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# Characteristics of the spatial distribution of pollutants in the Shkumbin River, using the Inverse Distance Weighting Method

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***Abstract*** –The Shkumbin River is one of the largest in the country, with a length of 181 km, a catchment area of 2444 km2, and an average height of its sources of 753 m. For the specificity of the Shkumbin River and the importance of the use of its waters, it is necessary to continuously study the level of water quality and the level of pollution, especially in its lower reaches, where agricultural and urban activities are concentrated and industrial.
The study was carried out in the period 2021–2022, in the Shkumbin River watershed, and eight stations were selected as representative points of the main stream of the Shkumbin River. In the context of industrial and urban development, the preservation of the natural environment takes on special importance. The solution to this problem requires the hydrochemical study of water sources, which is necessary for the control of their condition, and the study of compounds and polluting phenomena. In order to study the distribution of organic pollutants and heavy metals and obtain pollutant distribution pictures using the ArcGIS system, the Inverse Distance Weighting Method was used.

*Keywords –Shkumbin River, Pollutant Distribution, Water Quality Parameters, Inverse Distance Weighting Method*

## I. Introduction

In Central Albania, the Shkumbin River is one of the largest in the country, with a length of 181 km, a catchment area of 2444 km$^2$, and an average height of its sources of 753 m. It flows into the Adriatic north of the Karavasta lagoon. It originates on the eastern slopes of Valamara Mountain and Guri i Kamjes. Shkumbin's annual average flow is 61.5 m$^3$/sec., with an average flow modulus of 25.2 1/sec/km$^2$ and an average annual water volume of 1,900 million m$^3$. The amount of suspended solids transported by Shkumbini in the sea during a year is an average of 5.8 million tons. The waters have an average mineralization of 317 mg/liter and a temperature ranging from 6.30 °C in January to 22,0°C in August [6],[22]. The Shkumbin River watershed has very diverse hydrogeological conditions. It consists of very different rocks in terms of chemical and mineralogical composition and their water content. Thus, the construction of this basin includes carbonate rocks rich in karsts waters, porous and fissured sandstone-conglomerate rocks with medium water content, fissured igneous rocks with limited to medium water content, flyschoidal rocks with practically no groundwater, and alluvial deposits of friable (porous) gravels with very high water content. Atmospheric precipitation is the main element in the input part of the water balance equation. Their formation is inextricably linked to the amount of moisture contained in the atmosphere, its circulation, the distance of the territory from the sea and the ocean, the relief of the country, and many other factors [11], [22]. Water flow is one of the main elements of the water balance in river basins. The waters of the Shkumbin River mainly have human use in the irrigation of agricultural lands, in the processing of livestock products, in the metallurgical and chemical industries, in the processing industry of agricultural products and fruit trees, in the leather processing industry, in the wood processing industry, as well as in raising fish.

## II. Materials and Method

The study was carried out in the period 2021–2022 in the Shkumbin river basin, and eight stations (Fig. 1) of the Shkumbin river were selected as representative points of the main flow of the river, which are given below with the coordinates in Table No. 1.

The object of the study was focused on: (a) organic compounds (organochlorins, PCB, and BTEX); (b) heavy metals (Fe, Cr, Cu, Zn, Ni, and Cd).

The samples of organics and metals were taken in 1.5-liter plastic bottles, and acidification with HNO3 was done for the metals. Heavy metals were determined by atomic absorption spectrometry (AAS), graphite furnace atomization, and SAA/AET. The measurements were performed using the analytical spectrometer types JENA, NOVAA, and AAS.

Organochlorins pesticides and PCBs were extracted with the liquid-liquid technique in n-hexane solvent, purified on a florisil column, and their qualitative and quantitative determination carried out with the GC/ECD technique on a capillary column. The column used was Rtx-5 (30 m x 0.32 mm x 0.25 um).

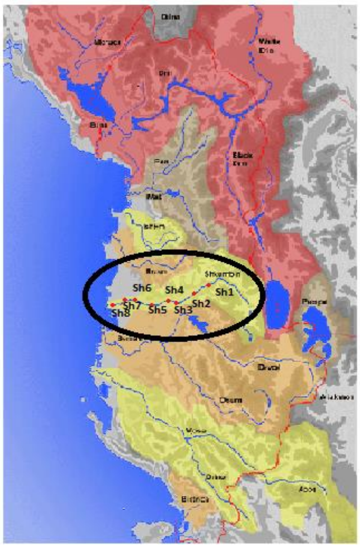


Fig. 1 The watershed of the Shkumbin river and the sampling stations

An BTEX were extracted by the HS technique on 100-um polydimethyl siloxane fibre. The injection was performed in the GC/FID apparatus with a capillary column VF-1ms (30 m x 0.32 mm x 0.25 um). The data found for organochlorines pesticides and PCBs are given in ng/l, while for BTEX it is in g/l.

The general assessment of the water quality of the Shkumbin River in terms of the content of organic compounds and heavy metals was made according to UNECE standards.[1],[2],[3],[13],[14],[16].

Table 1. Coordinates of the stations

| Stations | Coordinates | Coordinates |
|---|---|---|
| | X | Y |
| Sh 1 | 4429932 | 4557197 |
| Sh 2 | 4421210 | 4550617 |
| Sh 3 | 4418112 | 4549837 |
| Sh 4 | 4417187 | 4548883 |
| Sh 5 | 4411224 | 4547322 |
| Sh 6 | 4390271 | 4547657 |
| Sh 7 | 4386186 | 4548544 |
| Sh 8 | 4371310 | 4546896 |

In our case, the calculation of the values at the unknown points (by "unknown points," we mean the points where we have not performed measurements) for each of the parameters measured at the stations (the stations are known points) was performed with the inverse distance interpolation method IDW (Inverse Distance Weighting) [9], [10]. The inverse distance method is a local interpolation method that takes into account the principle of influence in relation to distance, i.e., at an unknown point, nearby points have more influence than distant points, and the influence decreases with increasing distance. The degree of influence of the parameter measured at station i (where by point we mean one of the stations where we have carried out measurements, so we have data) is expressed through the inverse distance between the points raised to the e- k power, with $\frac{1}{d_i^k}$ (in our case k = 2) and the value of the parameter $z_i$ at the i-th station. The general equation for calculating the value of a parameter at a certain unknown point in relation to known values is:

$$z_0 = \frac{\sum_{i=1}^{i=n} z_i * \frac{1}{d_i^k}}{\sum_{i=1}^{i=n} \frac{1}{d_i^k}}$$

where $z_0$ is the value that will be calculated (interpolated) at point 0 (which is a point from the set of points where we did not measure and for which we must calculate the values of the parameter in question).

$z_i$ is the value of the parameter z at point i (that is, the value of the parameter z at station i).

$d_i$ is the distance between station i and another point where we did not measure and

n is the number of stations where we performed measurements.

## III. RESULTS

As a result of the interpolation by means of the above method, we obtained the spatial distributions of the average values of the measured parameters, which are presented in the following maps.

### A. *Organic parameters*

PCB

Figure 2 shows the values of the average distribution of PCBs. From station Sh 1 to station Sh 3, we noticed an increase in PCB values. At station Sh 4, the maximum value is observed, and continuing towards Sh 5, a decrease in values is observed, which at stations Sh 6 and Sh 7 reach maximum values again. Then, continuing towards the Sh 8 station, a trend towards decreasing values is observed.

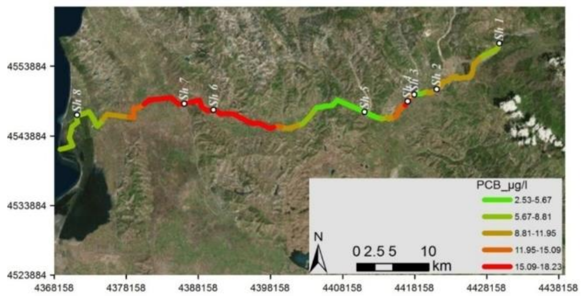


Figure 2. Spatial distribution of average values of PCBs ng/l.

### B. Organochlorins

Figure 3 shows the distribution values of chlorine-organic compounds. From station Sh 1 to station Sh 4, an increase in values is observed, reaching the maximum value at station Sh 4. Then a decrease in values is observed until station Sh 5, continuing with an increase at stations Sh 6 and Sh 7. Going towards the end station, Sh 8, a decrease in values is observed until the minimum values.

Figure 4 shows the BTEX distribution values. BTEX values increase by passing from station Sh 1 to station Sh 4 where the maximum value is observed. Then the values decrease and, going towards the Sh 6 station, they increase again. From station Sh 7 to station Sh 8, the values hardly change.

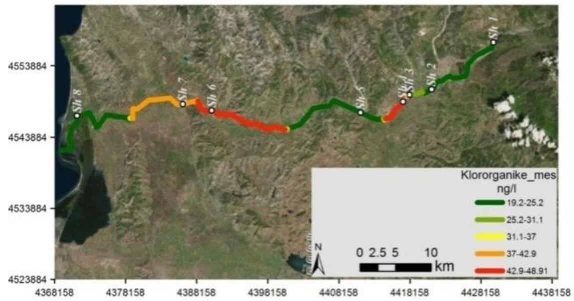


Figure 3. Spatial distribution of average values of Organochlorine ng/l.

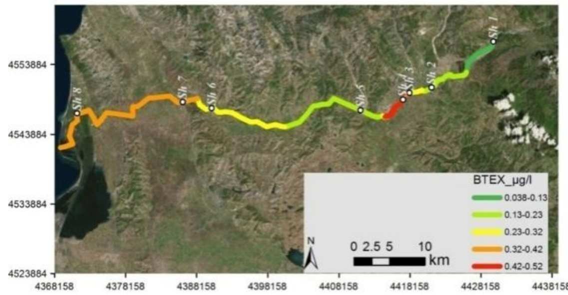


Figure 4. Spatial distribution of average values of BTEX µg/l.

### C. Heavy metals

Figure 5 shows the average iron distribution values. From station Sh 1 to station Sh 2, an increase in iron values is observed. At stations Sh 3 and Sh 4, the maximum value is observed, and continuing towards stations Sh 5 and Sh 6, it is observed that the values fluctuate in a narrow range. At station Sh 7, a decrease in values is observed, and then continuing towards station Sh 8, a decrease in Fe values is observed.

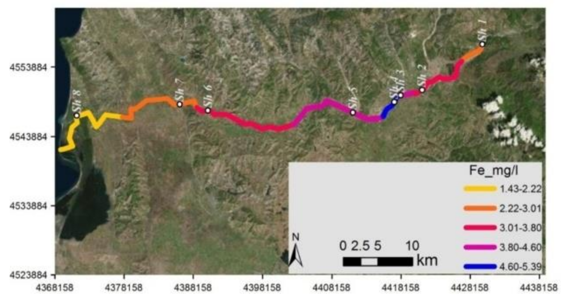


Figure 5. Spatial distribution of average values of Fe mg/l

Figure 6 shows the distribution of average copper values. From station Sh 1 to station Sh 3, a gradual increase in copper values is observed. From the station Sh 4 to the end station Sh 8, Cu values remain the same in the maximum range.

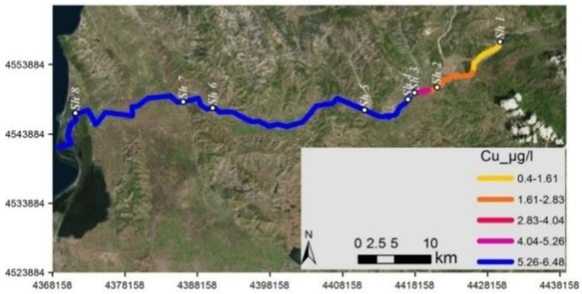


Figure 6. Spatial distribution of average values of Cu g/l

Figure 7 shows the distribution of average cadmium values. From station Sh 1 to station Sh 3, it is observed that the values fluctuate in a narrow range. At the stations Sh 5 and Sh 7, it is observed that the maximum Cd values are reached, and going towards the station Sh 8, a gradual decrease of the Cd values is observed.

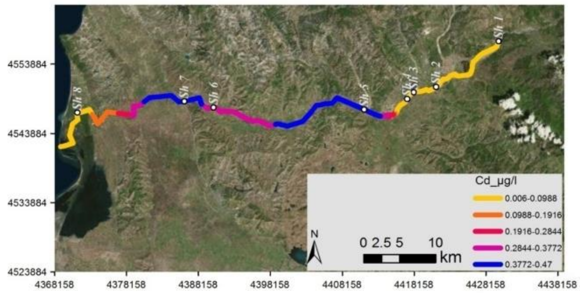


Figure 7. Spatial distribution of average values of Cd µg/l.

Figure 8 shows the distribution of average nickel values. From station Sh 1 to station Sh 3, a gradual increase in nickel values is observed. Then moving towards stations Sh 4 Sh 5 and Sh 6 it is observed that the values increase to the maximum. Then, towards stations Sh 7 and Sh 8, a gradual decrease in nickel values is observed.


Figure 8. Spatial distribution of average values of Ni µg/l.

Figure 9 shows the distribution of the average chromium values. From station Sh 1 to station Sh 4, a gradual increase in chromium values is observed, where the maximum values remain stable from station Sh 4 to station Sh 7. Then, moving towards station Sh 8, a small decrease in values is observed.

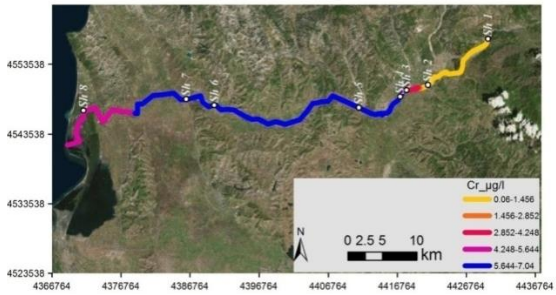


Figure 9. Spatial distribution of average values of Cr µg/l.

DISCUSSION

Based on the above, we can say that:

Relatively high values of the content of organic compounds were found in stations Sh 5, Sh 6, and Sh 7, where the impact of mainly urban and agricultural discharges is felt. In stations Sh 3, Sh 4, and Sh 6, PCB 28 and PCB 138 were detected, the origin of which may be from point sources on lands near the river. The highest level of organochlorins pesticides and BTEX was found at stations Sh 4, Sh 6, and Sh 7 and in the vicinity of agricultural land drainage canals located in the vicinity of various processing industries.

The content of heavy metals present in the waters of the nearby Shkumbin River resulted in the following order: Fe > Ni > Cu > Cr > Cd.

Monitoring and achieved results show that the content of iron, nickel, and copper is quite high for stations Sh 4, Sh 5, Sh 6, Sh 7, and Sh 8, above the limits allowed by classifying these polluted waters.

These heavy metals found in the waters of the Shkumbin River, as well as the presence of other elements in them in smaller concentrations, cause them to accumulate in the soil with the irrigation water, causing soil and groundwater pollution. In this way, these heavy elements potentially pose a risk for their transfer to agricultural plants and then to other links in the food chain.

## IV. CONCLUSION

In conclusion, we say that the waters of this river are mainly influenced by point sources (urban, industrial waters, chemicals, agricultural discharges) and non-point sources (pesticides, plant waste, dams), and the waters of the Shkumbin River maintain good physical and chemical quality for stations Sh 1 and Sh 2, average quality for stations Sh 3, Sh 4, and Sh 8, and poor quality for stations Sh 5, Sh 6, and Sh 7.

## ACKNOWLEDGMENT

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