ANTROPIC IMPACT ON WATER QUALITY IN THE LOWER MURES BASIN

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Abstract. *Water is life, it is an environmental factor without which man would not be able to carry out any kind of activity, being necessary both for daily personal consumption and for the development of industries. Water leakage on the earth's surface is the mechanism by which erosion sculpts the natural environment, leading to the creation of valleys and delts with fertile surfaces favorable to the development of human centers. It is a major topic of interest that this environmental factor is the most polluted of all. Thus, due to pollution, the biological and physico-chemical conditions of an ecosystem are modified. This aquatic ecosystem can be represented by both still and flowing waters. The work aims to present the water quality of the Mures River on the section Savarsin - Arad - Nadlac for a period of three consecutive years, namely, 2017, 2018 and 2019. The analyses were carried out within the Mures Water Basin Administration. Following water analyses carried out by the Water Quality Laboratory of the Mures Water Basin Administration, the results were compared and interpreted with the physico-chemical quality standards of Order 161 from 2006. The following indicators were targeted for assessing the ecological status/ecological potential of the chemical status respectively: biochemical oxygen consumption (CBO_{5}),chemical oxygen content (CCO-Cr), dissolved oxygen, total nitrogen (N total), ammonium ($N\text{-}NH_{4}$),nitrites ($N\text{-}NO_{2}$),nitrates ($N\text{-}NO_{3}$),total phosphorus (total P), phosphates ($P\text{-}PO_{4}$),anion-active detergents, total phenols, dissolved arsen, dissolved chromium (Cr3++ Cr6+), dissolved copper (Dissolved), dissolved zinc, dissolved nickel and dissolved lead. Based on the analyses carried out, it was found that most indicators fall into the higher quality classes, with the exception of the biochemical oxygen consumption (CBO_5), whose 2017 values were in the third quality class, and then improved their values thus reaching the second quality class from 2018. As well as the chemical oxygen content (CCO-Cr) which in 2017 and 2018 is in the quality class III, then in 2019 reaching the second quality class. The rest of the indicators are in the first and second quality classes.*

Keywords: *water quality, nutrients, pollutants, anthropogenic impact, quality indicators*

INTRODUCTION

Water is found in various forms in nature: water vapour and clouds in the atmosphere, waves and icebergs in the oceans, glaciers, at low latitudes or high altitudes, aquifers underground, rivers or lakes. The water circuit in nature is the phenomenon by which water is transferred from one form to another, through evaporation, precipitation and surface leakage.

Because of its importance (in agriculture, but also for mankind in general), water has been given various names depending on the forms it takes. Rain is known in most countries, while other forms are less common, and can be surprising when first seen. Examples are: hail, snow, fog, dew or chicory. A related phenomenon is the rainbow, found when light refracts through the water particles in the atmosphere.

Water from the surface of the globe plays important roles in human evolution; rivers and irrigation provide water intake for agriculture, are support for maritime or river transportation, whether commercial or recreational. A water with nutrient deficiencies is called oligotroph. Water leakage on the earth's surface is the mechanism by which erosion sculpts the natural environment, leading to the creation of valleys and delts with fertile surfaces favorable to the development of human centers. Water also seeps into the soil, reaching the groundwater web. This groundwater reaches the surface again in the form of springs, or hot springs and geysers. Groundwater is also artificially extracted through wells and fountains (FIROANDA, 2019,

MĂLĂESCU 2019, ȘMULEAC 2017, 2019).

In history, civilizations have developed mainly on the banks of rivers or seas: Mesopotamia, the so-called cradle of civilization is located between two rivers, ancient Egypt flourished on the banks of the Nile, and the great metropolises such as London, Paris, New York and Tokyo owe their success in part to the accessibility offered by the location next to a water, and the resulting commercial flowering. Islands with safe ports, such as Singapore and Hong Kong, have developed precisely for this reason. In places like North Africa and the Middle East, where water is not found in abundance, access to drinking water has been and still represents a big problem in the development of human communities. Water in nature exists in the form of surface waters (rivers, lakes, seas and oceans) about 44 billion km^2 and groundwater.

The life of every being, its processes, metabolism, are conditioned in their unfolding of the existence of water. For his activities, for his needs, man uses increasing quantities, which, after use, he spills into emissaries. For all his needs, man needs clean water. It is taken from surface and groundwater, is treated by physico-chemical processes and is delivered with as low a content as possible of suspensions, chemicals and microorganisms; after treatment it is called drinking water.

Depending on the quality of the water and the place of sampling, methods of treatment and production of drinking water can be more or less expensive. An additional problem is the systems of bringing this water from the treatment plant to consumers, systems that are often old or unsuitable, which generate possible quality alterations even along the way.

A special problem is the water supply to the countryside, from untreated natural sources (wells, natural springs) and which are not always suitable from a sanitary point of view. (RĂDULESCU, 2014, MARTONOS 2017, VĂDEANU 2009)

Water is the environmental factor most affected by pollution, and water pollution is the cause of 25% of hospital cases recorded annually. Life cannot exist without water and an important problem is the quality of this water (ZHU, 2011).

Water is also hygiene factors, energy factor, transport factor, raw material indispensable to technological activities, as well as a source of leisure.

According to Order No. 161 from 16.02.2006, published in the Official Gazette of Romania, 5 ecological estates are established for rivers and natural lakes:

I. very good
II. good
III. moderate
IV. weak
V. bad

Inland waters are the environment most affected by human activities. Quality deterioration is done physically, chemically, biologically and radioactively, ranging from minor damage (equivalent to background pollution of the ecosphere), to damage that turns certain rivers into real surface leaks of some canal waters.Inland water category includes rivers, lakes, snow, ice and groundwater. It is normal that for each one there will be different methods, techniques, and frequencies of sampling.

Rivers are the most used surface flowing waters to get rid of waste, on the logic that "let them be taken by the water to the valley and so we get rid of them". This has led to situations where some waters from the area of discharge of certain pollutants become unusable for any kind of use over tens or hundreds of kilometers. Rivers carry not only what comes from industry and human settlements, but also what is washed from farmland and zootechnical farms (RADULOV, 2016, IMBREA 2017).

MATERIAL AND METHODS

The Mures River is part of the Mures river basin, located in the western part of Romania, springing from the Hasmasul Mare Mountains, the Eastern Carpathians. The neighbouring river basins being Somes-Tisa, Crisi, Banat, Jiu, Olt, Siret.

According to ArcGIS, the hydrographic basin (including the Ier channel) has a total area of 28418km^2, thus representing 11.97% of the country's area. The hydrographic network consists of 798 cadastrate watercourses, 10861 km long and an average density of 0.39 km/km^2. Under the Management Plan of the Mures Hydrographic Basin, the criteria for analysis met, only 711 of the watercourses. (Fig. 1)

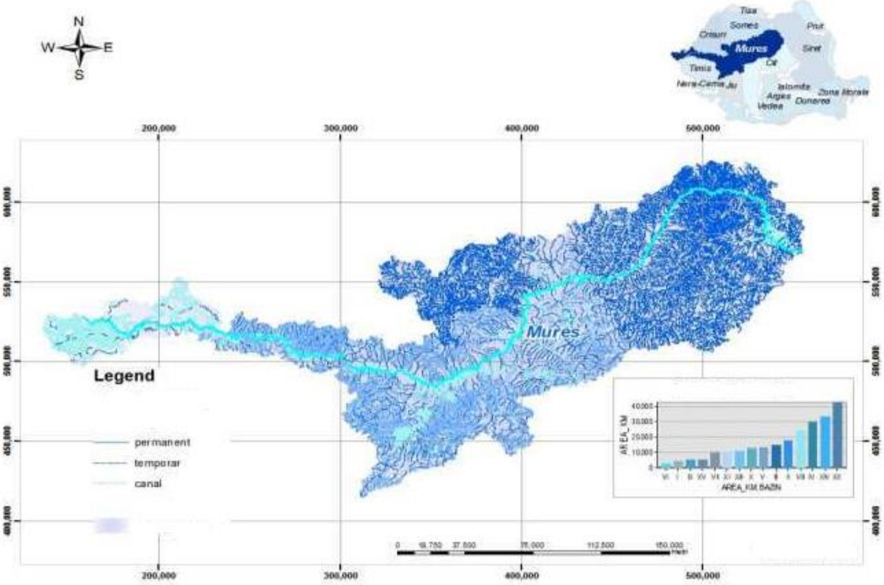

Fig. 1. Control section taken on the route Savarsin - Arad - Nadlac
from the Mures river basin

The average annual amount of precipitation on the surface of the basin is between 480mm and 980mm, the annual average being 610mm. In the Mures river basin we have 21 meteorological stations, with air temperatures ranging from 3.6˚C to 10.4˚C, thus having a multiannual temperature of 7.9˚C per basin (BAȘTEA 2018, IENCIU 2019).

On the surface of the Mures river basin, a total of approximately 5876.3 million m^3/year of the total surface water resources of which usable are approximately 1054.07 mil m$^{3.}$/year.

Non-permanent watercourses account for 26.8% of the total length of the cadastrate watercourses belonging to the Mures river basin.

The work is carried out the basis of seventeen physico-chemical indicators. Water samples were taken from the Savarsin, Arad and Nadlac checkpoints in 2017, 2018 and 2019. The following indicators were targeted for assessing the ecological status/ecological potential of the chemical status respectively: biochemical oxygen consumption (CBO_5),chemical oxygen content (CCO-Cr), dissolved oxygen, total nitrogen (N total), ammonium (N-NH_4), nitrites (N-NO_2), nitrates (N-NO_3), total phosphorus (total P), phosphates (P-PO_4), anion-active detergents, total phenols, dissolved arsen, dissolved chromium (Cr3++ Cr6+), dissolved copper, dissolved zinc, dissolved nickel and dissolved lead.

The analyses were carried out within the Mures Water Basin Administration. Following water analyses carried out by the Water Quality Laboratory of the Mures Water Basin Administration, the results were compared and interpreted with the physico-chemical quality standards of Order 161 of 2006.

RESULTS AND DISCUSSIONS

Based on the analyses of the **2017** water samples, it was determined that the biochemical oxygen consumption (CBO_5) in the water composition falls into the quality class III, having the lowest value of 5,15 mgO_2/l at the Arad checkpoint, and the highest value being found at the Savarsin control point with a value of 5,93 mgO_2/l.

As regards the chemical oxygen content (CCO-Cr), there is a minimum value of 31.38 mgO_2/l in the area of the Nadlac Control Point, the maximum value being 36.95 mgO_2/l the values presented within the third water quality class.

The dissolved oxygen quantity values in 2017 are in Quality Class II with a minimum value of 7.46 mgO_2/l recorded at the Arad control point and a maximum value of 7.9 mgO_2/l recorded at Savarsin.

The results of the analyses indicated a low total nitrogen level (Total N) i.e. the value of 2.23 mg/l N in the area of Savarsin and slightly higher in the Arad area with a value of 2.42 mgO_2/l, these values classifying the total nitrogen level in quality class II.

A low ammonium value ($N\text{-}NH_4$) is observed which falls into a higher quality category, i.e. category I, having a minimum value of 0,08 mg/l N at the Savarsin control point and the maximum value being 0,11 mg/l N found at the point in Nadlac.

The level of nitrites ($N\text{-}NO_2$) being 0,018 mg/l N in the area of Savarsin, this being the minimum, and the maximum being 0,021 mg/l N in the Arad area, these values falling within the level of nitrites in category II.

The nitrogen content ($N\text{-}NO_3$) slightly exceeds the category I values, thus classifying them in category II with the minimum values of 1,12 mg/l N at the Point of Nadlac. and the maximum values of 1,25 mg/l N in the Arad point.

The results of the analyses indicated a low level of total phosphorus (total P) representing the lowest value in the Area of Savarsin, 0.11 mg/l P and the highest value being represented in the Arad area with a value of 0.14 mg/l P thus framing the phosphorus values in quality category I.

The level of phosphates ($P\text{-}PO_4$) found in the water samples was 0.04 mg/l P in the area of Nadlac which came the lowest value, the highest, reaching 0.05 mg/l P in the Arad area, thus being in quality class I.

For anion-active detergents the values are low enough to be able to classify these specific pollutants in quality Class I with the value of 50 μg/l found at all three sampling points.

Total phenols also have a constant value in all three sampling areas, their value being 1,5 μg/l, slipping slightly from the first to the second quality class.

According to the level of dissolved arsen, the water of the Mures River can be classified in the first quality class having the same values at all three sampling points, these values being 0,5 μg/l suitable for the quality class mentioned above.

From the point of view of the dissolved chromium content (Cr3++ Cr6+), the maximum value being 11.08 μg/l in the Savarsin area, this being in quality class I, the minimum result being in the same quality class with the value of 3.96 μg/l in the Area of Nadlac .

As regards dissolved copper content, its values fall into quality class I with values of 5 μg/l being the minimum being analysed in the Nadlac area and the maximum of 9.98 μg/l found in the Arad area.

The level of dissolved zinc analysed in the Arad and Nadlac areas both have a value of 5 µg/l representing the minimum and the value of 19 µg/l in the Savarsin area is the maximum thus being in the first quality class.

The dissolved nickel content is found in the Area of Nadlac by its minimum value of 2 µg/l and in the area of Savarsin by its maximum value of 6,54 thus being in quality class I.

The dissolved lead content has the lowest value of 3,5 µg/l in the Nadlac area and the highest value of 5,25 µg/l is in the Savarsin area, these values falling within the level of dissolved lead in quality category I.

Following water analyses in **2018** it was found that the level of biochemical oxygen consumption (CBO_5) falls within Class II quality with a minimum value of 3.11 mgO_2/l in the Area of Nadlac and the maximum value of 4.83 mgO_2/l in the Arad area.

As regards the CCO-Cr content, the values range from the minimum of 12.7 mgO_2/l in Nadlac and the maximum of 44.69 mgO_2/l in Savarsin thus framing the quality of the water in the third quality class.

Based on the analyses it was established that dissolved oxygen is represented by the minimum value of 7,55 mgO_2/l in the Arad area and the maximum value of 9,25 mgO_2/l in the Nadlac area, ranking in quality class II.

A fairly low total nitrogen value is observed, thus falling into the 2nd quality class with values of 2.39 mg/l N in Nadlac lower than the value of 2.87 mg/l N found in Savarsin

The ammonium content ($N\text{-}NH_4$) in this year is down from the previous year as minimum values of 0.05 mg/l N in Arad and maximum values of 0.09 mg/l N in Nadlac are recorded which falls into quality class I.

The level of nitrites ($N\text{-}NO_2$) is represented by the minimum value of 0,017 mg/l N at the Arad control point reaching the maximum value of 0,02 mg/l N at the Savarsin control point. These values framing nitrite levels in quality class II.

The results of the analyses showed a slightly low nitrogen content ($N\text{-}NO_3$), the lowest value of 0.99 mg/l N being found in Arad and the highest value of 1.05 mg/l N being found in Savarsin these values fall within quality class II.

For total phosphorus (total P) the values are classified in quality class II, its values being 0,15 mg/l P in the Area of Nadlac, this being the minimum value, the maximum value being 0,27 mg/l P in the area of Savarsin

As regards phosphates ($P\text{-}PO_4$), they are low, so they fall into the first quality category with values of 0,052 mg/l P in Arad representing the minimum value, 0,07 mg/l P in Savarsin committing the maximum value.

Following water analysis, a level of anion-active detergents of 50 µg/l was indicated in all three analysis areas by classifying them in 1st quality class.

The total phenol content is the minimum value of 3,55 µg/l in the Nadlac area and the maximum value of 3,75 µg/l in the Arad area, the class being in the 2nd quality class.

The level of dissolved arsen may be classified as quality class I following the results of analyses in all three zones, in which a constant value of 0,5 µg/l is found.

Dissolved chromium values (Cr3++ Cr6+) are grade I quality following analyses that show that the minimum chromium in water is 8.07 µg/l in Arad and the maximum is 9.92 µg/l in Savarsin

The minimum dissolved copper content is 4,13 µg/l in Nadlac and the maximum is 7,06 in Savarsin, these values framing the water in quality class I.

Dissolved zinc values are 12,5 µg/l in all three monitored areas, which fall within quality class I.

In the case of dissolved nickel, the minimum value is 6,36 µg/l in the Nadlac area and the maximum value is 15,78 µg/l in the Arad area, the values presented thus being in quality class II.

For lead, it is classified in the first quality class with a minimum value of 3,43 µg/l in Nadlac and a maximum value of 6,99 µg/l in Savarsin

In the buletins of water samples taken in **2019** the biochemical oxygen consumption (CBO_5)is represented by the minimum value of 3,25 mgO_2/l in the Arad area and by the maximum valueof 4,46 mgO_2/l in the Savarsin area, thus framing the water in quality class II.

The concentration of the chemical oxygen content (CCO-Cr) falls into quality Class II following the minimum result of 15.4 mgO_2/l in the Arad area and the maximum result of 24.71 mgO_2/l in the Savarsin area.

The dissolved oxygen value represented in the minimum analysis bulletins is 7.63 mgO_2/l in the Nadlac area and the maximum is 9.59 mgO_2/l in the Arad area thus fall into the second quality class.

The total nitrogen content (Total N) reaches the minimum value in the Area of Nadlac, which is 2,019 mg/l N and the maximum value being reached in the Arad area with a value of 2,34 mg/l N and thus being classified in Quality Class II.

Ammonium($N\text{-}NH_4$) occurs in quantities of 0,099 mg/l N in the Savarsin which is minimal, and the maximum occurs in Nadlac with a value of 0,146 mg/l N and ends up being classified in quality class I.

The nitrite content ($N\text{-}NO_2$) falls into quality class II with values of 0,0287 mg/l N in Arad, which is the minimum and the maximum belonging to the Nadlac area with a value of 0,034 mg/l N.

The level of nitrates ($N\text{-}NO_3$) in the water is quite low, but it falls into quality Class II with a minimum value of 0,96 mg/l N in Savarsin. and a maximum value of 1,16 mg/l N in Nadlac.

A total phosphorus level falling within quality Class II, with a minimum value of 0,16 mg/l P in the Arad area and a maximum value of 0,24 mg/l P in the Savarsin area, was detected following the analyses carried out.

For phosphates ($P\text{-}PO_4$) the values are sufficiently low for this category to be classified in quality class I with very low values of 0.0723 mg/l P in Savarsin and up to 0.0776 mg/l P in Nadlac.

The concentration of anion-active detergents is found in each of the three sampling areas in identical quantities, which are 50 µg/l and are thus classified in quality Class I.

With regard to the total phenol content, a small difference can be observed between the minimum and the maximum value, the minimum value being 1,5 µg/l in Arad and the maximum being 4,7 µg/l in Savarsin. however, the values fall into the 2nd quality class.

A fairly low dissolved arsen value is observed, which is constant in all three points so that it is represented by 0,5 µg/l and is classified in I-a quality class.

Dissolved chromium content (Cr3++ Cr6+) with low values falls into the 1st quality class, with a minimum value of 7,39 µg/l in Savarsin and a maximum value of 9,44 µg/l in Arad.

As regards dissolved copper, it is present with the minimum value of 3,3 µg/l found at the point in Savarsin, the maximum value being 4,49 µg/l at the point in Nadlac. Copper values fall into quality class I.

The presence of dissolved zinc is 12,5 µg/l in all three areas from which water samples were collected, it falls into quality Class I.

The level of dissolved nickel present in water has a minimum value of 5,49 µg/l in the Nadlac area and the maximum value of 8,44 µg/l in the Savarsin area, these values framing the water in terms of nickel in quality class I.

The concentration of dissolved lead found in water has a minimum value of 5,61 μg/l in Nadlac and a maximum value of 8,57 μg/l in Savarsin these values framing the water in quality class II.

Comparative examination of the indicators analysed in this paper between 2017, 2018, 2019

The comparative analysis of 2017, 2018, 2019 tracks the status of all indicators analysed. With regard to biochemical oxygen consumption (CBO_5), there is obvious an improvement in water quality in this respect becausein 2017 CBO_5 was in the third quality class, in 2018 it improved its condition thus reaching quality Class II, and in 2019 remaining in the same quality class (figure 2).

Comparing the chemical oxygen content (CCO-Cr) during the three-year period, there is a slight progress , especially in 2019 in which the chemical oxygen content is classified in the second quality class, until then it is found in the third quality class during 2017 and 2018 (figure 3).

Fig.2 Evolution of biochemical oxygen consumption

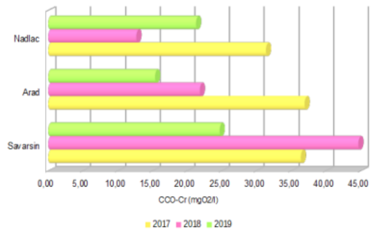

Fig.3 Concentration of chemical oxygen content

In the dissolved oxygen indicator we can see a slight variation in quantity, but not one large enough to reach the quality class I, thus remaining throughout the three years in quality Class II (figure 4).

In the case of the total nitrogen indicator (Total N) we also have a change in values over the course of all three years, with values falling within the second quality class (figure 5).

Fig.4 Level of dissolved oxygen

Fig.5 Evolution of total nitrogen

As regards the ammonium regime ($N\text{-}NH_4$), it is classified during the three years studied in quality class I, also showing a slight variation (figure 6).

Nitrites ($N\text{-}NO_2$) during all three years of analysis fall into the same quality class, i.e. in Class II even though they show a slight lysting (figure 7).

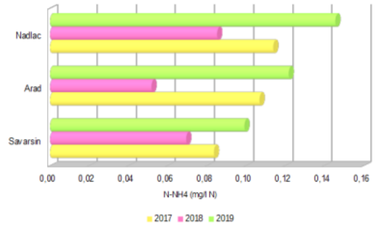

Fig.6 Ammonium concentration

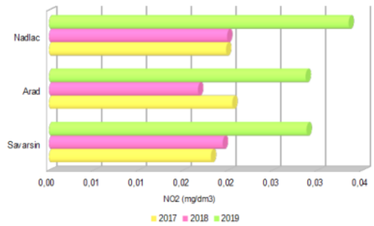

Fig.7 Nitrites levels

The nitrogen content ($N\text{-}NO_3$) is slightly varied, however, during the three years taken into account, the quality Class II threshold has not been exceeded (figure 8).

With regard to total phosphorus (total P) we can see an increase in value in each of the three years studied, so that in 2017 the amount of phosphorus is found in quality class I and then, from 2018 it passes into quality class II, the value is still increasing during 2019 , but remains in quality Class II (figure 9).

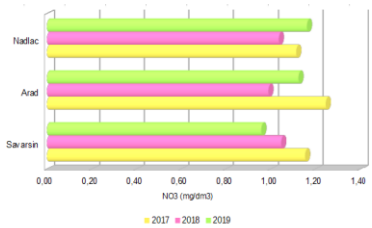

Fig. 8 Nitrogen content

Fig.9 Level of phosphorus

From the point of view of phosphates ($P\text{-}PO_4$), they are in a slight, continuous growth but not affecting the quality class of which they belong, i.e. not having sufficient values to leave quality class I (figure 10).

In the case of anion-active detergents, they show neither variation nor increase, they remain at 50 µg/l by ranking in quality class I throughout the study period (figure 11).

Fig.10 Evolution of phosphates

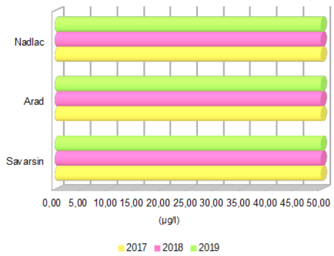

Fig.11 Levels of anion-active detergents

In the three years the total phenols show an increase between the first two years of study, then a decrease, then returning to a value closer to that of 2017. In all three years being in quality Class II (figure 12).

In the 2017, 2018 and 2019 years, the dissolved burn value remained unchanged at 0.5 µg/l and classified in the first quality class (figure 13).

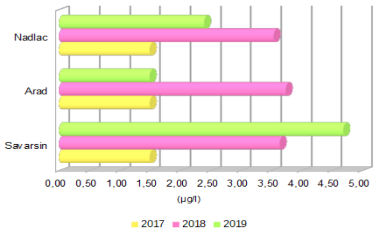

Fig. 12 Levels of total phenols

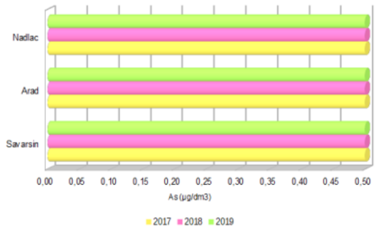

Fig.13 Concentration of Arsen

According to the samples analysed, we can also see a slight decrease in dissolved chromium (Cr3++ Cr6+), which is classified throughout the study period in quality class I (figure 14).

The value of the dissolved copper indicator remains throughout the study in quality class I (figure 15).

Fig.14 levels of chromium

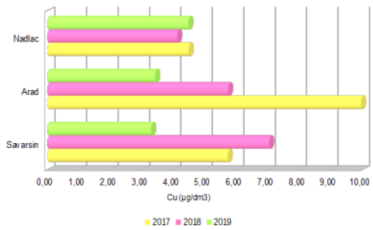

Fig.15 Concentration of dissolved copper

As regards the dissolved zinc indicator, it has a variability on the river course in 2017, after which, during 2018 and 2019, the value of 12,5 µg/l becomes constant at all three checkpoints over the two years. However, the indicator remains classified in quality class I throughout the three years studied (figure 16).

During 2017 dissolved nickel values were in quality class I, then in 2018 in the Arad area there was a major increase that ranked the 2018 river values in terms of nickel in quality Class II, returning back to quality class I. in 2019 (figure 17).

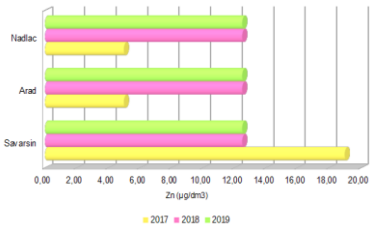

Fig.16 Zinc concentration

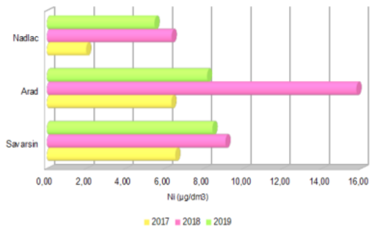

Fig.17 Dissolved nichel levels

According to the analyses we note that the dissolved plumb indicatorshows an increase over the three years, so in 2017 and 2018 it ranks in the first quality class, then in 2019 it reaches the quality class II (figure 18).

Fig.18 Evolution of lead

CONCLUSIONS

The present paper analyzes the water quality of the lower basin of Mures for 17 quality indicators over a period of 3 years: 2017, 2018 and 2019. The following indicators were targeted for assessing the ecological status/ecological potential of the chemical status respectively: biochemical oxygen consumption (CBO_{5}),chemical oxygen content (CCO-Cr), dissolved oxygen, total nitrogen (N total), ammonium (N-NH_{4}),nitrites (N-NO_{2}),nitrates (N-NO_{3}),total phosphorus (total P), phosphates (P-PO_{4}),anion-active detergents, total phenols, dissolved arsen, dissolved chromium (Cr3++ Cr6+), dissolved copper (Dissolved), dissolved zinc, dissolved nickel and dissolved lead. The analyses were carried out within the Mures Water Basin Administration and the results were compared and interpreted with the physico-chemical quality standards of Order161 from 2006.

The analysis showed a higher pollution in 2017, which was found in the increased value of the biochemical oxygen consumption that classified the water in category III of use, as well as in the CCOCr indicator. As for dissolved oxygen, water is in the second quality class. Water nutrients (nitrogen, ammonium, nitrites and nitrates, phosphates) have low values that have not exceeded the quality class II level, which shows that the impact of agriculture on water through the fertilizations used is reduced..

In the metal category (Cu, Fe, Ni, Cr), water has very good variations between class I and second quality.

Pers overall, the water quality of the lower basin of the Mureş River presents very good quality indicators, it is noted that from 2017 to 2019 there is a tendency to improve them, thus minimizing the impact of industry and agriculture on water.

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