QUALITATIVE ASPECTS OF CRIŞUL REPEDE RIVER

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ABSTRACT. Qualitative aspects of Crisul Repede River. The evolution of water quality over the Crişul Repede River is atypical because of natural and anthropic factors. The most significant factors are the geological substrate, and the settlements with their agricultural and industrial activity. The study was performed at three gauging stations for the period 1996-2006, taking into account the annual average values. The considered elements were: the discharge values, temperature, suspensions, oxygen regime, nutrients and phosphorus, taking into consideration their temporal and spatial variation. By comparing them with the admitted limits we could enroll them in various quality classes.

Keywords: Water quality, control section, spatial and temporal variation, admissible concentration, quality classes.

1. INTRODUCTION

The Crişul Repede River springs from the Gilău Mountains at 710 m altitude near the Izvorul Crişului settlement. It is a 2nd order left affluent of the Tisa River. It is a trans-boundary river, from its total length of 209 km, 171 km is found in Romania. It crosses a variety of landforms with alternating areas of narrowing and widening of its valley. Three sectors can be distinguished, upper course until Vadul Crişului, a main course until Oradea and a lower course until the confluence with Tisa in Hungary.

In the Huedin Depression the strong meandering gives it the characteristics of a lowland river. Here the slope is reduced from 15 m/km to only 3-5 m/km. In the gorge located downstream the river changes its physiognomy and dynamics having upper course characteristics. At its mouth the river slows down again and it's characterized by a wide meadow and terraced, with average slope of 3 m/km.

The catchment area has 2986 km^2. It is strongly asymmetrical because of the numerous left tributaries with significant discharge and length (Călata, Henţ, Drăgan, Iad), the right tributaries are few and short.

2. WATER QUALITY INFLUENCING FACTORS

2.1. Physico-geographic factors

The geological substrate presents a remarkable variety. The crystalline and eruptive bedrock of the mountains, does not allow significant infiltration and erodibility. In the hills and depression the characteristic is the alternations of hard

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and soft rocks (shale, andesite, rhyolite, sandstone, clay, marl). In the plain the young sedimentary rocks have a high permeability, allowing an active exchange between surface waters and the groundwater.

The landscape is varied and diverse due to it petrography and the selective erosion. The main tributaries descend from the Vlădeasa Masiv, Bihor, Gilau and Piatra Craiului Mountain. The main course of the Crişul Repede River drains the Vad, Ciucea-Negreni, Bratca and Borod depressions.

These are alternated by narrower parts at the confluence with the Plopişului and Vad River and then at the epigenetic gorge between Bologa and Vadul Crişului settlements. Here it crosses a karst region with landforms characteristic. In the Crişuri Plain the river leaves the contact area having low sector characteristic, but it's dammed.

The climate is influenced by the orographic barrier of the Apuseni Mountains. In the upper basin the air masses bring heavy rains and lower temperatures than the normal climatic background. Heavy rains, around 1000 mm, result in runoff rich tributaries which drain the mountain region. In spring this is amplified by snow melting and this can lead to flooding. In summer the convective circulation on the western slopes generates heavy rains. A particularity is given by the winter rains, which are due to the oceanic climate influence.

The discharge is influenced by the water supply types, the catchments elongated form and the asymmetry towards the collector. In the upper course the tributaries supply is moderately nival (snow). With the loss of altitude it becomes moderately rain supplied and then predominantly in lowlands. In the karst zone the underground contribution becomes predominant.

At its spring the discharge is small and the river meanders with a low course characteristic. After the confluence with Călata, Henţ, Drăgan and Iad tributaries the discharge raises significantly reaching mountain river characteristics.

The runoff regime type of the Crişul Repede River is High Carphatic and West-Carphatic which is reflected in the quite balanced seasonal discharge: 35% spring, 27% fall, 24% winter and 14% in summer. In specific discharge distribution we find the influence of the relief, the orientation and the air masses general circulation.

Soils influence the runoff by infiltration and drainage. In the mountains we find soils with are rich in humic materials and this leads to a high degree of acidification. In poorly drained areas where groundwater is shallow wet leachates chernozems predominate.

The vegetation, especially the forest, influences significantly the snow preserve and the redistribution of leakage in time, in the catchment the forest cover 1286 km^2. In the mountains we meet coniferous forests alternated with meadows. In lower parts, in depression, the broadleaf forests are represented by Beech, Oak, Holm and Turkey Oak.

2.2. Anthropic factors.

The human presence in the Crisul Repede catchment leads to major changes in the original landscape and the water quality influencing environment. The settlements evolutions lead to the decrease of forests and increase of agricultural areas. The Huedin, Ciucea, Aleşd and Oradea cities represent important sources of pollution. Fifty-four sources of pollution are monitored in the catchment, most notably Sinteza Co., Florelia Co., Santanderi Co., Androni Co. of Oradea, some from Aleşd and Huedin, and certain even in some communes.

The hydro technical and hydropower managements started from 1970 lead to significant changes in the rivers flow regime. These managements have expanded both in the mainstream and the tributaries. The current situation presents four hydrotechnical units: Leşu on the Iad River, Drăgan on Drăgan, and on the main course Tileagd and Lugaşu. To these we have to add the industrial water intake and water plant, both in Oradea. The system also includes the groundwater drainage channels from the plains.

3. METHODS AND DATA BASE

In the Crişul Repede catchment there are 19 hydrometrical stations and five of them are on the main course. In the present study we used data from three representative gauges covering an eleven year period (1996-2006). The first gauge from Şaula, is situated at the exit from mountain area, at a distance of 20 km from the spring. The Oradea hydrometric station is at the contact between the depression and the plains, in the maximum potential pollution zone. Tărian station is monitoring the river's water quality before leaving the country.

The analysis of the water body's qualitative indicators was carried out both in space and time. The analysis in time was based on Crişul Repede annual and multiannual water quality assessments from the mentioned period. Spatial distribution of the indicators is based on processing and interpreting the stations annual data. We emphasized main, minimum and maximum values as warnings of possible extreme phenomena and events. We studied the cases of maximum permissible concentrations exceeds (MPC).

4. RESULTS

4.1. Discharge

Discharge significantly influences the water quality by dilution. The relatively small values in the upper course increase significant after receiving the strong left tributaries, reaching 22.5 m^3/s at Oradea. Downstream from the town the increase is much slower, by 3.5 m^3/s, at Şaula the discharge is very small, not exceeding 1 m^3/s. The evolution during the year reflects the characteristics of the natural runoff regime. Significant high average values were in 2001, when after a snowy winter and a rainy summer, the amount of water doubled. In Oradea the flow variation is significant, with peaks in 1996, 2000 and 2006 and minimum in

1998 and 2003. The variation interval is strongly influenced by the dams in the catchment, the runoff regime is controlled.

At the Tărian gauge, Crişul Repede reaches the highest discharge values from the country (more than 43 m^3/s). Except for 1997 and 2006 when the tributaries from the Plopiş Mountains were not allowed to supplement the main course runoff.

4.2. Water temperature

The normal increasing trend of water temperature (from spring to mouth) is well evidenced during the main course because it is directly influenced by the landform in which the gauge is. Thus the lowest average values were recorded at Şaula (10 ºC) and the highest in Tărian (12 ºC). But there are some exceptions in 1999 and 2005 due to local factors. In terms of extreme values, they are between 14.7 ºC in 1997 at Tărian and 6.1 ºC in 2005 at Şaula.

4.3. Hydrogen ion concentration

At Şaula the water is slightly acidic, with pH values between 7.8 and 8.3, given by the presence of bicarbonates and hydroxides. The highest values are observed between 2000 and 2003. Downstream appears a decreasing trend under the influence of the limestone canyon and the urban waste waters. After 2003 the values increase slightly over 8.0 and then stabilize (Fig.1.a).

The variation interval is not very large, ranging from 8.3 at Şaula in 2000 and 2003, and 7.4 at Tărian in 1999. The average values don't fall below 7.7 due to the massive limestone gorge. Annual evolution of the pH values is proportional to the increase in discharge, meaning proportional with the dilution phenomenon of calcium ion concentration.

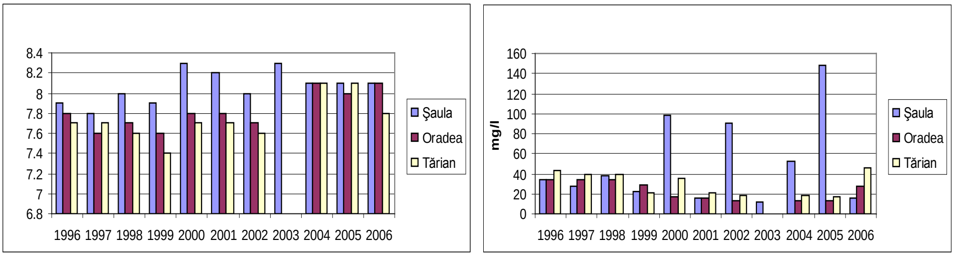


Fig.1. a) hydrogen ion concentration and b) suspended materials

4.4. Suspended materials

The general trend is descending until 2003, after which concentrations increase again. The suspended materials quantities are excessively high in 2000, 2002 and 2005 at Şaula (90 mg/l). In the remaining years at all stations the values are below 40 mg/l. Downstream there is a decreasing trend in concentration. After Oradea due to industrial activities and sewage the quantities of suspended materials increase. Therefore at Tărian are the highest recorded values in nine years out of eleven. The average yearly suspension is 23 mg/l in Oradea and 30 mg/l at Tărian.

Along the longitudinal profile of the river we can observe that the main sources of suspended materials are not natural, but are due to human activities. The variation interval is very high and significantly anthropic: the maximum 148.7 mg/l was registered in 2005 at Şaula, and the minimum at Oradea with only 12.8 mg/l in 2005 (Fig.1. b).

4.5. Oxygen regime

Dissolved oxygen has a natural evolution along the main course, being in a slight decrease from the spring to its mouth, with an average variation interval of 3 mg/l. the values at Şaula show the most oxygenated water throughout the study period, and excel in 2004 with a maximum of 14 mg/l. At Oradea, this indicator is relatively homogeneous around 10.5 mg/l. At Tărian the oxygen shows a slight sinuosity with two peaks in 1999 and 2005. In the first seven years the difference between the amount of dissolved oxygen at Tărian and Oradea sections is the most pronounced, as a result of industrial activity that enriches the water with oxidizable substances. The 2005 year was the most balanced, with almost identical values (11.8 - 11.9 mg/l).

In the study period the annual values range between 13.6 mg/l and 8.9 mg/l. the values of the dissolved oxygen is sufficient (more than 7 mg/l) to fit the best water quality class (fig.2. a).

BOD_5 value vary sinuously along the river, the lowest records are in Oradea's section. It is a special case, because this shows that in the upper course and near the border the decomposition of organic matter is enhanced. The cause must be found in the contaminated water intake upstream of Şaula and downstream of Oradea. At Tărian the amount of BOD_5 has a significant increase due to industrial activity that facilitates biochemical decomposition. The extreme values range between 1.8 mg/l in 2005 at Oradea and 4.7 mg/l in 1997 at Tărian.

At Şaula section the amplitude of variation is 1.77 mg/l, with a maximum of 4.23 mg/l in 2004. At Tărian in the first half of the study period are measured the highest concentrations, this is then followed by a decrease under the values in the upper sector.

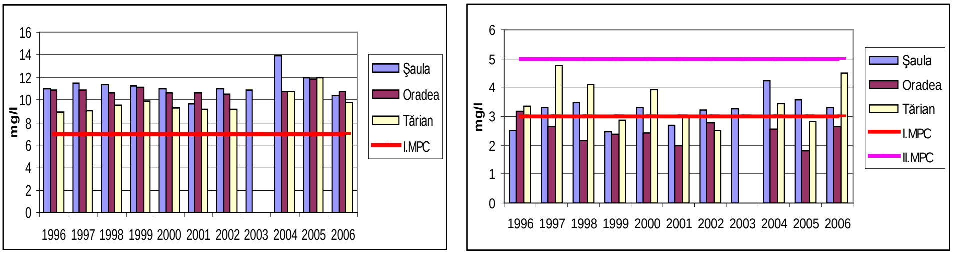


Fig.2. a) dissolved oxygen and b) BOD_5

In terms of maximum permissible concentrations there are problems in each section, but in different years. In Oradea the threshold of 3 mg/l is exceeded just in the first year of study. At Şaula the threshold exceeding frequency is 8 of 10 years, and at the Tărian is 7 of 10 years. At both stations this is due to the high percentage of urban sewage from upstream (Izvorul Crişului respectively Oradea). Generally the BOD_5 fits is in the 2nd class, which means values falling between 3 and 5 mg/l (fig.2.b).

COD-Mn in most years has the highest values at Şaula (3-4 mg/l). In Oradea's section is a significant drop, which is followed then by a minor increase due to slower oxidation or smaller quantities of oxidizable organic substances. The variation is between the maximum of 5.5 mg/l and minimum of 1.9 mg/l.

In Şaula's section the variation is relatively constant and high compared to local conditions. Lower values were reported in 1999 and 2006. At Tărian section the values are decreasing at the study period start, with a minimum of 2.3 mg/l in 2000, then appears a slowly rising trend (fig.3. a).

In terms of water quality only the maximum of 5.45 mg/l at Oradea rises over the 1st quality class threshold. This sudden increase in the concentration of COD-Mn, compared to the other years and neighboring sections, denotes an accidental pollution.

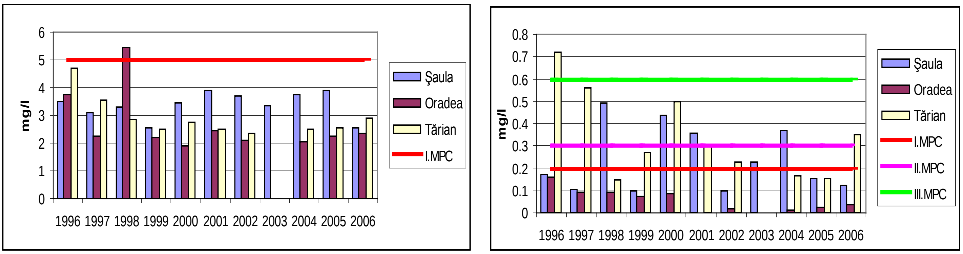


Fig.3. a) COD-Mn and b) ammonia

4.6. Nutrients

The evolution of ammonia in the longitudinal profile is sinuous. In Şaula section the variation reaches 0.4 mg/l. This variation decreases significantly in the second section, and then at the third gauge is much higher than at the first. The extremes range between 0.7 mg/l and 0.003 mg/l.

At the first section in the average values variation we distinguish three peaks. The water charging with ammonium at Oradea is low throughout the study period. Tărian has again a sinuous evolution. Also there is a maximum of over 7 mg/l in the first year, which may be regarded as an accidental pollution.

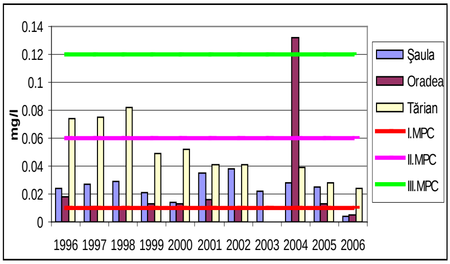
Crişul Repede in terms of ammonium load presents some problems. Qualitatively it fits in classes ranging from 1st to 3rd both in time and space. In time, 2005 is the only year without quality problems on this indicator. For the second class the threshold of 0.3 mg/l is exceeded in eight years. The year 1996 is the only one in which the limit of the 3rd class (0.6 mg / l) is exceeded at Tărian. Along the river the 2nd class limit has been exceeded four times at Şaula and Tărian (fig.3. b). The best situation is at Oradea where the average falls in the first class. Large fluctuation of concentration may come from decomposition of organic substances and/or are due to industrial-waste.

Nitrites concentration varies like the ammonium regarding its sinuosity and minima from Oradea. The variations amplitude is lower at its spring that at its mouth, demonstrating the effects of human activity. Maximum value is 0.13 mg/l, while the minimum recorded is only 0.004 mg/l.

Şaula presents small variation amplitude in its average values over the study period, with extremes in 2002 and 2006. The relative uniformity in concentrations at Oradea is justified by crossing a relatively natural habitat. The last gauge excels in much higher values than the others in every year.

In the longitudinal profile only the first sector falls in the first-class quality, and only for a short period. Most of the values correspond to 2^{nd} class. The last section around the mouth falls in the third class (fig.4. a).

Regarding the temporal variation, the 2^{nd} class is the most representative. Only in the years 1998 and 2006 the first class (0.01 mg/l) concentration was not exceeded. The worst situation appears in 2004, when the limit of 0.12 mg/l was exceeded at Oradea due to an accidental pollution.



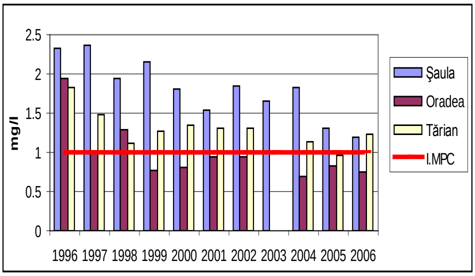


Fig.4. a) nitrites and b) natrates

Nitrates have a greater variation interval in different sections than the previous indicator: at Şaula 1.17 mg/l and at Tărian 0.87 mg/l. The extreme concentrations are registered at Şaula (2.36 mg/l) in 1997 and in 2004 (0.69 mg/l) at Oradea.

This indicator has the highest values at Şaula, which is due to the presence of nitric acid in water. In Oradea the nitrate concentrations decrease. The multiannual evolution shows a sinuous trend with maximum in 1998 and 2005. At Tărian the values are similar between 1998 and 2004, moving around 1.25 mg/l (fig.4.b).

The nitrate concentration in the river exceeds the firs quality class (1 mg/l) concentration throughout the study. Şaula and Tărian sections fall into the 2^{nd} class (3 mg/l). At Oradea only the first three years of study fall in the 2^{nd} quality class after which the nitrogen concentration decreases and enters in the first class (1 mg/l). The maximum average value of 2.36 mg/l was recorded in 1997 at Şaula. If one compares the evolution of nitrites and nitrates there is an inverse proportionality in the marginal sections, both in the temporal and the spatial evolution.

The total phosphorus evolution is almost symmetric at the Oradea section, except for the last two years. Higher levels in the upper sector are due to agricultural fertilizers, and at its mouth to organic debris and detergents loaded into the water. The year 2005 presents unvarying values (0.10-0.11 mg/l) along the entire river. The maximum discrepancies occurred in the last year (0.05 mg/l at Oradea and 0.36 mg/l at Tărian).

At Şaula the phosphorus has a continuing upward trend reaching 0.22 mg/l. In Oradea's section the values don't exceed 0.04 mg/l, only in last three years. Highest values (0.36 mg/l) were measured in the last section due to intense human activity.

Qualitatively, only the period between 1999 and 2001 falls in the first concentration class (0.1 mg/l). The situation is under control for the 2nd class, except for the last year. Year 2006 was exceptional; the phosphorus concentration exceeded the 3rd quality class (0.4 mg/l) threshold.

5. CONCLUSIONS

Crişul Repede River presents an unusual situation in the spatial evolution of the water quality indicators. This is due to the varying geological substratum and the special features of some settlements along the river. The existence of a major limestone mass in the Pădurea Craiului Mountains explains the predominance of carbonated waters downstream. Water quality upstream of the Şaula hydrometric station is mainly influenced by the presence of agricultural and urban pollution and downstream by the influence of Oradea. This is reflected also in various quality classes in which the water bodies of the river fall in.

Crişul Repede River, before crossing the border, is within the 1st quality class regarding the oxygen regime and in the 2nd class according to the nutrients and general ions concentration.

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