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Water chemical composition of the river Váh

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Abstract. The results of this study show a deterioration in water quality downstream of the Váh River, under WWTP Hrboltová, sampling sites RK5 and RK6. Indicators such as COD, TDS, COND, S, SO_4^{2-} Cl, NaCl and PO_4^{3-} visibly growing under WWTP (RK5, RK6). This deterioration is mainly correlated with wastewater from the paper industry, which WWTP processes, but also partly wastewater from aglomeration. These substances are highly toxic to fauna and flora and thus also for humans to which they get through the food chain. The paper industry produces very toxic compounds – dioxins and furans that have carcinogenic effects. This water should not be used for irrigation, because soil contamination could occur.

Key words: waste water, paper industry, chemical compostion of river

Introduction

Water pollution from the paper industry determines the material used for the production of pulp, the type of pulping and bleaching. Most water is consumed in cooking which is the major source of pollution. Water pollution includes washing water, water from the evaporator, cellulose bleaching and dewatering. Waste water is organically and inorganically contaminated, has a high content of insoluble solids, especially fibers, is warmed and slightly browned (Geffert *et al.* 2000). To produce one ton of paper the factory uses 200 m^3 of water. Production of one ton of paper represents pollution from 200 to 900 inhabitants per day (Šudý *et al.* 2010). The characteristics of waste water from the paper industry are shown in Table 1.

The waste water from individual production processes is shown in Fig. 1. In the process of pulping, resin acids, unsaturated fatty acids, terpenes, alcohol and chlorinated resin acids enter the waste water. Pulping process produce the largest amount of waste water. Resin acids are found in tree resin and in the tree bark. These are weak acids but are toxic to fish. The most toxic resin acid is methyltestosterone. Unsaturated fatty acids are found mainly in soft wood and are also toxic to fish. In the process of bleaching, chlorates, dioxins, furans, chlorophenols, acetone and other substances enter the waste water. These substances are considered to be the most dangerous. Dioxins and furans belong to chlorinated aromatic compounds. They are insoluble in water and are very slowly decaying. Elimination from the human body takes approximately 7.5 years. They have carcinogenic effects.

Mondi SCP a.s. Ružomberok is one of the largest manufacturing companies of Mondi Group and the largest integrated company for the production of paper and pulp in the Slovak Republic, with a production capacity of 560,000 tons of uncoated paper, 66,000 tons of packaging paper and 100,000 tons of dried pulp offered for sale (MONDI 2016). SCP a.s. Ružomberok is currently the most modern pulp and paper combine in Slovakia. With its production of more than 200,000 tons of pulp and almost 270,000 tons of production of paper, cardboard and other paper products, Mondi occupies a leading position in this industry within Europe (Geffert *et al.* 2000). In addition to paper production, the company is engaged in the sale of surplus energy, which means that the company supplies heat to the town. Aside from pretreatment of waste water from production Mondi SCP a.s. also operates the sewage treatment plant Hrboltová where industrial water from Mondi SCP, urban industry and municipal water from the city and surrounding villages are cleaned (Vince *et al.* 2010).

Before the waste water from the pulp and paper production is fed to sewers, sewage collectors that are on Mondi SCP properties, it is cleaned in three facilities. The first device processes waste water from pulp production. This waste water is acidic and alkaline. It is treated by the addition of calcium milk which neutralizes the waste water and also by the addition of flocculant. This purification is carried out in the pipeline before entering settling tanks where the sludge is separated, which was created by the flocculant. Then the waste water is drained into chemical pipelines and sewers and from there goes on to WWTP Hrboltová. The second device processes the waste water from the line for paper production. This water is chemically treated with coagulant and flocculant prior to purification. Cleaning is performed in clari-flocculator. After purification, the water is drained by pipeline to sewers and then into WWTP Hrboltová. The third device is composed of two processes. The first is coagulation, followedby sedimentation that takes place in two sedimentation tanks, where the sludge is separated from the water. Purified water is discharged

Parameters	Concentration	Parameters	Concentration
pH	8.4	COD (mg/L)	1,810
Color (units)	1,736	TSS (mg/L)	958
Lignin (mg/L)	452	TDS (mg/L)	1,524
AOX (mg/L)	32	BOD (mg/L)	960

Table 1. Waste water characteristics of the paper milleffluent.

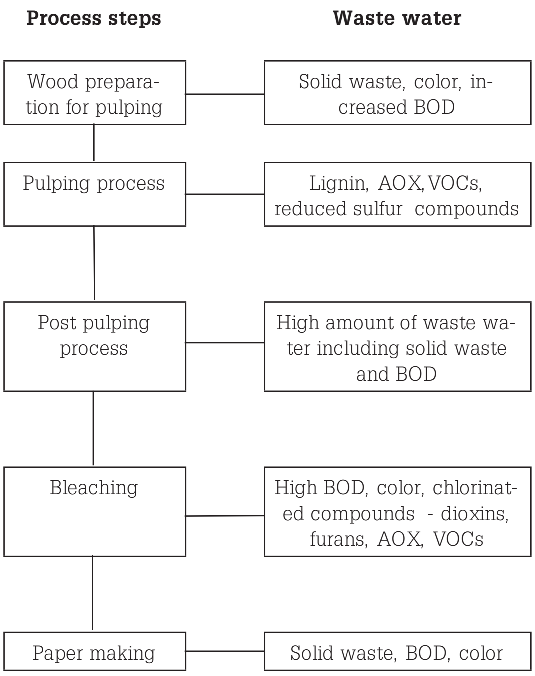

Fig. 1. Steps for paper making and types of waste water (Pokhrel and Viraraghavan 2004).

througha pipeline into the WWTP Hrboltová (Fig. 1). The joint waste water treatment plant (WWTP) in Ružomberok was built between 1977 and 1982. In 1982 it was commissioned as a joint waste water treatment plant for treatment of sewage from the town of Ružomberok and surrounding communities as well as for the treatment of industrial waste water from industrial enterprises located in the Ružomberok area. WWTP is a mechanical–biological treatment plant with sludge management. The complex is located approximately 400 metres outside of the inhabited area of Hrboltová. It is bordered on one side by the River Váh and on the other side by railway.

WWTP Ružomberok is a mechanical–biological WWTP with sludge management. Mechanical cleaning consists of a gravel trap, coarse hand-wiped and mechanically wiped rakes and sand traps. Mechanical pre–treatment includes an input thread waste water treatment plant and a measure of the amount of incoming water. The quality of waste water, which flows into the waste water treatment plant, is analyzed. The temperature, pH, COD and conductivity are detected. Pre–treated water proceeds to a mechanical cleaning consisting of four steps. From activation, the water enters to circular sedimentation tanks. In WWTP Ružomberok, there are eight tanks and between 5 and 8 of these are operated as needed. From dosing tanks, the purified water is piped into the facility. It is monitored for quality and the quantity released into the River Vah is measured.

Quality monitoring is conducted by pH, temperature, COD and BOD indicators. The specialty of WWTP is an underwater ejector that discharges treated water to the recipient. They were able to eliminate the formation of foam on the surface of the recipient prior to leaching from the WWTP. The process of sludge management consists of a gravity thickener for primary sludge thickening, two pieces of mechanical thickeners for excess sludge, mechanical sludge dewatering and chemical sludge treatment. Dewatered sewage sludge is sanitized by adding lime and zeolite as part of chemical hygienization. The annual production of hygienisated sewage sludge of WWTP is about 26,000 tons (Gejdoš and Derco 2001).

Biological treatment of WWTP consists of activation with separate sludge regeneration. To quickly remove organic contamination they use the accumulation capacity of activated sludge and the absorption of undissolved forms of pollution after primary sedimentation.

Material and Methods

Ružomberok is the district's major town. It is located in the Žilina region. Ružomberok district has an area of 646.83 km^2 and 57,543 residents live there (www.naseobce.sk 2011). The southern parts extend deep into the territory of the Great Fatra, Low Tatras and only the immediate vicinity of the town lies in Liptov basin (www.ruzomberok.sk 2012). Paleogene fill in the basin forms Hutianske and Zuberecke formations (sandstones, calcareous claystone), in the South-East and South-West basin connecting with the Low Tatrasborovske formations (conglomerates, sandstone, limestone, breccia). The basin is situated at an altitude of 470-900 m. Sediments angle down from the mountains towards the river Váh. Upland, with relative heights of 30-150 m is the middle of the basin of low highlands (Lukniš *et al.* 1972). The river Váh is created by the confluence of White Váh, with source water in High Tatras in Green mountain lake (2,206 m a.s.l.) on the southwest side of Kriváň and Black Váh, with source water

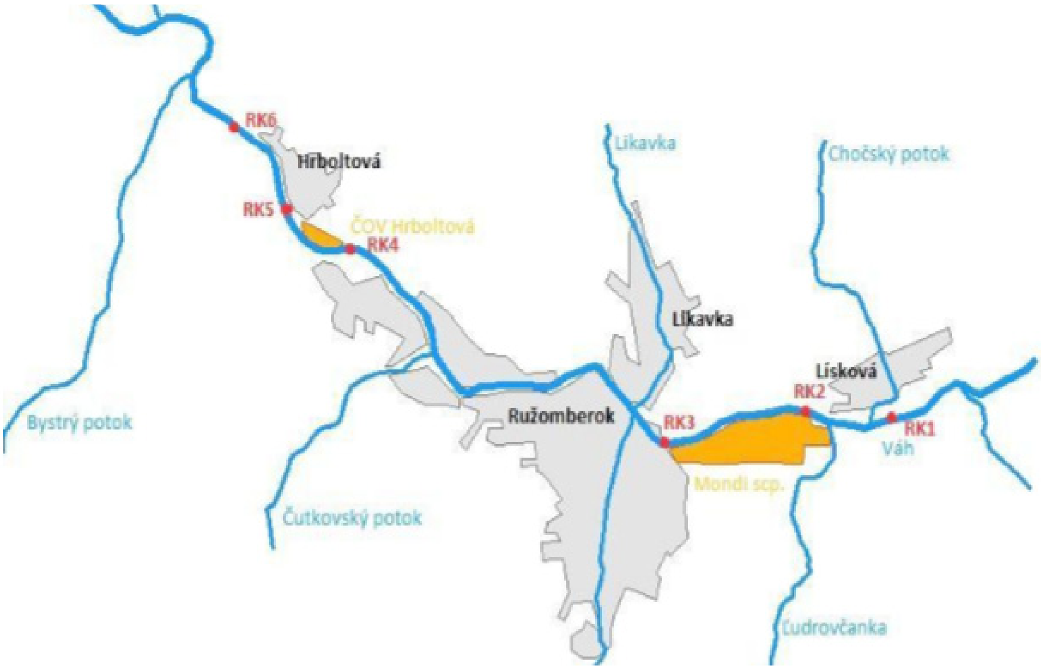

Fig. 2. Sampling sites (RK1-6) of water quality in area of Ružomberok. Orange area-paper mill factory MONDI SCP a.s.; gray – urbanarea.

in Low Tatras under Kráľova Hoľa (1,097 m a.s.l.). According to the water management division, Váh flows into the Danube in Komárno. The Nitra river basin and Little Danube river basins are parts of the Váh River.

Sample collection was conducted from September 2011 to January 2017. The samples were collected from six sampling sites (RK1-6) on the River Váh (Fig. 2).

RK1 – The first sampling site is located at the beginning of the village Lisková, near the railway-line. Village Lisková is located in a suburban area of the town Ružomberok.

RK2 – The second sampling site is located near the artificial waterfall under which deletes water from paper industry of Mondi SCP a.s.

RK3 – The third sampling site is located in Ružomberok, near the railway station.

RK4 – The fourth sampling site (RK4) is located about 3 km outside of the town Ružomberok, in front of the WWTP Hrboltová.

RK5 – The fifth sampling site is located at the outskirts of the village Hrboltová, below WWTP Hrboltová.

RK6 – The sixth sampling site is located at the end of the village Hrboltová, near railway line.

Table 2 contains data on the number of samples colected and table 3 contains GPS information about sampling sites.

Physical parameters such as conductivity

	RK1	RK2	RK3	RK4	RK5	RK6	Total
January	7	7	7	7	7	7	42
February	5	5	5	5	5	5	30
March	4	4	4	4	4	4	24
April	5	5	5	5	5	5	30
May	4	4	4	4	4	4	24
June	5	5	5	5	5	5	30
July	6	6	6	6	6	6	36
August	5	5	5	5	5	5	30
September	8	8	8	8	7	6	45
October	10	10	10	10	10	10	60
November	8	8	8	8	8	8	48
December	5	5	5	5	5	5	30
Total	72	72	72	72	71	70	

Table 2. The data on the number of samples.

Locality	N	E	m.a.s.l.
RK1	49° 05.076’	019° 21.203’	484
RK2	49° 05.023’	019° 20.557’	480
RK3	49° 04.782’	019° 18.823’	474
RK4	49° 05.861’	019° 15.220	463
RK5	49° 06.021’	019° 14.648’	460
RK6	49° 06.535’	019° 14.055’	457

Table 3. GPS coordinates of sampling sites.

(CON), pH, total dissolved solids (TDS), dissolved oxygen (Ox), salinity and water temperature were measured by the Multi 3430 device (WTW GmbH, Weilheim, Germany) at each sampling site.

The samples were collected in sterile polyethylene bottles with a capacity of 700 mls from the center of the flow. Samples were transported for further analysis (ISO 5667 – 3 2003) into the laboratory of the Institute of High Mountain Biology, Žilina University.

Laboratory analysis

Using the YSI 9500 photometer, (YSI inc, Ohaio, USA) calorimetrical concentration of chloride (Cl-) nitrate (N – NO_3) sulphate (SO_4^{2-}) Cu total, phosphates (PO_4^{3-}) amonia ions (N – NH_3) and hardness ($CaCO_3$) were determined.

Chemical oxygen demand (COD) was determined by analysis of titration with potassium permanganate ($KMnO_4$).

Statistical analysis

Measured values of water quality were analysed by the Statistica 12 software (StatSoft, USA). Each measured variable was tested by one-way or two-way analysis of variance in relation to individual sampling site and months.

Results

The water quality in the Váh River was monitored from September 2011 until January 2017. Measured indicators are in Table 3.

Between the village of Lisková to the outskirts of the village of Hrboltová (RK1, RK2, RK3, RK4), the TDS ranged from 275.1852 mg/l (RK3) to 285.1229 mg/l (RK1) (Fig. 3), the conductivity ranged from 270.0615 μs/cm (RK2) to 274.4856 μs/cm (RK4) (Fig. 4), COD ranged from 3.608859 mg/l (RK2) to 3.977344 mg/l (RK4) (Fig. 5), salinity ranged from 0.051944 mg/l (RK2) to 0.082250 mg/l (RK4) (Fig. 6), Cl ranged from 6.067647 mg/l (RK2) to 7.077941 mg/l (RK1) (Fig. 7), NaCl ranged from 10.48305 mg/l (RK2) to 12.23559 mg/l (RK1) (Fig. 8), S ranged from 11.03333 mg/l (RK2) to 12.01667 mg/l (RK1) (Fig. 9), SO_4^{2-} ranged from 32.79710 mg/l (RK2) to 35.55072 mg/l (RK1) (Fig. 10), Cu ranged from 0.124854 mg/l (RK4) to 0.183146 mg/l (RK1) (Fig. 11). At the sampling sites RK3 and RK4, the pH is highest. The value of the ph at the sampling site RK3 is 8.425731 and at sampling site RK4 is 8.411902. At these two sampling points, the water is more alkaline than at other sampling sites. Pollution is likely to arise from insufficient purification of waste water releasted from WWTP Hrboltová. At the RK5 sampling site, the TDS concentration increased from 281.3729 mg/l (RK4) to 364.3263 mg/l and at the RK6, the TDS concentration slightly decreased to 355.9359 mg/l. Conductivity also increased from 274.4856 μs/cm (RK4) to 362.3083 μs/cm (RK5), COD from 3.977344 (RK4) to 5.778436 (RK5), salinity from 0.082250 mg/l (RK4) to 0.126887 mg/l (RK5), Cl from 6.632356 mg/l (RK4) to 8.364179 mg/l (RK5), NaCl from 11.23220 mg/l (RK4) to 13.97069 mg/l (RK5), S from 11.38333 mg/l (RK4) to 19.52542 mg/l (RK5), SO_4^{2-} from 33.17391 mg/l to 52.52941 mg/l (RK5) and PO_4^{2-} from 0.424386 mg/l (RK4) to 1.058596 mg/l (RK5). We found that the most pollution occurs at the RK5 sampling site, under the WWTP Hrboltová. Considering the amount of COD (CHSK), the values increased in the summer months at all localities, and decreased in winter. This was best exemplified locality RK2 where the river enters into the town in front of the paper mill factory.

Variable	Maximum	Minimum	Mean
Temperature (° C)	21.4300	1.4000	10.7956
ph	9.4000	7.6700	8.3465
COND (μS/cm)	524.3333	174.3000	299.4155
TDS (mg/l)	524.0000	22.0000	307.0106
salinity (mg/l)	0.3000	0.0010	0.0810
O_2 (mg/l)	16.5800	8.6000	12.0737
COD (mg/l)	14.1096	1.2536	4.4072
$CaCO_3$ (mg/l)	500.0000	11.0000	135.0827
N (mg/l)	4.0500	0.0310	0.7854
NO_3 (mg/l)	8.9100	0.1370	2.5328
NH_3 (mg/l)	1.5600	0.0010	0.1939
NH_4 (mg/l)	3.3000	0.0010	0.1945
Cl (mg/l)	25.5000	2.5000	7.0277
NaCl (mg/l)	42.0000	4.5000	11.9974
SO_4^{2-} (mg/l)	110.0000	9.0000	39.2512
S (mg/l)	36.0000	3.0000	13.7416
Cu total (mg/l)	1.0000	0.0010	0.1578
PO_4^{3-} (mg/l)	19.0000	0.0100	0.4464
P (mg/l)	1.3000	0.0100	0.1319

Table 4. Measured values from 2011 to 2017, maximum values, minimum values and average.

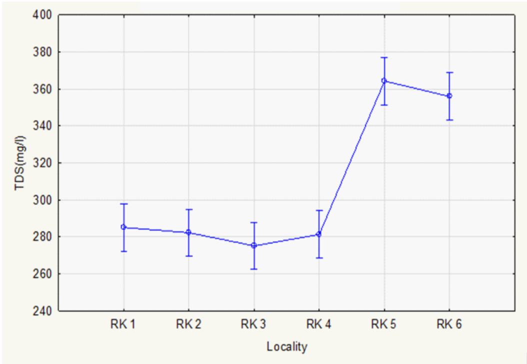

Fig. 3. Differences of measured values of total dissolved solids (TDS) in the Váh River.One – way ANOVA F (5, 423) = 39.480, p = 0.0000. TDS has visibly risen to RK5. There was the highest value - 364.326 mg/l.

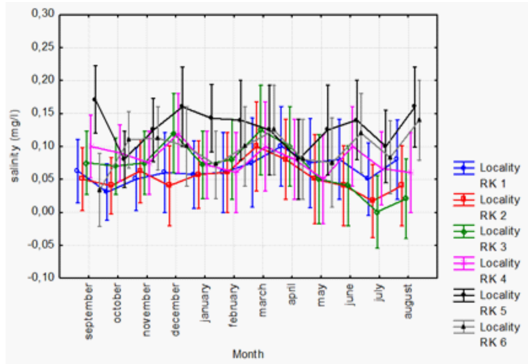

Fig. 6. Comparison of mean monthly salinity (mg/l) between localities, ANOVA. Locality (F = 10.27, p = 0.000) * Month (F = 1.33, p = 0.206) Interactions: F (55.357) = 0.756, p = 0.89790.

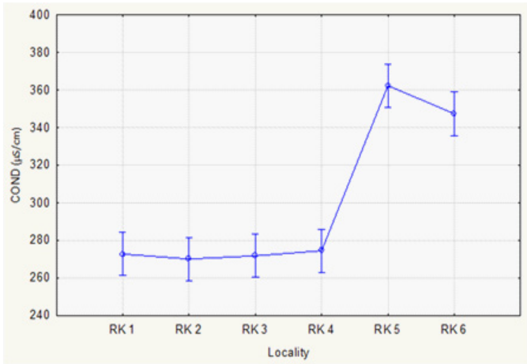

Fig. 4. Differences of measured values of conductivity (COND) in the Váh River. One – way ANOVA F (5, 423) = 54.071, p = 0.0000. The conductivity value increased at the RK5 (the highest value) – 362.308 µs/cm.

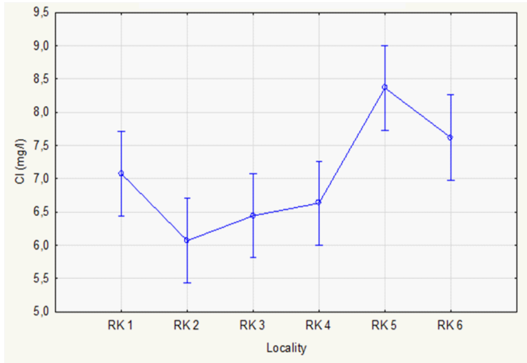

Fig. 7. Differences of measured values of chlorine (Cl) in the Váh River. One – way ANOVA F (5, 399) = 6.7882, p = 0.00000. The highest value was measured in RK5 – 8.364 mg/l.

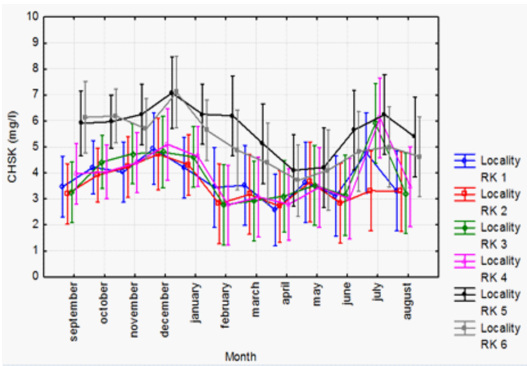

Fig. 5. Comparison of mean monthly COD (mg/l) between localities. ANOVA Locality (F = 19.07, p = 0.000) * Month (F = 6.84, p = 0.000). Interactions: F (55, 309) = 0.458, p = 0.999.

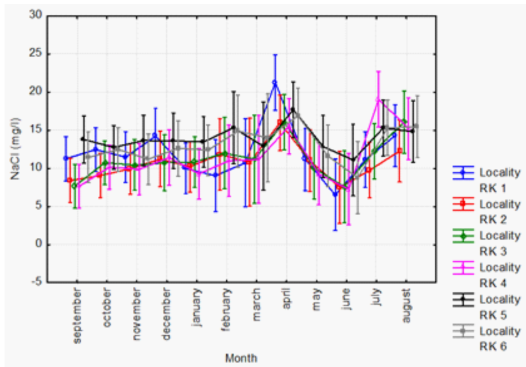

Fig. 8. Comparison of mean monthly NaCl(mg/l) between localities by ANOVA. Locality (F = 4.415, p = 0.001) * Month (F = 8.737, p = 0.000). Interactions: F (55, 279) = 0.672, p = 0.962.

At all sampling sites, the water was coldest in January and warmest in August (Fig. 12). The water at all localities was the most acidified from August to September, and alcalic water mainly occurred in May/June (Fig. 13). The amount of $CaCo_3$ was also highest in June (Fig. 14)

The highest mean values of oxygen were found in January and February, mainly at locality RK4. This effect is probably connected with inflow from the mountain river Revúca. Later during the year, the amount of oxygen decreases and then again increases in the autumn. The waters contain elevated amounts of oxygen during the winter cold period.

Nitrates and ammonia

The seasonal variation in N, nitrates and ammonia are presented in figures 15–19. Their variation is not site dependent and from this point of view, we may conclude that waste managment does not significanly influence the river chemistry. Elevated amounts of N in the waters were noticeable at all localities in February, while the

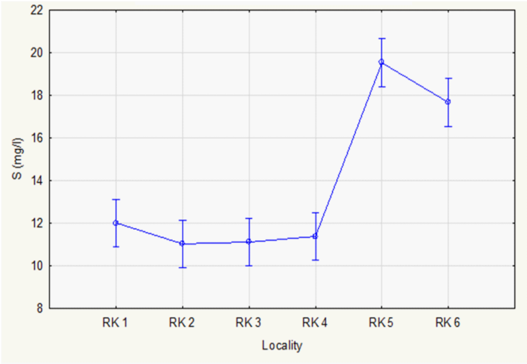

Fig. 9. Differences of measured values of sulphur (S) in the Váh River. One – way ANOVA $F(5, 350) = 44.245$, $p=0.0000$. The sulphur value rapidly increased at the RK5 – 19.525 mg/l.

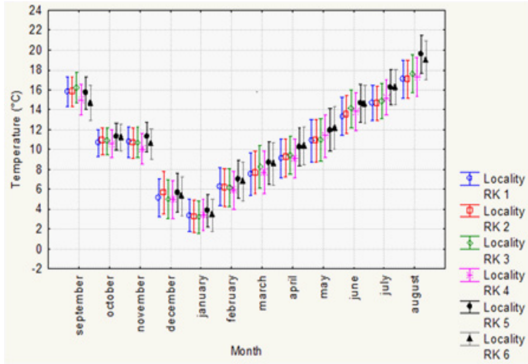

Fig. 12. Comparison of mean monthly Temperature (° C) among localities by ANOVA [Locality ($F=2.3$, $p=0.000$) * Month ($F=143.8$, $p=0.000$) Interactions: $F(55, 356) = 0.20042$, $p=1.0000$].

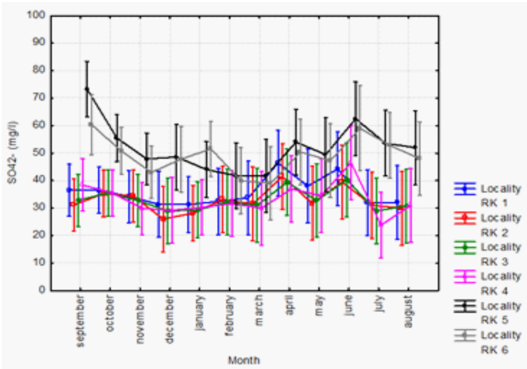

Fig. 10. Comparison of mean monthly SO42-(mg/l) among localities by ANOVA. Locality ($F=26.13$, $p=0.000$)* Month ($F=3.61$, $p=0.000$). Interactions: $F(55, 338) = 0.542$, $p= 0.997$.

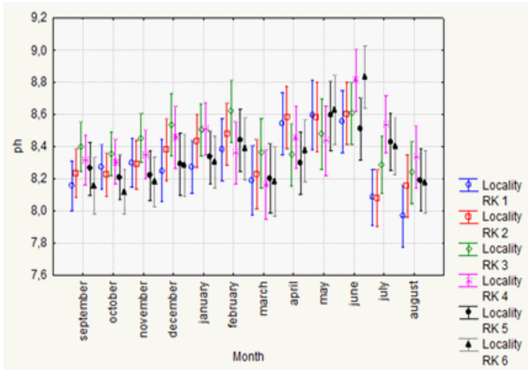

Fig. 13. Comparison of mean monthly pH among localities by ANOVA. Locality ($F=3.90$, $p=0.002$)* Month ($F= 12.75$, $p=0.000$). Interactions: $F(55, 357) = 1.1917$, $p= 0.17801$.

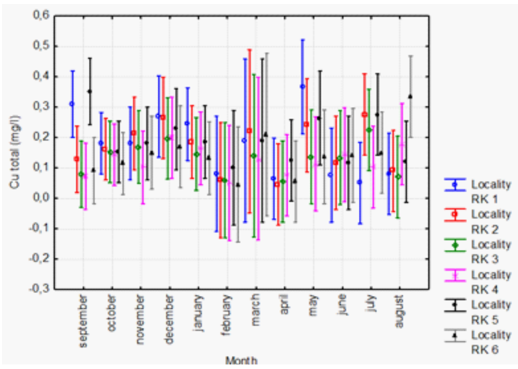

Fig. 11. Comparison of mean monthly Cu total (mg/l) among localities by ANOVA. Locality ($F=1.425$, $p=0.216$)* Month ($F=2.437$, $p=0.007$). Interactions: $F(55, 216) = 0.927$, $p=0.622$.

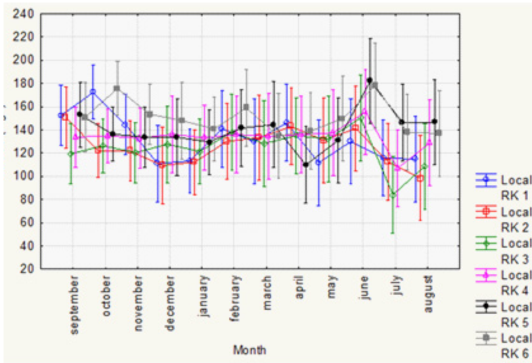

Fig. 14. Comparison of mean monthly $CaCO_3$ (mg/l) among localities by ANOVA. Locality ($F=4.628$, $p=0.001$)* Month ($F=2.563$, $p=0.004$). Interactions: $F(55, 339)= 0.68251$, $p=0.95743$.

amounts of NO_3, N-ammonia and NH_3 gradually increased in summer and autumn. Their rapid decrease started around October and lasted until the end of December.

Phosphorus and phosphates

The variation of both components does not reflect any differences among the sites of water collection or among the seasons. The increased amounts of P or PO_4^{3-} likelly depend on localized human activity (Fig. 20 and 21).

In Table 4 the principle component weights of the original measured variables are presented. The components (factors in the table) indicate mutual interactions among physico–chemical properties in the water samples. Highlighted numbers represent the link betweenthe most significant variables at each factor. Factors are usually independent, and there is a high probability this is caused by different environmental stressors.

The most serious synergic effect in the water ofthe

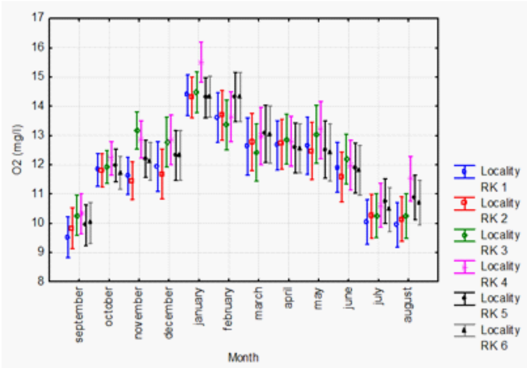

Fig. 15. Comparison of mean monthly O2 (mg/l) among localities, two-way ANOVA. Locality ($F=4.41$, $p=0.001$)* Month ($F=77.76$, $p=0.000$) Interactions: $F(55, 288) = 0.658$, $p = 0.969$].

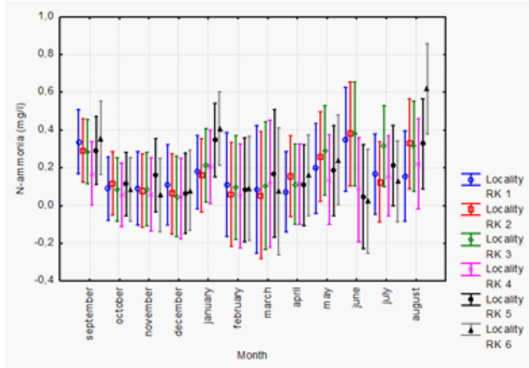

Fig. 18. Comparison of mean monthly N-ammonia (mg/l) among localities, two -way ANOVA [Locality ($F = 0.693$, $p = 0.630$)* Month ($F = 4.174$, $p = 0.000$) Interactions: $F(55, 279) = 0.464$, $p = 0.999$].

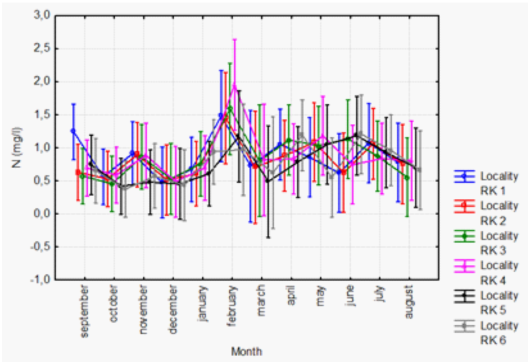

Fig. 16. Comparison of mean monthly N (mg/l) among localities: two-way ANOVA [Locality ($F = 0.430$, $p = 0.828$)* Month ($F = 4.479$, $p = 0.000$) Interactions: $F(55, 284) = 0.443$, $p = 0.999$].

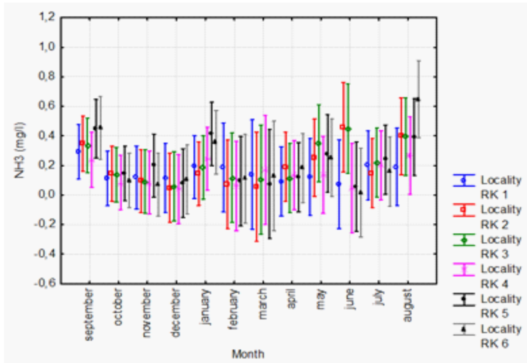

Fig. 19. Comparison of mean monthly NH3 (mg/l) among localities, two-way ANOVA [Locality ($F = 0.760$, $p = 0.579$)* Month ($F = 4.379$, $p = 0.000$) Interactions: $F(55, 279) = 0.45748$, $p = 0.999$].

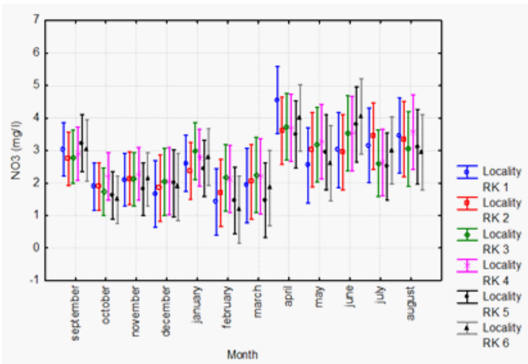

Fig. 17. Comparison of mean monthly NO3 (mg/l) among localities, two way ANOVA [Locality ($F = 0.42$, $p = 0.834$)* Month ($F = 12.17$, $p = 0.000$) Interactions: $F(55, 338) = 0.312$, $p = 1.000$].

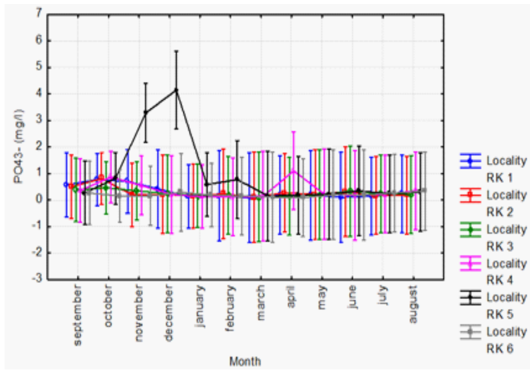

Fig. 20. Comparison of mean monthly PO43- (mg/l) among localities by ANOVA [Locality ($F = 1.742$, $p = 0.125$)* Month ($F = 0.960$, $p = 0.484$) Interactions: $F(55, 266) = 0.672$, $p = 0.961$].

river Váh is mean value of sulphates, sulphur and carbonates that are affecting conductivity. This trend increased in the autumn months, and it was always higher at localities RK5 and RK6 than at the other four sites. In the summer months the levels of this synergic pollution were very intensive at the localities RK5 and RK6, while at the localities RK1 – RK4 were low (Fig. 21). The flooding out of ammonia and ammonia salts is a natural phenomenon, that varied between months, but not between localities. The lowest levels of ammonia occurred during the cold weather in winter, and the highest levels were recorded during the warm months, from May to September (Fig. 22).

The third factor reflects the seasonal variation in the amount of sulphates in synergic effect of TDS and COND. This phenomenon was evidently considerable at localities RK5 and RK6. The pollution was consistently high under the wastereatment plant and it increased, particularly during summer and autumn (Fig. 23).

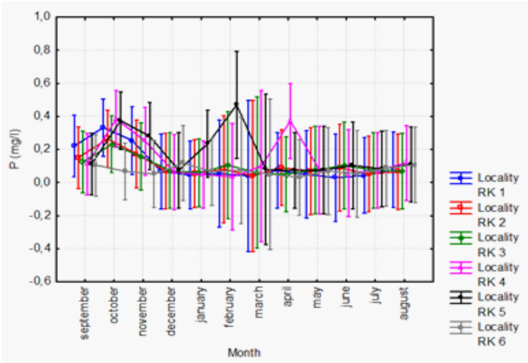

Fig. 21. Comparison of mean monthly P (mg/l) among localities. Two – way ANOVA. Locality ($F=0.864$, $p=0.506$)* Month ($F=2.428$, $p=0.007$). Interactions: F (55, 216)= 0.387, $p=0.999$.

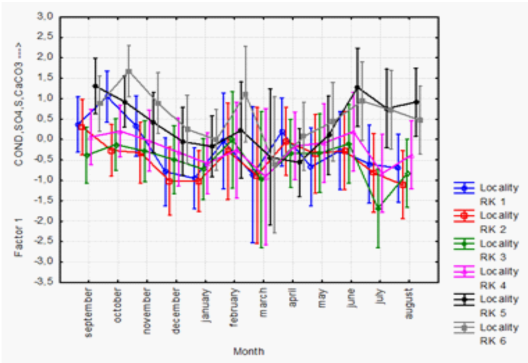

Fig. 22. Comparison of mean synergic effect of COND, SO_4, S, $CaCO_3$ among different localities and in different seasons. Two – way ANOVA of principal component 1 scores. Locality ($F=11.5$, $p=0.000$), Month ($F=5.9$, $p=0.000$), Interaction between locality and months: F (55, 210)=0.743, $p=0.903$. The samples from the sites RK5 and RK6 under the waste water treatment plant were highly polluted by sulphates. The effect increased in summer and autumn.

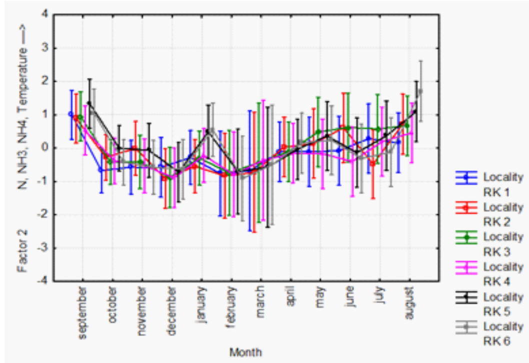

Fig. 23. Comparison of mean monthly N, NH_3, NH_4 between localities. Two way ANOVA of principal component 2 scores. Locality ($F=0.801$, $p=0.550$)* Month ($F=8.997$, $p=0.000$). Interactions: F (55, 210)=0.383, $p=0.999$. The variation of ammonia strictly depended on seasons. Amount of N, NH_3, NH_4 was low in the winter cold period.

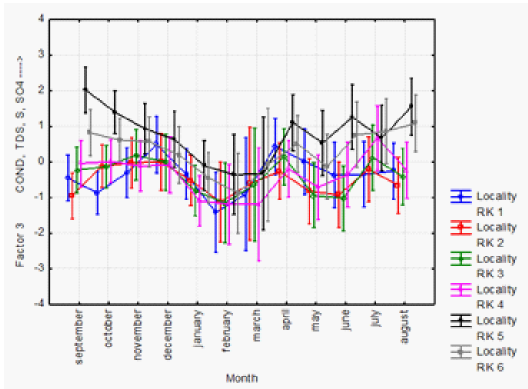

Fig. 24. Comparison of mean monthly COND, TDS, S, SO_4 among localities, two –way ANOVA. Locality ($F=15.31$, $p=0.000$), Month ($F=4.97$, $p=0.000$). Interactions: F (55, 210) =0.983, p=0,515.

Discussion

The overwhelming part of the River Váh is in an average ecological state with the exception of the areas above and below the reservoir Liptovská Mara – Bešeňová which are in good environmental condition. The bad chemical condition of the Váh River is in the part where the river is influenced by the town of Ružomberok and then in lower part of the flow of the Váh River (MŽP SR 2014). Although the River Váh is on the one hand in good or average ecological condition (SHMÚ 2008), it is clear from our results that WWTP Hrboltová has a significant impact on the quality of the water in sampling sites RK5 and RK6. Industry is among the largest polluters of surface water, and industrial wastewaters contain a wide range of substances that include organic substances, inorganic substances and specific pollution (Langhammer 2009). The paper and cellulose industry produces waste water with large quantities of organic substances, which are difficult to decompose. The composition of wastewater from the paper industry depends on the technology used. Two basic processes are used for pulp production - in alkaline or acidic ambient.

At the sampling sites in the center of the stream (RK3, RK4), the water in the flow is more alkaline than at the beginning (RK1, RK2) and at the end (RK5, RK6). Acidification occurs due to anthropogenic activity and geological background. Factors that affect the basicity include: type of dissolved inorganic and organic substances, TDS and the amount of bicarbonate in water (Garcilaso 2001).

Phosphorus in water comes from both communal and industrial sources. The main and stable source of phosphorus emissions from communal sources is phosphorus from fecal waste present in sewage effluent. The second component of phosphorus from communal sources is phosphorus contained in household washing and cleaning products (Langhammer 2009). Soluble phosphates have long been used in artificial fertilizers and subsequently flushed into the flow.

In the process of bleaching, chlorates, dioxins, furans, chlorophenols, acetone and other substances enter the wastewater. These substances are considered to be the most dangerous. Dioxins and furans belong to the family of chlorinated aromatic compounds. They are insoluble in water and are very slowly to decay. Elimination from the human body takea approximately 7.5 years, and they have carcinogenic effects. A substantial part of the chlorides in surface water, come from anthropogenic activity. An essential source is municipal waste water (Langhammer 2009). About 500 different chlorinated organic compounds have been identified in paper mill effluents. The high chemical diversity of these pollutants causes a variety of clastogenic, carcinogenic, endocrinic and mutagenic effects on fish and other aquatic communities in recipient water bodies (Sharma *et al.* 2014). According to Synáčková (1996). Humans release about 9 g of chlorides per day in their urine. During the winter, a small amount of chlorides also get into the river. Chlorine acts as an oxidizer and this explains the increase in the measured values at the sampling sites under the WWTP Hrboltová (RK5, RK6). Copper is found in water from natural and anthropogenic sources. Natural sources include geological activity, volcanic activity and watering. Anthropogenic sources include agriculture, metal production, and used pesticide.

To eliminate this pollution, it is necessary to improve wastewater treatment. One solution would be the introduction of tertiary treatment in WWTP and improvement of wastewater in enterprise complex.

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