The water of particular trickles was polluted in various degree. The most were polluted the trickles in the central part where dark stains were perceived on the ceiling. Thus the measured values of the specific electric conductivity did not surpass 700 $\mu S\ cm^{-1}$, but the caught water in the solution cups indicated considerably higher values - more than 1000 $\mu S\ cm^{-1}$ - and at the same time the highest values of nitrates (175 mg $NO_{3}^{-} l^{-1}$), sulfates (63 mg $SO_4^{2-} l^{-1}$), chlorides (49 mg $Cl^- l^{-1}$) content together with high values of COD (24 mg $O_2\ l^{-1}$) in comparison with freshly taken samples of infiltrated water.

In freshly infiltrated water we have measured up to 85 mg $NO_{3}^{-}\ l^{-1}$ of nitrates, up to 5.5 mg $PO_4^{3-}\ l^{-1}$ of phosphates, up to 53 mg $SO_4^{2-}\ l^{-1}$ and up to 16 mg $Cl^-\ l^{-1}$ of chlorides. The water had the COD up to 8.7 mg $O_2\ l^{-1}$, and $BOD_5$ did not surpass 2 mg $O_2\ l^{-1}$. The difference in quality among the particular trickles was registered. Obviously the pollution is considerable but it must be defined it in future more in detail in order to find out the capacity of the autopurification through the cave roof. Maximal registered values of measured parameters of the percolated water in Mahorčičeva and Mariničeva jama are gathered in Table 1.

TABLE 1

Polluted infiltrated water in Mahorčičeva and Mariničeva jama - maximal registered values

| infiltrated water | SEP | $Cl^-$ μS/cm | $NO_3^-$ mg/l | $SO_4^{2-}$ mg/l | $PO_4^{3-}$ mg/l | COD $mgO_2/l$ | $BOD_5$ $mgO_2/l$ |
|---|---|---|---|---|---|---|---|
| fresh water | 656 | 16 | 85 | 53 | 5.5 | 8.7 | 1.7 |
| in sol. cups | 1060 | 40 | 175 | 63 | 1.1 | 29 | 3.5 |

## THE QUALITY OF THE REKA RIVER

G. Timeus (1912) cites the results of the first measurements of Reka at the end of the last and at the begining of this century already, when its quality could still be compared to the quality of Bistrica in Ilirska Bistrica. Some values are given in Table 2 for comparison with later measurements.

But in this century due to progressive industrialization and urbanization the pure Reka had to receive more and more untreated waste waters. The decrease of its quality was observed before 1960 already. The first serious warning happened when in 1966 the capture of Reka was stopped for the Divača water supply. In the years 1969-79 systematic 24-hours observations of Reka in Ilirska Bistrica, in Nova Sušica and in Matavun followed. B. Mejač, M. Roš, M. Dular, M. Rejic and P. Ponikvar- Zorko (1983) reported about the results.

According to the measurements from 1969-1979 the ratio $COD/BOD_5$ in Ilirska Bistrica was 1.5 which means that the pollution mainly consisted of organic matters having fast decomposition and using all the oxygen transported by Reka into Ilirska Bistrica. In Matavun this ratio was 2.5 to 5 which means that easy degradable organic substances were up to Matavun in general decomposed and the ratio of hardly degradable substances increased. In that time Reka was on the section Ilirska Bistrica - Nova Sušica a virtual sanitary sewer where intensive anaerobic processes of decomposition have taken place. Such decay is accompanied by gas and easy volatizable products causing an odour in the valley of Reka and in Škocjanske jame which was unpleasant surprise for the visitors.

In particular unfavourable effects to the Reka quality were caused by heavy short lasting showers which released the seasonal increase of pollution washing off and transporting the sedimented particles from the bottom of the river bed, the decay products originating during the decomposition and the biomass even. When the water lowered its transport power decreases as well and the conditions for progressive resedimentation of the suspended particles arise, this time in downstream direction, in Škocjanske jame and further in the underground where anaerobic processes start again. A. Mihevc (1984) reported on the methane gas in Kačna jama. When Reka leaves Škocjanske jame it reappears after 1.5 km (aerial distance) of subterranean flow in Kačna jama. A. Mihevc reports about the channels in lower level of Kačna jama where a typical smell was felt and he linked it with piles of decomposed leaves and other organic material and brushwoods accumulated on the bottom and he mentions the methane gas in such a quantity that it could be lighted.

The example clearly shows that in case of excessive pollution received by Reka, the solid impurities are in great extent deposited on the bottom of the river bed. Under certain circumstances this pollution is carried over by the water stream, from the surface deep into the karst underground. It is not only the pollution of the underground with the impurities dissolved in the river, but with solid organic substances which need for their decay much more oxygen and much more time. The same was inferred by the researches of the polluted percolated water in Pivka jama (Kogovšek 1987) and by the measurements of the Nanoščica brook quality at the occasion of liquid manure spill (Kogovšek 1992).

In 1982 the daily quantity of pollution from the Factory of the organic acids and Lesonit from Ilirska Bistrica was diminished for one third due to various measures. Although even the analyses of the Reka showed the diminishing for one third the total pollution received by Reka was to far too big to be autopurificated. Obviously the measures of pre-purification should be followed by construction of common biological treatment plant.

The Karst Research Institute has analysed in the second half of 1981 and in 1982 within the percolated water sampling in Škocjanske jame the water of Reka river five times. $BOD_5$ and dissolved oxygen at the ponor to Škocjanske jame were analysed. $BOD_5$ oscillated from 2.9 to 8.5 $mgO_2\ l^{-1}$, the contents of dissolved oxygen was from 10 to 12.1 $mgO_2\ l^{-1}$, or 78 to 103% of saturation with oxygen being the contents of the dissolved oxygen inversely proportional to the values of $BOD_5$.

From July 1982 to June 1983 we observed the Reka quality near Ribnica with monthly sampling. The water temperature oscillates between 3 and 19$^0$C, specific electric conductivity between 254 and 672 $\mu S\ cm^{-1}$, the chlorides content between 3 to 30 $mgCl^-\ l^{-1}$, nitrates between 0.3 to 2.7 $mgNO_3^-\ l^{-1}$, phosphates below 0.35 mg $PO_4^{3-}\ l^{-1}$, dissolved oxygen oscillated between 0 and 10.1 $mgO_2\ l^{-1}$, $BOD_5$ was from 8.5 to 48 $mgO_2\ l^{-1}$ and more, as we several times used to small a dilution. Low values of dissolved oxygen and the highest

$BOD_5$ occurred during low water level; in October, November, December and March the oxygen content was higher, $BOD_5$ usually lower.

Seasonally though the improvement of the Reka quality was observed probably due to pre-purification in the factories Lesonit and Organic acids. But, from time to time the quality was extremely bad and we suspected that the water is retained and later released in bigger quantities from the industrial plants into Reka.

In autumn 1990 the production in the factory of the Organic acids was stopped and very soon the positive changes in the Reka river were seen. The abatement of pollution indicated what a burden were the waste waters from the factory of Organic acids, in particular huge amount of undegradable pollution. Within the Karst Research Institute we have analysed Reka in Mahorčičeva jama several times in connection with water studies in Škocjanske jame.

On December 18, 1991 at low water table COD was 7.5 $mgO_2\ l^{-1}$, on June 6, 1992 the COD was 6.1, $BOD_5$ was 2.3 $mgO_2\ l^{-1}$ at 100% of saturation with oxygen. On October 8, 1992 at medium water level the COD was 6.9 $mgO_2\ l^{-1}$, on October 23, 1992 at high water level we have measured the COD of 3.3 $mgO_2\ l^{-1}$. The nitrates and chlorides concentration was at all the measurements below 5 mg $l^{-1}$, o-phosphates were below 0.12 mg $l^{-1}$.

In considerably less loaded river the autopurification processes started again. During extremely low water level in July 1993 we analysed the water of Reka in Svetinova dvorana again. COD was 12, $BOD_5$ 2 mg $O_2\ l^{-1}$ only. Chlorides and nitrates were low 5 mg $l^{-1}$ as they were in 1992 too, and nitrates were below 0.01 mg $l^{-1}$. The ration COD/$BOD_5$ was 6 even which is probably due to absence of dilution because of low water table. The decomposi-

TABLE 2

Reka river quality

| | Il.Bistrica | Matavun |
|---|---|---|
| 1974-79 | | |
| $BOD_5$ ($mgO_2\ l^{-1}$) | 100 - 200 (400) | 10 - 15 |
| COD " | 160 - 300 (700) | 25 - 80 |
| Dissol. Oxigen " | 0.1 - 0.5 | 5 - 8 |
| COD/$BOD_5$ | 1.5 | 2.5 - 5 |
| 1981-82 | | |
| $BOD_5$ ($mgO_2\ l^{-1}$) | 2.9. - 8.5 | |
| Dissol.Oxigen " | 10.0 - 12.1 | |
| 1991-92-93 | | |
| COD ($mgO_2\ l^{-1}$) | 3.3 - 12 | |
| $BOD_5$ " | 1.3 - 2.3 | |
| COD/BOD | 2.7 - 6 | |

tion of degradable substances was all the same successful while the one of the non-degradable components obviously less. At high water level in October 1993 the COD was 7, $BOD_5$ 1.3 $mgO_2 l^{-1}$, the ration $COD/BOD_5$ was 5.4. All results are in tabel 2.

Literature treating the autopurification ability and its results at karst waters flow over the surface and in the underground (Preka & Preka-Lipold 1976; Sket & Velkovrh 1981; Kogovšek 1991) and the knowledge of the effects at vertical percolation of the polluted water through the carbonate rocks (Kogovšek 1987) gives the basic information on otherwise not well known proceeding of the autopurification processes in the underground.

The above mentioned results indicate rather improved quality of the Reka river on its ponor to Škocjanske jame. Pollution flowing into the river is in some extent eliminated on its way to the ponor. The actual ratio $COD/BOD_5$ nevertheless shows the presence of hard degradable pollution due to gradual washing off out of the river bed after purification of degradable substances, or else it is a property of the actual waste waters. In any case the improvement is considerable but we must find out the source of hard degradable pollution.

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# ČLOVEKOV VPLIV NA ŠKOCJANSKE JAME

## Povzetek

Onesnaževanje kraškega površja ogroža tudi kraško podzemlje. Odpadne vode, ki se stekajo v kraške ponikalnice se tako pojavljajo v podzemju, kot tudi onesnaženje ki prenika s kraškega površja. Takih vidnih primerov je kar precej, zato je pomembno preučevanje vrste onesnaženja, hitrosti pojavljanja v podzemlju ter procesov samočiščenja v krasu, kar je pomembno za varovanje zalog kraške pitne vode, kot tudi kraškega podzemlja kot naravne dediščine.

Gradnja industrije v dolini Reke, predvsem v Ilirski Bistrici, je povzročila postopno slabšanje Reke do leta 1966, ko so zaradi slabe kvalitete ustavili zajetje Reke za vodovod v Divači. To je sprožilo tudi sistematične raziskave kvalitete Reke v letih 1969-79, ki jih je opravil Inštitut Boris Kidrič. Reka je imela v Ilirski Bistrici visoko kemijsko potrebo po kisiku (KPK) in biokemijsko potrebo po kisiku ($BPK_5$), razmerje KPK/BPK je znašalo 1.5 in ni vsebovala raztopljenega kisika. Tako je bila Reka na odseku Il.Bistrica - Nova Sušica praktično odvodni kanal. Do Matavuna, ponora v Škocjanske jame, se je njena kvaliteta izboljšala, vendar je voda vsebovala še vedno le malo raztopljenega kisika, razmerje KPK/$BPK_5$ pa je znašalo 2.5 do 5, kar je kazalo na znatno večji delež težko razgradljivih in nerazgradljivih organskih nečistoč v primerjavi z lahko razgradljivimi. Najbolj neugodne razmere so nastopale v Matavunu ob intenzivnih nalivih, ko se je občasno močno poslabšala kvaliteta Reke na ponoru, saj je vodni tok spiral organsko onesnaženje iz struge v zgornjem toku Reke in ga nosil s seboj, tako, da je prišlo do njegove sedimentacije tudi globoko v kraškem podzemlju, Škocjanskih jamah in dalje v Kačni jami, kjer pa so se nadaljevali anaerobni procesi razgradnje. Kasnejše spremljanje kvalitete Reke, posebno po letu 1990, ko je prišlo do vidnega izboljšanja Reke zaradi zaprtja tovarne TOK v Ilirski Bistrici, je pokazalo znatno izboljšanje njene kvalitete in upad vrednosti merjenih parametrov, tako da so v Reki lahko zopet potekali samočistilni procesi. Vendar pa je bila ob nizkem vodostaju v letu 1993 KPK kar 12, razmerje KPK/$BPK_5$ pa 6, kar nakazuje sorazmerno večji delež težko razgradljivih organskih snovi v primerjavi z lahkorazgradljivimi.

Vzorčevanja in analiziranje preniklih voda v različnih delih Škocjanskih jam so pokazala v večini primerov še čisto vodo, z izjemo curka v Tihi jami, ki ima povišane nitrate zaradi intenzivneje obdelane njive na površju ter curkov v Mahorčičevi in Mariničevi jami. V te curke priteka tudi odpadna voda iz naselja Škocjan na površju po prenikanju skozi 50 do 80 m debel jamski strop. Očitno je količina odpadnih voda majhna, saj so ob suši le posamezna kapljanja. Ob dežju pa se pojavljajo v jami večji curki onesnažene vode, ki kljub precejšnjemu razredčevanju dosega do 85 mg$NO_3^-$ $l^{-1}$, do 5.5 mg $PO_4^{3-}$ $l^{-1}$, do 53 mg $SO_4^{2-}$ $l^{-1}$ in do 16 mg $Cl^-$ $l^{-1}$ ter KPK do 8.7 mg $O_2$ $l^{-1}$ in $BPK_5$ do 2 mg$O_2$ $l^{-1}$. Hitro in direktno prenikanje odpadnih voda skozi jamski strop onemogoča učinkovito samočiščenje, zato bi bilo potrebno odpadne vode na površju čistiti, odtok očiščene vode pa speljati izven območja jam, kjer bi v karbonatnem masivu prišlo do dokončnega samočiščenja te vode.