

SIMION A. (*University of Petrosani, Petrosani, Romania*)LAZAR M. (*University of Petrosani, Petrosani, Romania*)**IDENTIFICATION OF SOURCES PRODUCING IMPACT ON WATER QUALITY
IN EAST JIU BASIN**

Abstract. The main economic activity in the Jiu Valley is mining, which produces valuable mineral raw materials required for the region development and progress, representing the main link in the value producing chain. The majority of mining operations and other economic activities existing within the East Jiu basin produce negative environmental impact (more or less severe), as well as and positive effects such as those related to increasing employment, staff training, creating infrastructure, etc. In most cases, the negative impact of the human activities can be considerably mitigated or even completely eliminated through remedial measures, particularly through the environment rehabilitation in the affected areas. But if a water body is strongly affected by pollutants generated by the human activities, the pollution impact is especially heavy near the water body bottom, with significant negative changes of the aquatic ecosystems and impossibility of consumption and use of the water resources by the riparian population. The main objective of this paper consists in identification and description of all human activities presented within East Jiu basin and analysis of their impact on the river (and other water bodies) water quality. For assessing the East Jiu water quality and monitoring its variations with time, water quality index (WQI) was used, aggregating individual quality indicators (expressed in physical units) into a single unique water quality measure.

Keywords: East Jiu, environment, human activities, mining, water quality.

1. Introduction

The Jiu Valley coal basin, also called the Petroșani Basin, is located in the southern part of Hunedoara County and in the south-west of Transylvania in the Depression of the Southern Carpathians called the Petroșani Depression or the Jiu Valley Depression. The

Jiu Valley Depression area is 163 km², and it lies along the Jiu rivers: the East Jiu and the West Jiu, surrounded by four mountain ranges: Retezat Mountains in the north-north-west, Sureanu Mountains in the north-east, Parang mountains in the east, and the Valcan Mountains in the south (Fig. 1) [8].

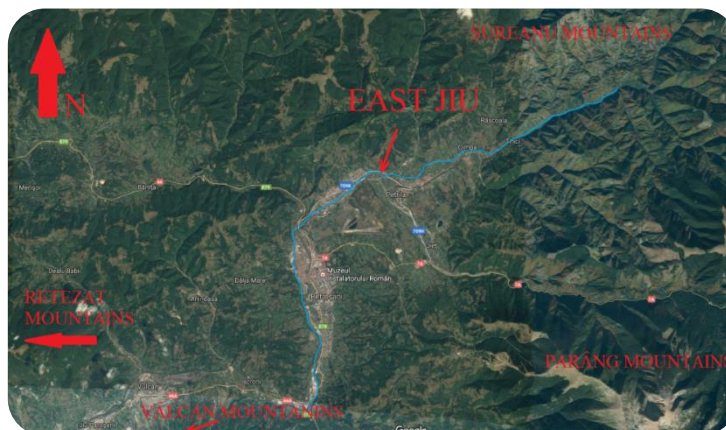


Fig. 1. The Jiu Valley Depression

Hydrographic network of the basin consists of two major rivers: East Jiu and West Jiu, with many tributaries. East Jiu is 28 km long, and its hydrographic basin covers area of 479 km² [8]. The river flows from the south of the Sureanu Mountains, having the following tributaries on the right

side of the Sureanu Mountains: the Voievodul, the Bilele, the Revolta, the Taia, the Banita, and on the left side, from Parâng Mountains, the following tributaries: the Sterminos, the Lolea, the Cimpa, the Giorganu, the Jieț, and the Slătioara [8]. The use of East Jiu water resources as drinking water and for



other regional economic needs strongly depends on the water quality. Physicochemical and geological conditions determine formation, regime and quality of the natural water resources (6). Water is universally distributed resource of vital importance for living beings. In order to determine the quality of surface water the following steps should be implemented: selecting relevant quality indicators, establishing rigorous monitoring program, permanent monitoring and control of the main sources of pollution.

2. Water pollution sources

Water pollution means direct or indirect (as a result of human activity) leakage of some substances into water resources that can harm human health and quality of aquatic ecosystems or river basins dependent on aquatic ecosystems.

Within East Jiu river basin, potential water pollution sources were identified and classified into point and diffuse sources. Point sources of wastewater (domestic, urban, industrial, rainwater and drainage) are those collected in sewerage systems and discharged into natural recipients via ducts or drainage channels. Diffuse sources of pollution are discharged into the environment in dispersed manner with no specific locations of pollutant drainage (pipelines, etc.). Major sources of diffuse pollution identified along East Jiu are: agriculture, atmospheric deposition, construction materials, mining industry (Lonea EM, EM, and EM Petrila Livezeni), road traffic, rural population.

2.1 Mining industry

The existing deposits in the Jiu Valley due to their shape, size and especially the deep occurrence depth are exploited through

underground mining using different methods and processes [1].

The subsidence phenomena can be caused by collapse of underground mining workings and changing hydrogeological and hydrological conditions due to high intensity drilling of aquifer system in the area [1]. When underground excavations and especially coal faces exceed the critical dimensions in terms of stability of the surrounding rocks, and no adequate measures are taken to support and stabilize formed voids (mined-out space), rupture of the covering rocks starts, which gives rise to a complex of phenomena, known as subsidence effects, which can extend over the entire thickness of the cover rock up to the surface.

The areas fractured and affected by underground mining comprise at the Petroșani basin over 20 ha and they cannot be used for construction or agricultural activities, because the surface subsidence resulted in lowering groundwater table, and the phenomena of desertification through disappearance of local flora and fauna take place as well [1].

The main type of waste resulting from mining operations and processing plant activities and entering water bodies is presented by barren rock material suspended in water. In this basin, sedimentation of fine-grained solid material takes place, whereas coarse-grained solid material is mostly used in construction of dams, while the clarified water is discharged into regional hydrographic network, possibly after some treatment.

One more mining-induced factor, potentially capable to produce negative environmental impact, is a phenomenon, called Acid Rock Drainage and Metal Leaching



(ARDML). The phenomenon essence consists in the fact that sulfide minerals (first of all, pyrite), contained in deposit ores and enclosing rocks both in-situ (and in ore stockpiles and waste rock dumps, being exposed to action of oxygen and water, contained in atmospheric precipitations, superficial waters, and groundwater, react with oxygen and water. As a result, sulfuric acid is generated, which, in turn, promotes dissolution of metals, for instance, heavy metals, contained in ores and enclosing rocks, with formation of soluble aqueous species (complexes), capable to move in water flows for large distances and, finally, cause pollution of different water bodies, including aquifers, rivers, lakes, etc. I.e. ARDML promotes conversing heavy metals into mobile forms. In this connection, special measures should be provided to prevent or mitigate consequences of ARDML.

2.2 Industrial and urban wastes

They are presented by leakage from the slopes of waste dumps near East Jiu river and contribute to its pollution with organic substances and suspensions. The non-impermeabilized urban waste dumps located in the lower reach of East Jiu river are often the sources of nitrate and nitrite pollution, as well as other pollutants.

landfill life cycle, in terms of sustainable development, covers a period of time more than two generations, including periods of construction (1–3 years), exploitation (15–30 years), closure and land reclamation and post-closure monitoring (15–20 years).

2.3 Forestry and timber processing generate wood waste that can pose actual environmental hazard. Wood processing generates 60 % of all wood wastes. Wood waste

(first of all, sawdust) has a number of peculiarities: low specific gravity, high hygroscopicity, medium calorific power that varies depending on species of wood [2]. Sawdust driven by rain water may enter water bodies, pollutes water and produce negative impact on aquatic habitat and aquatic flora and fauna.

Wood waste decomposition is a slow process that can produce leachate with time. In the long run, in the presence of water, due to frequent rains, naturally occurring substances such as acids, lignin, fatty acids, and tannin are dissolved and spread over at high concentrations. Moving wood waste contains leachate until saturation [2, 4]. At this stage, the leachate is discharged into the environment and produces negative impact. The polluted water is dark and has unpleasant smell and disgusting taste, up to reaching pollutant concentrations harm to health. Biochemical oxygen demand for biodegradation may be lethal to fish such as trout and invertebrates. Wood waste can also generate hydrogen sulfide and ammonia under anaerobic conditions. In water, ammonia can reduce the blood's ability to carry oxygen up to inducing fatal effect on water life by suffocation.

2.4 Earthworks cause moving fine earth particles, which may reach surface waters. Deposition of solid particles in watercourses changes bottom sediment grain size and can affect aquatic flora and fauna. Production and using of building materials (concrete, bitumen, aggregates, etc.) causes specific (by material and process) pollutant emission. If the works are performed near watercourses, they are sources of direct water pollution. Rainfalls and superficial waters also contribute to penetration of these pollutants into water bodies as well as



into groundwater [4]. Vehicle and other machinery operation in the vicinity of water bodies is one more potential source of pollution due to accidental spills of fuel and lubricants.

Besides, friction processes in earth-work machinery cause additional pollution of soil, surface, and groundwater [4].

2.5 Agriculture practiced in the Jiu Valley produces heavy environmental impact. It is true that pollution as a process of degradation of quality of environmental factors being vital for human health has not been recognized as important [5]. Environmental pollution by agricultural activities is caused by too large volume of fertilizers applied in areas near watercourses, far in excess of actual demand of agricultural crops. As a result, excessive nitrates are accumulated in food products and also pollute groundwater and surface water [2]. Chemical fertilizers (especially nitrogen fertilizers) are applied here in excessive amounts and often not taking into account actual demand of crops in different phases of growing [4]. The fertilizers are often applied to frozen ground covered with thick layer of snow. Sometimes, due to sudden melting owing to changing weather, these fertilizers, are removed by melting water and pollute various water bodies, including those used as drinking water sources. Applying too much volumes and concentrations of fertilizers and pesticides in improper period and consumption of products with toxic components has multiple negative impact on plants, animals and humans [3]. Insufficient attention to sticking correct procedures of preparation of pesticide solutions, washing of the solutions from agricultural equipment and discharging of the remaining solutions.

Uncontrolled storage of mineral fertilizers and livestock manure in many private households produces negative effect, namely, causes leakage of toxic components into natural waters, including groundwater.

Agricultural machinery operation produces additional environmental impact (exhaust gases, noise, vibration, leakage and losses of POL polluting soil, destruction of soil structure by compaction).

3. Impaired quality parameters

Surface water quality is defined as the conventional set of physical, chemical, biological and bacteriological characteristics, expressed in terms of value, which allow the classification of water quality into a certain category suitable for some specific use/uses [2, 7].

In nature, water is never present in pure state but contains many mineral and organic impurities, dissolved salts or dispersed solids, biogenic substances and biological organisms, has certain organoleptic, physical, chemical, biological and bacteriological characteristics [5].

Referring to surface a quality category is very important criterion for analysis aimed at delimitation of water bodies.

Due to the fact that the quality of surface waters is interconnected with technogenic impact on them, the delineation of water bodies is a continuous process.

Although biological elements are considered as integrators of all types of the technogenic impact, assessment of water ecological status requires analysis of some supporting elements, represented by: general physico-chemical indicators, specific pollutants, and hydro-morphological elements [2].

Important physical and chemical indicators used to assess the ecological status of

water for all water bodies (natural and heavily modified) are as follows:

1. Hydrogen ion concentration (pH);
2. Oxygen concentration (dissolved oxygen);
3. Nutrients (N – NH_4^+ , N – NO_2^- , N – NO_3^- , P – PO_4^{3-} , P_{total});

Specific pollutants are synthetic (organic: acenaphthene, toluene, phenol, xylene, PCBs - polychlorinated biphenyls), and non-synthetic (metals: copper, zinc, arsenic, chromium).

The ability of water to dissolve mineral and organic compounds is very important for development of aquatic ecosystems. Thus, dissolved inorganic material is always found in water; it can be transformed into organic substances by phytoplankton a present in water, the first link of the trophic chain [3].

4. Determination of water quality index

To assess quality of East Jiu waters and monitor the water quality variations with time, water quality index (I_{CA}) modified method was used to aggregate the individual indicators expressed in physical units (Tab. 1) into an unique water quality index (using conventional scale of 0–100). The Water Quality Index (I_{CA}) was conceptually defined in early 1970s by the National Sanitation Foundation (NSF) [4].

The analyzed water sample was taken on 04.03.2017 at 10:00 from East Jiu river downstream from the confluence with the Taia River. The analyses results were used to determine the Water Quality Index (pH – Fig. 2, temperature – Fig. 3, dissolved oxygen – Fig. 4, biochemical oxygen demand – Fig. 5, total phosphates – Fig. 6, turbidity – Fig. 7, total dissolved solids – Fig. 8 and nitrites – Fig. 9).

Table 1

Indicator	Unit of measurement	Weight
Dissolved oxygen	saturation, %	0.19
BOD	(mg/l)	0.14
pH	-	0.12
Nitrates	mg/l	0.12
Temperature variations	°C	0.12
Total phosphates	mg/l	0.12
Turbidity	NTU	0.1
Total dissolved solids	mg/l	0.09

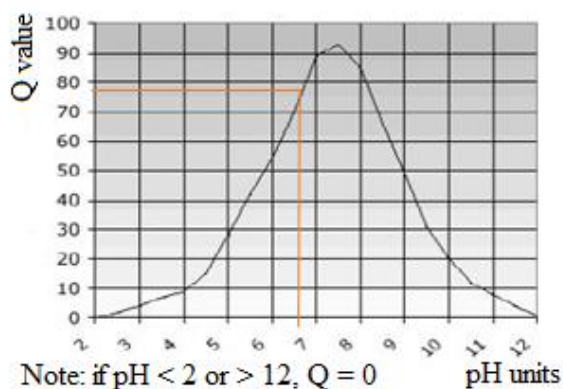


Fig. 2. pH

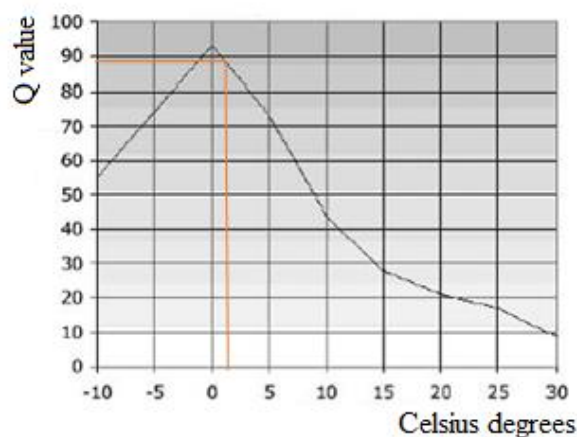
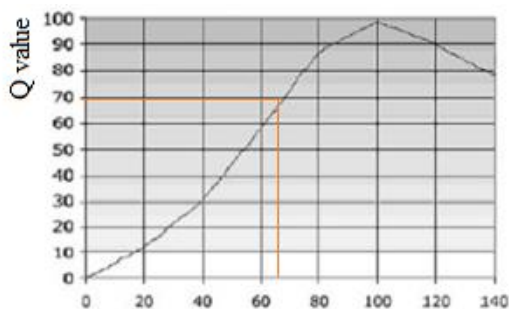
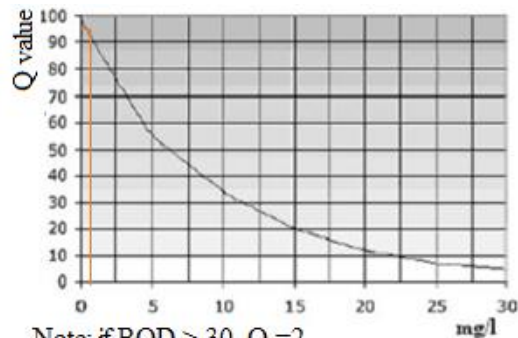


Fig. 3. Temperature Variations



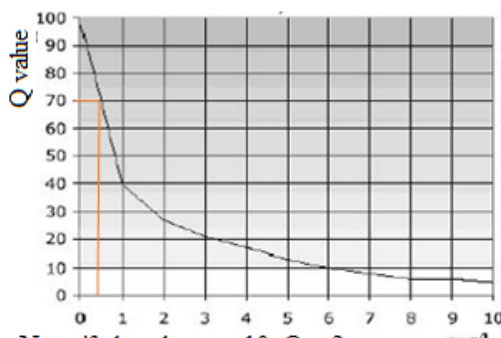
Note: if % saturation > 140, then Q = 50

Fig. 4. Dissolved Oxygen



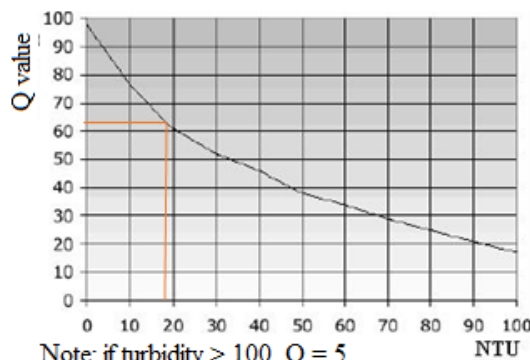
Note: if BOD > 30, Q = 2

Fig. 5. Biochemical Oxygen Demand



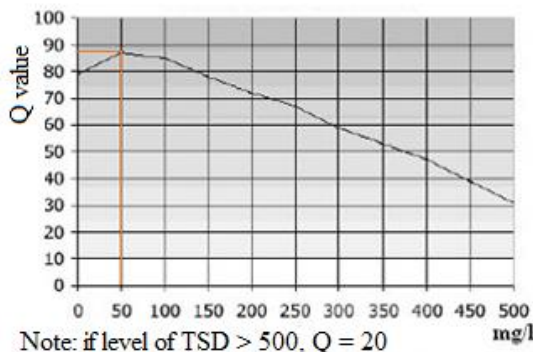
Note: if phosphates > 10, Q = 2

Fig. 6. Total phosphates



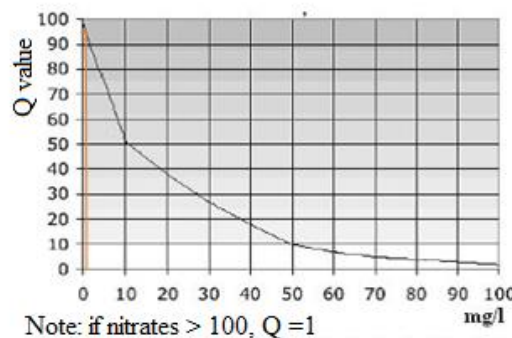
Note: if turbidity > 100, Q = 5

Fig. 7. Turbidity



Note: if level of TSD > 500, Q = 20

Fig. 8. Total dissolved solids



Note: if nitrates > 100, Q = 1

Fig. 9. Nitrates

Table 2

Indicator	Test result	Value Q	Weight W	Total
BOD	0.68 mg/l	94	0.19	17.86
Dissolved oxygen	66.2 %	70	0.14	9.8
Nitrates	1.35 mg/l	92	0.12	11.04
pH	6.79 unit pH	77	0.12	9.24
Temperature variations	2.36°C	89	0.12	10.68
Total dissolved solids	50.1 mg/l	87	0.12	10.44
Total phosphates	0.38 mg/l	70	0.1	7
Turbidity	18.7 NTU	80	0.09	7.2
ICA TOTAL		83.26 (good quality)		

Table 3

Intervals of the Water Quality Index	Description (quality category)
0-25	Bad
26-50	Unsatisfactory
51-70	Medium
71-90	Good
91-100	Excellent



For aggregation of the values into the single Water Quality Index (Table 2), the value of exceeding an indicator representative interval was used together with weighting of the multiplication coefficient according to the formula below [4]:

$$I_{CA} = \sum_1^i Q_i W_i.$$

The values obtained allow to refer the water sample was taken on 04.03.2017 at 10:00 from East Jiu river downstream from the confluence with the Taia River to the good quality category.

Conclusions

East Jiu River Basin, being industrialized, suffers from high technogenic pressure on water quality. With the closure of mining operations in the area, this pressure decreases over time, and the water quality tends to improve, but diversification of economic activities, population growth, waste disposal, motor traffic and unsustainable farming practices threaten the East Jiu water quality. Analysis of the East Jiu water and applying the method of assessing Water Quality Index showed that this water can be referred to

“Good quality” category. However, it should be mentioned that the water sampling was performed after a period of abundant precipitation, producing effect on the water quality through dilution.

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