

Chlorophyll α and β biomass as an indicator of water quality conditions. A case study of an old mine water discharge

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SAMPLING AREA and METHODOLOGY

The Arieș River catchment is an area affected by the past mining activities. Roșia Poieni, a large copper mine from Arieș basin, produces tons of copper/year, the resulted sterile is being deposited in Geamăna tailing pond located in the vicinity of Valea Șesii, one of the Arieș River tributaries, contributing decisively to the quality of its water.

The aim of this study was to (I) assess the current quality of the Valea Șesii stream and to (II) correlate the microorganisms distribution with the level of water pollution present in the studied area.

A sampling campaign has been done along the stream, during the 2019 hot season. pH, EC, TDS, heavy metals (Cd, Pb, Cr, As) were analyzed to establish the quality status of the surface water, and the micro- (Zn, Mn, Cu, Ni, Co) and macronutrients (Mg, Ca, K, Na, S, N), BOD, chlorophyll α and β , to determine the presence of microorganisms on the water to define the quality trend of the analyzed samples. Also, in order to evaluate the quality of the groundwater and its impact on the human health, several quality indices, like *WQI* – water quality index, *HEY* – heavy metal evaluation index; *HPI* – heavy metals pollution index were used.

The analytical methods used to determinate the surface water quality were according to international standards: SR ISO 10390:2015, SR EN 27888:1997, SR EN ISO 11885:2009, SR EN ISO 17294-2:2017 and STAS 9187:1984. To determinate the chlorophyll α and β , a spectrophotometric method was used.

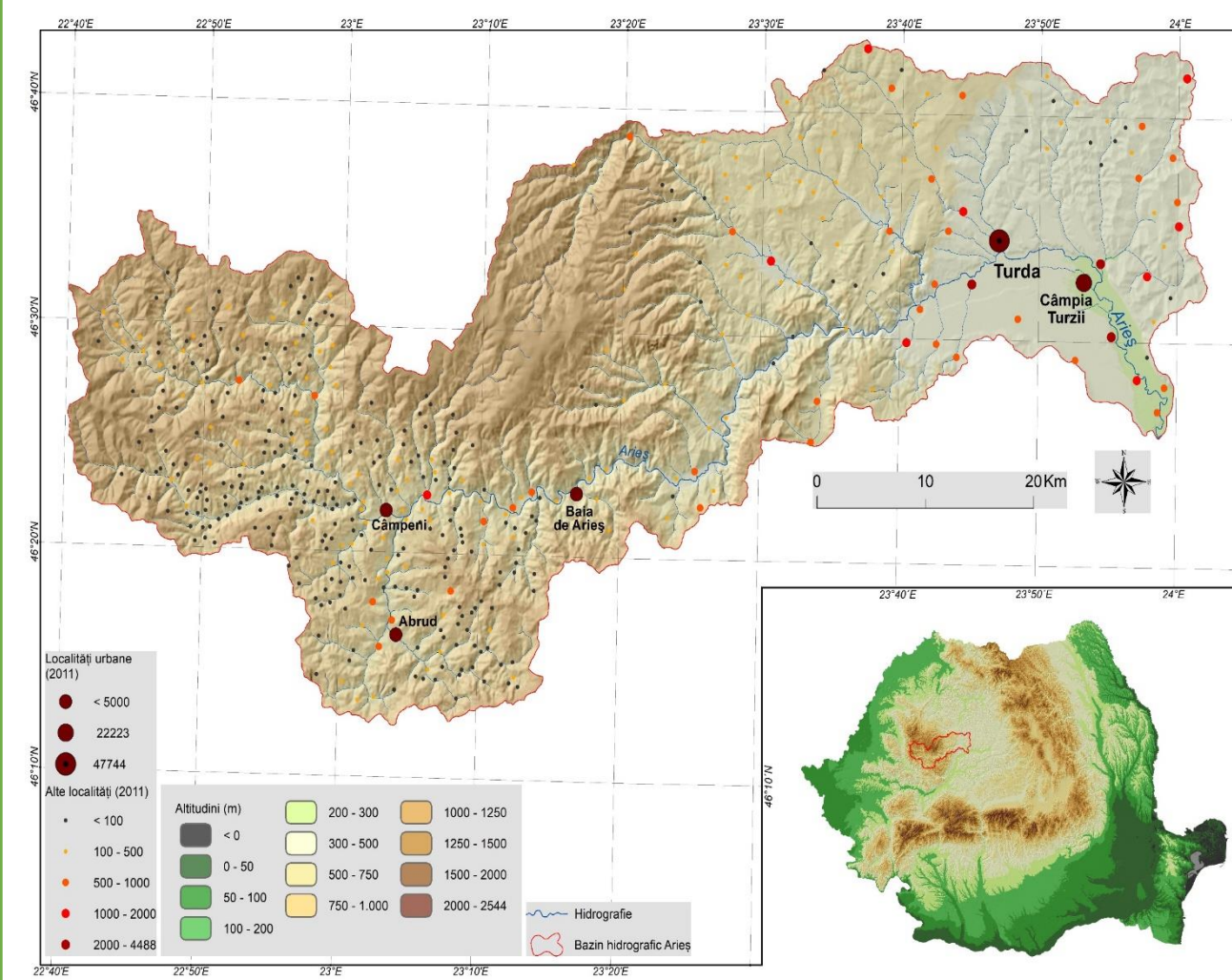
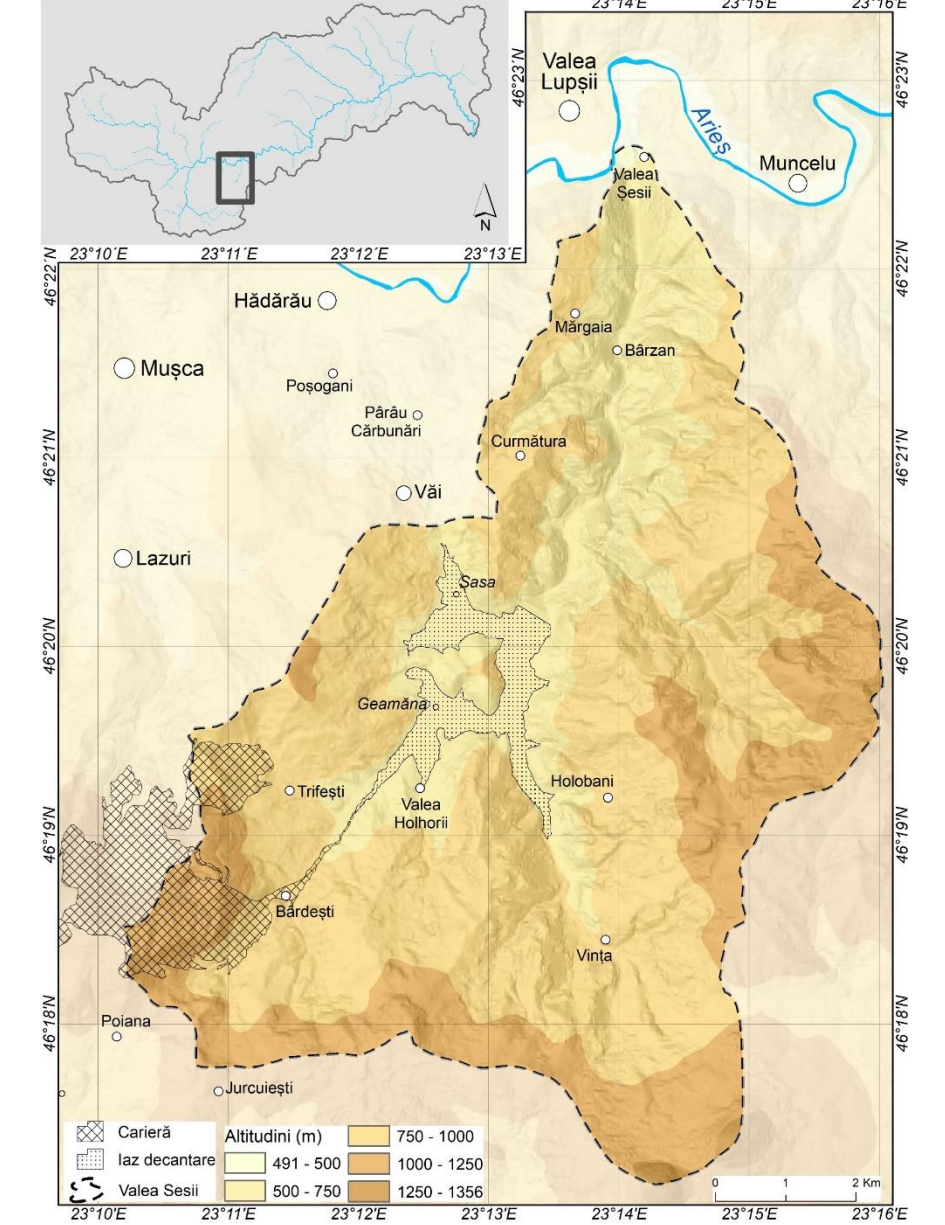


Fig. 1a. The Arieș River basin
Fig. 1b. Valea Șesii catchment



RESULT and DISCUSSIONS

Heavy metals evaluation index

$$HEI = \sum_{i=1}^n \frac{H_c}{H_{max}}$$

where: H_c is the determined value of the i^{th} parameter and H_{max} represents the maximum allowable concentration (MAC) of the parameters, according to the national legislation.

Heavy metals pollution index

$$HPI = \frac{\sum_{i=1}^n Q_i W_i}{W_i}$$

$$Q_i = \frac{\sum_{i=1}^n |M_i - I_i|}{S_i - I_i}$$

where: Q_i is the sub-index of i^{th} parameter, W_i is the unit weightage of the i^{th} parameter and n is the number of parameters considered, M_i , I_i and S_i are the values of the i^{th} parameter monitored, the ideal and the standard values respectively, according to the national legislation.

Water quality index

$$WQI = \sum_{i=1}^n q_n * W_i / \sum_{i=1}^n W_i$$

$$q_n = [(V_n - V_{id}) / (S_n - V_{id})] * 100$$

$$W_n = k / S_n$$

$$k = \left[1 / \left(\sum_{i=1}^n 1 / S_{n1,2,...n} \right) \right]$$

where: V_n represents the amount of the determined chemical indicator, V_{id} is the ideal value of the chemical parameter; S_n is the standard value or MAC, according to the national legislation and k is a proportional constant.

Sampling point	HPI	HEI	WQI
S1	367	17,3	157
S2	344	15,8	163
S3	287	11,4	102
S4	256	9,42	97,7
S5	233	7,25	97,5
S6	234	7,31	98,3
S7	212	6,90	95,4

To determine the correlation between the BOD, chlorophylls α and β , micro- and macronutrients and to classify the water samples based on that correlation, a agglomerative hierarchical cluster analysis (HCA) was performed.

The HCA classifies all water samples (S1-S7) into 3 clusters:

- ✓ cluster 1 contains BOD, Mg and Na;
- ✓ cluster 2 contains chlorophylls α and β and all the micronutrients analyzed (Zn, Mn, Cu, Ni, Co);
- ✓ cluster 3 contains K.

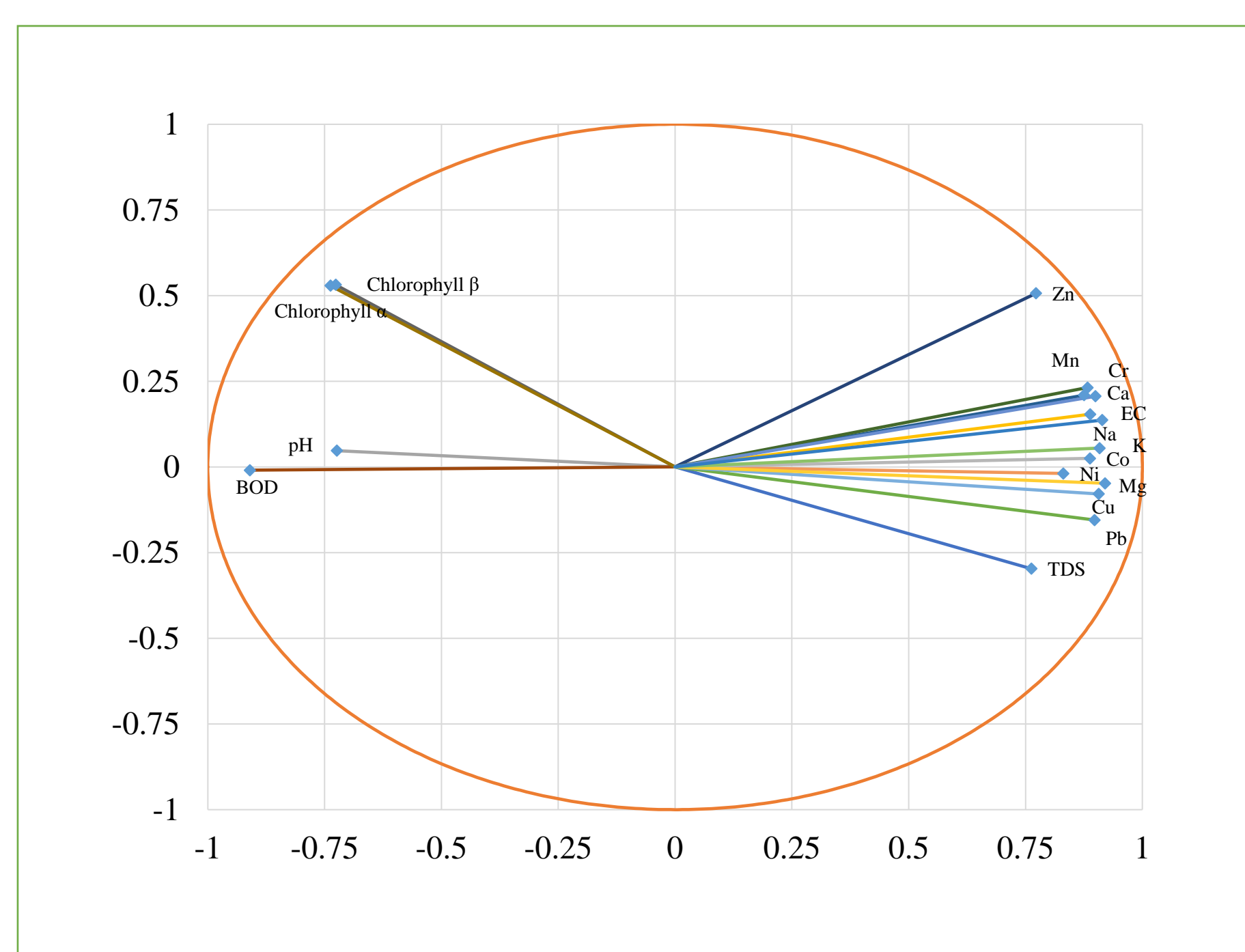


Fig. 2. Principal Component Analysis (PCA) for chemical and bio-chemical parameters

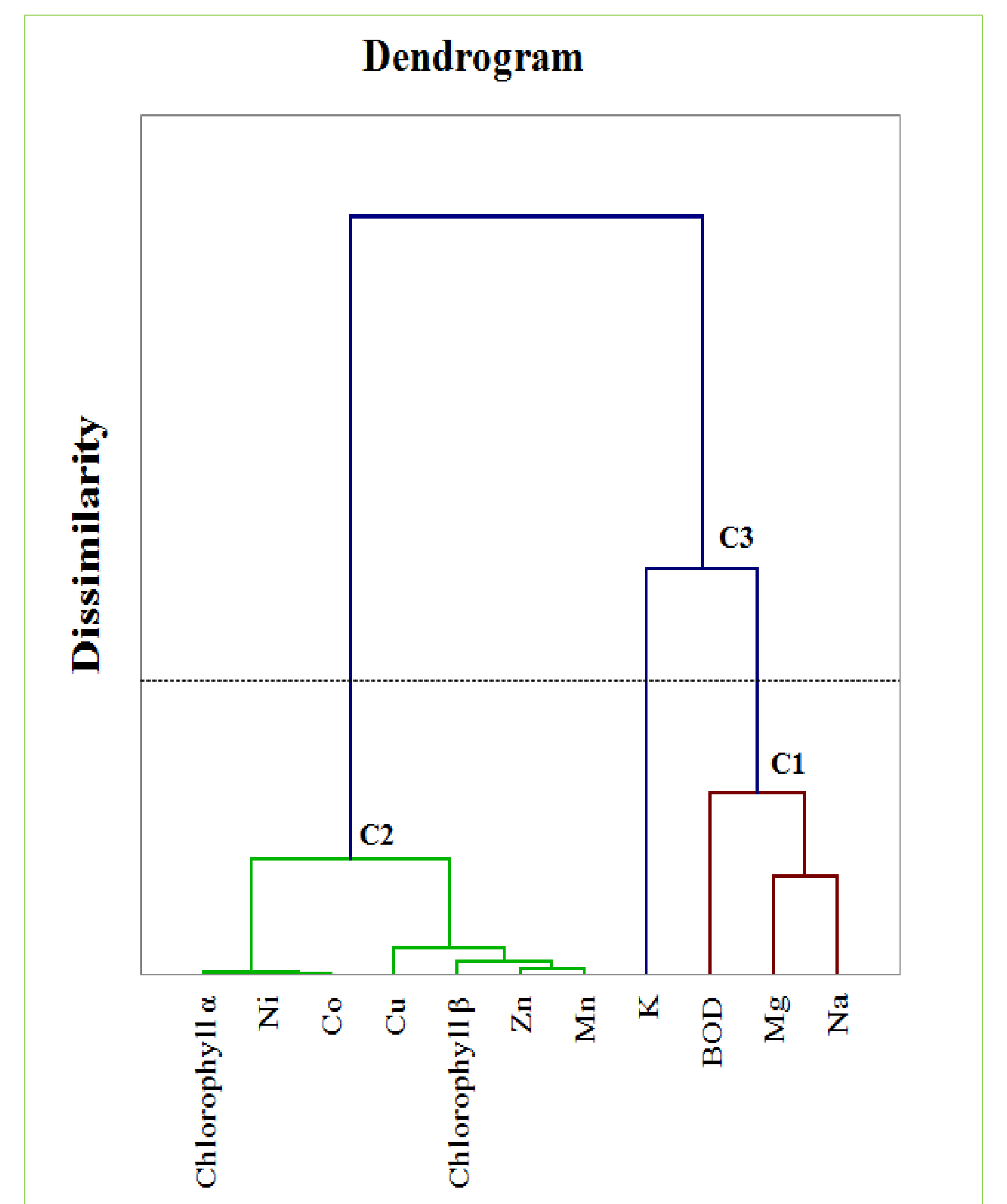


Fig. 3. Dendrogram of the clusters of the biochemical parameters analyzed

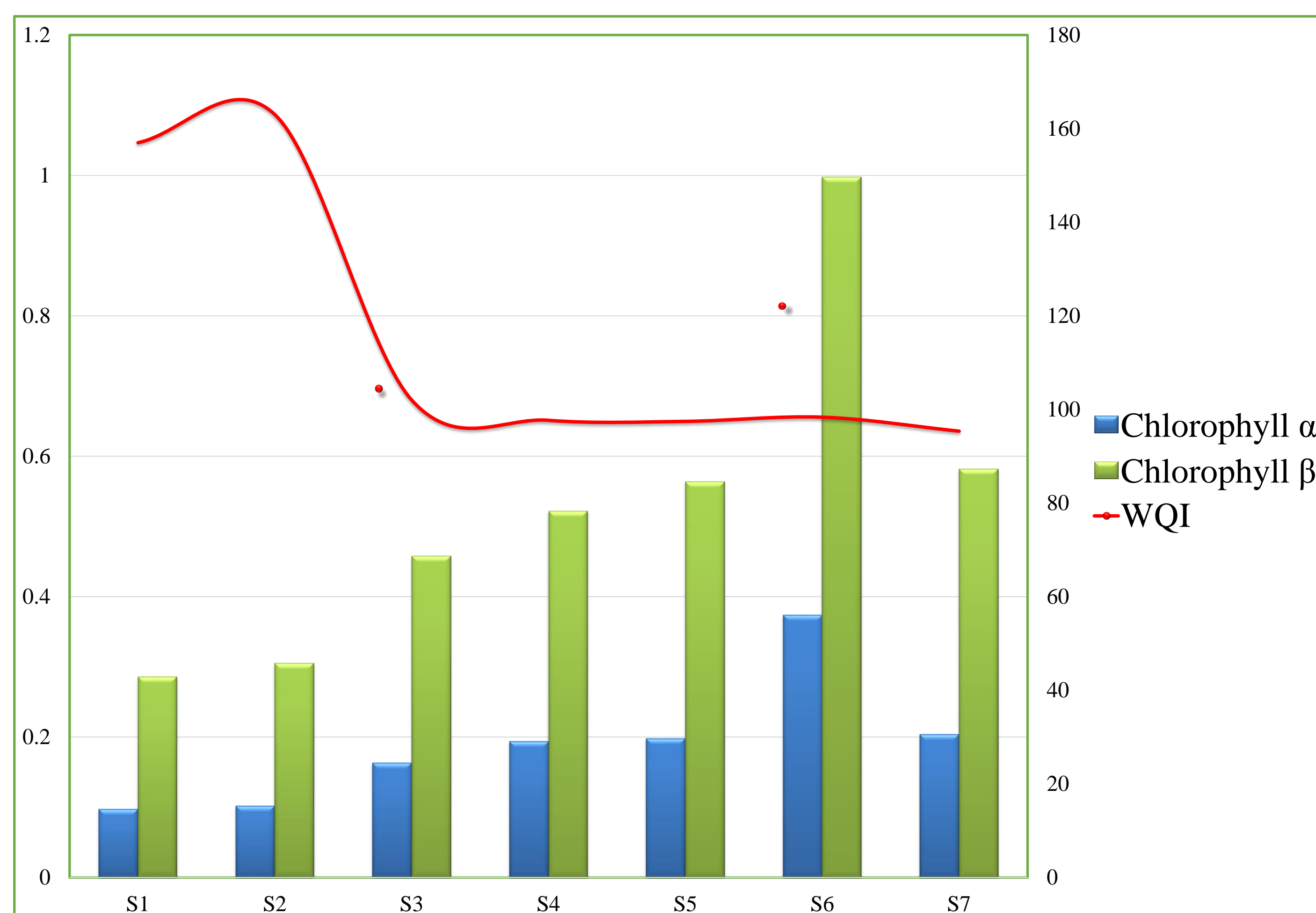


Fig. 4 The correlation between the presence of the chlorophylls in water and water quality index WQI

CONCLUSION

- The surface water sampled from Valea Șesii stream was divided in two different categories of quality: bad and relatively good. The first three water samples exceed the maximum values of concentration of pH, TDS, Pb, Zn, Cu approved by law.
- There were noticed some variations of the parameters: a increase of the BOD, chlorophylls α , β and a decrease of the heavy metals content, micro- and macronutrients, while getting closer to the main course – Arieș River. Those chances could be a sign of an improvement trend of the water quality while getting away from the mine.
- The first three stations were also found to have poor water qualities with high level of heavy metals according to the heavy metal evaluation index *HEI* and heavy metal pollution index *HPI*.
- The study showed a correlation between the water quality index *WQI* computed for the surface water sampled from the catchment and the organisms' bioactivity.
- The PCA revealed a strong bond between the presence of all metals and BOD, pH and chlorophylls and the HCA of the bio-chemical parameters analyze divided them into three clusters. All the statistical analysis confirming once again the solid bond between water quality and the presence of the organisms within it.

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