# Phytostabilization Potential of *Salix alba* as Biomonitors of Heavy Metals in Soil Pollution near the Erzeni Riverbank

Enkelejda Kucaj*, Marilda Osmani, Anira Gjoni, Azem Bardhi, and Besim Kucaj

***Abstract*—The great sources of water pollution in Albania in the last decade are urban discharges which indicate in other sistems. The aim of this study was to evaluate the concentration of heavy metals in the soil and plant of *Salix alba.* Samples was collected from the Erzen riverbed. The objectives are based on assessment of the concentrations of physico-chemical characteristics heavy metals obtained from the sediment and willow (*Salix alba)* in Erzeni river. The presence of organic matter in soil - the willow plant - was also analyzed. The use of plants in the recuperation of contaminated soil is low cost, sustainable, and environmentally sound. Heavy metals concentration in soil range as follows: Ni (42.2–98.4 mg/kg); Cr (18.9- 34.5 mg/kg), and Pb (53.2-98.4 mg/kg). Some statistically significant differences were observed in the data on the amounts of metals accumulated in the soil, significantly more than in the data on the metal concentrations achieved in the tissues of the *Salix alba* plant. Heavy metal concentration in plants reach values Ni (0.9–3.54 mg/kg); Cr (0.57 - 0.89 mg/kg), and Pb (0.06 -0.19 mg/kg). Average concentrations in heavy metal plant samples were listed in the order Ni> Cr> Pb. The results of nickel, chromium, and lead clearly show higher concentrations in samples 0-25 cm across the range of extractors. The use of diversified plant materials is essential and optimal for the phytoremediation process. These species offer different opportunities through their metallic tolerance and accumulation of underground biomass metals for the permanent removal of these metals from the terrestrial substrate.**

***Index Terms*—Environmental pollution, heavy metal, phytoremediation, *Salix alba*, soil contaminated.**

## I. Introduction

Urban development in recent years more and more, the Erzeni River has been invaded and continues to be captured by a rampant human invasion. It has happened due to human activities for indiscriminate use of aggregates for economic purposes. It includes delicate habitats that are very important in terms of their values and has been a lot damaged by human interventions [1]. Utilization of riverbed and shore inert without any criteria is closely related to significant damage to the environment directly influencing the growth of erosion and damage to vegetation [2].

Heavy metal pollution has been a problem due to the discharge and distribution of waste materials into the ecosystem. Uncontrolled discharge of sewage into the river causes the process of eutrophication as well as higher flowering of algae. Lack of dissolved oxygen in surface waters leads to the killing of fish and other oxygen-seeking organisms [3].

Emissions from the production of cement, leather, ceramics, textiles, mining, extraction, and processing of oil and gas, and wood processing plants [4] remain a concern for the industry. Partially treated and untreated waste is discharged into the river. Human activity in rivers and their catchment area can affect water quality and the biodiversity of the aquatic ecosystem. Erzen River and its floodplains are springs with large reserves of sand and gravel, which can be exploited, conveniently and economically, for various uses.

Changing the riverbed, because of the use of aggregates, can severely damage public infrastructure (bridges, pipelines, roads, etc.) and create a loss of biodiversity, the recreational potential of watercourses, and agricultural lands along the river, and other assets. real estate. Above the "Ura e Peshkatarit" where the use of inert materials is not allowed until the estuary, the activity of inert use is present, where the damages to the agricultural and non-agricultural land are very visible [5]. Based on previous studies, high concentrations of Pb, Ni, and Zn in water are found [6]. In polluted sites, organic and inorganic pollutants are often combined in the same locality [7]. Soil contaminated with heavy metals can impede the successful germination of seeds and seedlings [8].

Phytoremediation is a complementary or alternative, cost-effective, environmentally friendly technology, that utilizes suitable plant species to remove or degrade organic and inorganic pollutants [9]. The genus Salix alba (willow) has a specific capacity to catch heavy metals from soil pollution. [10] has distinguished three types of plants, that are accumulators, excluders, and indicators. The genus Salix (Willow) belongs to the plant family Salicaceae. There are four hundred willow species and more than two hundred hybrids listed [11].

The concentration of heavy metals in the soil is not the only factor to be studied, toxicity and mobility of metals are also affected by their shape and physio-chemical association with soil components, or specification. Heavy metals in soils are often concentrated in surface horizons because of this atmospheric deposition, as well as through vegetation and adsorption by organic matter [12]. Vegetation serves as a buffer between the water and underlying soil. Sediments act as "suffocation" for pollutants, and can remain in the aquatic environment for decades, allowing these pollutants to enter the food chain, and thus into fish tissues [13].

These metals can be transported, dispersed, and accumulated in plants and then passed through the food chain to human beings as the final consumer [14]. However, such remediation technique strategies as immobilization or

Manuscript received June 9, 2022; revised July 12, 2022; accepted July 19, 2022.

Enkelejda Kucaj, Anira Gjoni, and Azem Bardhi are with the Department of Meteorology - Institute of GeoSciences, Polytechnic University of Tirana, Albania.

Marilda Osmani is with the Department of Chemistry, Faculty of Natural Sciences, University of Elbasan "Aleksandër Xhuvani", Albania.

Besim Kucaj is with the Department of Agro-environmental, Agricultural University of Tirana, Tirana, Albania.

*Correspondence: enkilusha@gmail.com

doi: 10.18178/ijesd.2023.14.1.1411 

extraction by physic-chemical techniques are too expensive and generally impractical [15]. The aim of this study was to evaluate the concentration of heavy metals in the sediment and plant samples of *Salix alba* collected from the pollution of the Erzen riverbed.

However, metal concentrations in willows depend on species, growth performance, root density, distribution within the soil profile, and sampling period [16]. Moreover, willow has been recently recognized as a good accumulator of heavy metals [17].

## II. Materials And Methods

This study was based on the assessment of the concentration of heavy metals in plants *(Salix alba)* and sediments in the Erzen River. Sampling for both solutions was performed in the period June 2020.

### A. Study Area

Erzen River originates in the south-east of the region, from the pit mountain, behind the Dajti mountain range, cutting the mountainous and hilly areas of Shëngjergji and Qaf-Molla and forming deep valleys, especially in the upper parts of its flow [18].

Erzeni River during its flow takes with it a series of streams that flow in its bed starting from the Shengjergji area of Qaf Molla, and continuing north of Krraba, in Mullet, Farka, Fortuzaj, Arbana, continuing towards Peza e Vogël, Ndroqit e Shijakut, crosses the Erzeni Lowland north of the city of Durrës and flows into the Adriatic Sea in the bay of Lalzi [18].

The catchment area of this river is about 759 $km^2$ while the annual volume of its discharge is about 1,439 million $m^3$, with a specific discharge of about 31 $L/sec*km^2$. Water quality is poor as the river flows through one of the most developed urban areas of central Albania. Efforts to avoid the negative effects of heavy metals on human health and ecological hazards are increasing [4].

Fig. 1. Erzen River Basin [19] and collected samples of soil and plants.

### B. Soil Samples and Plant Samples (Salix alba)

The concentration of heavy metals has an important role in the dynamics of water, backing material and plant. Industrial effluents and sewage/household waste are dumped into these rivers without prior treatment, thus increasing the concentration of pollutants, including heavy metals in the river water, sediment, and plant. Based on the procedures and methodology according to the geological, morphological, and pedological conditions, five sampling sites were selected in Ndroq, Albania (Fig. 1). Samples of sediments and plants *(Salix alba*) were taken in this area which was analyzed for the concentration of heavy metals in the period of summer 2020.

Soil samples were collected in the root zone of the plant about 0-30 cm deep at each station, using the metal probe and then this material was placed in polyethylene boxes. Each soil and plant sample were representative of 5 sub-samples collected in each sector about 20 m apart, a total of 25 soil and plant samples collected. Samples were transported to the laboratory within the same day. The sediment samples were dried in a thermostat at a temperature of 105 ℃ for 24 hours. Each sediment sample was ground in a grinding mill used for soils and then passed through a 2 mm sieve.

Samples were digested using nitric acid or aqua regia, HCl: $HNO_3$ (2:1). The filtered samples were left to rest for a few minutes, and then their measurement was done in the Spectrophotometric Atomic Absorber.

- Determination of trace elements S SH EN 14084:2003

Determination of lead, cadmium, zinc, copper, and iron by atomic absorption spectrometry (AAS) after microwave dissolution. Estimation of heavy metal sediment pollution has been made possible based on the standard limits of [19]-[21] The textural class of the soil is determined by the percentage of sand, mud, and clay [22]. The soils of these stations consist of clay, silt, and sand with different % respectively.

The plant samples were first washed and dried in a thermostat at a temperature of 70 ℃ to constant weight. Drying the materials protects the plant materials from microbial decomposition and provides a constant value (Aksoy et al., 1999). The plant samples were passed through the grinding mill, digested using nitric acid or aqua regia, HCl: $HNO_3$ (2:1). One gram of sediment was then weighed and dissolved with 12 ml of the mixture. After it was diluted with 20 ml of nitric acid and filtered with filter paper in a flask, we put the concentration of the solution in distilled water. The filtered samples were left to stand for a few minutes and then the measurement of heavy metals was done in the Spectrophotometric Atomic Absorber.

### C. Assessment of Metal Contamination in Soil

To evaluate the degree of contamination in the sediments, we used five parameters: enrichment factor (EF), geo-accumulation index (I), contamination factor (CF), contamination degree (Cd), and pollution load index (PLI).

- Enrichment Factor (EF)

In our study, enrichment factor (EF) according to [23] was used to assess the level of pollution and potential anthropogenic impacts on river sediments and to identify metallic concentrations. Enrichment factor classification according to [24], EF = Cn in samples taken / C in soil crust

- Geo-accumulation Index (Igeo)

Enrichment of metal concentration above baseline concentrations was calculated using the method proposed by [25] termed the geo-accumulation index (Igeo), which is expressed as follows: I-geo = log2(Cn / 1.5 Bn)

According [24], proposed seven grades or classes of the geo-accumulation index (Igeo).

- Contamination factor (CF)

The pollution factor and the contamination degree were used to determine the contamination in the sediments at the time of the study. The value of the pollution factor has been suggested by [26] and is calculated: CF = Cm of metal / Cm background, Background and crustal values are obtained according [27].

- Pollution Load Index (PLI)

Pollution and its variations across stations are determined using the pollution load index. [28] explained that the application of PLI provides a simple way to assess pollution in sediment quality [29].

PLI = n$\sqrt{}$ (CF1 CF2 CF3⋯ CFn), where n is the number of heavy metals studied and CF = are the pollution factors described above.

- Contamination Degree (Cd)

The degree of contamination Cd = ΣCF [30] is defined as the sum of all contamination factors depending on each metal in all analyzed sediment samples.2.3.

- Bioconcentration Factor, BCF

BCF provides an index of the plant's ability to accumulate or accumulate metals that are concentrated in the substrate. BCF is calculated using the equation: BCF = [Metal] plant / [Metal] sediment. A ratio of BCF > 1 indicates the best phyto accumulative capacity of metals in plants [31].

## III. Results and Discussion

There is a fundamental concern about the concentration of heavy metals in the environment in soil and plant „Salix alba" and their threat to human health. The study area is widely affected by progressive discharges of urban, agricultural, and industrial liquid waste without any prior treatment are the main source of water pollution in the Erzen River.

Soil samples were taken in the area below the willow root system. The concentrations of heavy metals obtained from the plant samples show a steady trend of nitrogen, phosphorus, and potassium shown in Table I. The accumulation of nutrients in plants reflects their nutrient requirements, depending on several factors, such as level of production, species, cultivar, soil fertility and/or fertilization, climate, and crop treatments [32].

In general, crops have nutritional needs that represent the number of macronutrients and micronutrients that plants receive from the soil to meet all stages of development [32].

Table II are presented the obtained values of physicochemical characteristics of the soil taken in the bed of the Erzen River, Ndroq. It is noticed that the properties of the soil have a strong influence on the effect of plant growth on the concentrations of heavy metals in the soil substrate as well as nutrients.

Based on size test analyses that sediments have the following composition: Clay (9.2%) - Silt (28.7%) - Sand (62.1%) and Gravel (0.0%). Soils were classified as sandy because the percentage of silt was twice the percentage less and clay is less than 30%.

TABLE I: Nutrient of *Salix alba* Plant in Soil at Erzeni River Bank, Ndroq, Albania

| | Determination of nitrogen $NH_4^+$ (%) | Total Phosphorus $P_2O_5$ (%) | Total Potassium $K_2O$ (%) |
|---|---|---|---|
| S1 | 3.36 | 0.71 | 1.45 |
| S2 | 3.024 | 0.726 | 1.57 |
| S3 | 3.12 | 0.89 | 1.74 |
| S4 | 2.95 | 0.95 | 2.01 |
| S5 | 3.47 | 0.84 | 1.37 |

TABLE II: Physico-Chemical Characteristics in Soil, at Erzeni River Bank, Ndroq, Albania

| **Large sand particles (%)** | **Small sand particles (%)** | **Powder (%)** | **Clay (%)** | **CE mS/cm** | **pH** | **CaCO3 (%)** | **Potassium K2O mg/100g** | **Humus (%)** | **Nitrogen (%)** | **Organic matter M.O (%)** | **Humidity (%)** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0% | 62.1% | 28.7% | 9.2% | 0.2 | 8.26 | 16.72 | 3.53 | 0.93 | 6.128 | 2.84 | 25.02 |

The concentration of heavy metals in the soil depends on many factors, but they occur naturally at low concentrations in the soil or are considered soil pollutants at high concentrations due to their acute and chronic toxicity [33]. All results from soil and plant samples in Erzen River flow were expressed based on dry mass mg/kg.

The average values of heavy metals in the ground in Erzen sediments were in the following order: falling levels for metals Pb> Ni> Cr clearly showing higher concentrations in samples 0-25 cm across the range of samples taken for study. In this study, was found that the concentration of heavy metals in sediments was higher than the permissible limits of [20], [21].

Table III presents the concentration of heavy metals in the soil and the *Salix alba* plant as well as the bioconcentration factor that the plant has to accumulate metals from the soil around the Erzen riverbed, in the period July 2020.

TABLE III: CONCENTRATION OF HEAVY METALS IN SOIL AND *SALIX ALBA* PLANT SAMPLES OF ERZENI RIVER DURING PERIOD JULY 2020

| | Soil sample results | | | *Salix alba* sample results | | | ***BCF*** **Bioconcentration Factor** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Mostrat** | Ni | Cr | Pb | Ni | Cr | Pb | Ni | Cr | Pb |
| **S1** | 63.2 | 27.2 | 53.2 | 1.8 | 0.76 | 0.07 | 0.0285 | 0.0281 | 0.0014 |
| **S2** | 55.1 | 18.9 | 66.4 | 0.9 | 0.89 | 0.06 | 0.0164 | 0.04709 | 0.0011 |
| **S3** | 42.2 | 29.1 | 97.1 | 1.2 | 0.72 | 0.19 | 0.0285 | 0.0246 | 0.0021 |
| **S4** | 98.4 | 31.2 | 85.6 | 2.35 | 0.57 | 0.11 | 0.0239 | 0.0183 | 0.0013 |
| **S5** | 85.6 | 34.5 | 78.3 | 3.54 | 0.61 | 0.13 | 0.0414 | 0.0179 | 0.0017 |
| **Min. Value** | 42.2 | 18.9 | 53.2 | 0.9 | 0.57 | 0.06 | | | |
| **Max. Value** | 98.4 | 34.5 | 97.1 | 3.54 | 0.89 | 0.19 | | | |
| **Mean Value** | 68.9 | 28.18 | 76.38 | 1.96 | 0.71 | 0.12 | 0.0277 | 0.0272 | 0.0015 |
| **STDEV** | 22.889 | 6.1179 | 17.859 | 1.0665 | 0.1289 | 0.0528 | | | |
| **WHO (2004)** | - | 25 | - | | | | | | |
| **USEPA (2007)** | 16 | 25 | 40 | | | | | | |
| **FAO** | | | | 2.5-5.5 | 2.1-3.8 | 0.4-1.3 | | | |

Nickel concentration is another toxic and harmful element, which is a moderate concern due to its potential carcinogenicity in humans; it also has various harmful effects on aquatic life. It is toxic to plant life, too and is a danger to fish. Nickel toxicity is generally a result of wastewater discharges. This chemical element has the property to be easily and quickly absorbed by plants [34]. Nickel concentrations in all soil samples were above the permissible values (35 mg/kg), ranging from 42.2 mg/kg dry mass to 98.4 mg/kg dry mass. The average value achieved for nickel in the study area was 68.9 mg/kg dry mass.

The lead content in the sediments of the Erzen River resulted in an average value of 76.38 mg/kg dry mass resulting in higher values compared to the norm. Chromium is toxic, the element is considered carcinogenic (in high concentrations) and can act as an irritant to the skin if it is passed on to human health. The achieved values for lead were (53.2 mg/kg up to 97.1 mg/kg dry mass), the source of which in the environment can come mainly from anthropogenic sources (mines, plants, etc.). The mean value of all samples was 76.38 mg/kg dry mass, which resulted above the set norm.

Chromium concentrations in soil samples were below the limit values (25 mg / kg), ranging from 18.9 mg / kg dry mass to 34.5 mg / kg dry mass. The average value of this chemical element was 28.18 mg/kg, which was considered above the allowed values, which can show negative effects on biological processes in soil, plants, animals, and humans.

The results for the willow plant samples in the Erzen riverbed are presented in Table III. Nickel concentrations ranged from 0.9 mg / kg dry mass to 3.54 mg / kg dry mass. The mean Ni values were 1.96 mg / kg dry mass within the permissible nickel limit in plants recommended by FAO.

The Pb concentration ranged from 0.06 to 0.19 mg/kg dry mass and the mean value was 0.12 mg/kg dry mass. Compared to the allowed values for sediment quality, the average value has exceeded the limits and this result shows that the sediments of the Erzen River are polluted by Pb. This may be due to increased human activity as these are inhabited areas.

Chromium concentrations in the *Salix alba* plant samples ranged from 0.57 mg / kg dry mass to 0.89 mg / kg dry mass. The mean value for Cr in the *Salix alba* plant samples obtained was 0.71 mg/kg dry weight which was within the limits allowed by FAO. The chromium content in plants is mainly controlled by its soluble content in the soil. Plants absorb heavy metals from the soil through some of these processes, such as redox reactions, ion exchange, dissolution of precipitation, etc.

The transfer of metals from soil to plant tissues has been studied using evaluation indices and relevant parameters of the accumulation of heavy metals from soil to plants. BCF provides an index of the plants ability to accumulate metals that are concentrated in the substrate. BCF is calculated using the equation: BCF = [Metal] plants / [Metal] sediments

A ratio BCF > 1 indicates the best phytoaccumulative capacity of metals in plants [31]. Table III presents the results of the Bioconcentration Factor for the Plant (BCF) of the average values of the two plant and sediment study periods around the riverbed and the ability of metals to pass from sediment to plant.

In average values these factors represent the ascending order Ni> Cr> Pb, the ratio of metals in plants/sediment is <1, a fact that indicates a phytoaccumulative ability of metals from poor sediment.The research proved a weak link between the concentration of metals in sediments and in plants.The mobility of metals in plants, from roots to leaves is higher than from sediments in plants [35].

### *A. Assessment of Metal Contamination in Soil*

The enrichment factor (EF) is a convenient measure of geochemical trends and is used to make comparisons between areas [36]. The EF values of heavy metals in the Erzeni river sediments are listed in Table IV and presented in Fig. 2, calculated as the concentration of heavy metals in the study area. The average value of the EF enrichment factor for Pb in the Erzen River sediments was 3,819 in the range 2 ≤ EF <5, these sites are classified as moderate enrichment (Table IV).

TABLE IV: ESTIMATION OF ENRICHMENT FACTOR (EF), GEO-ACCUMULATION INDEX (I-GEO) IN ERZEN RIVER SEDIMENTS, JULY 2020

| | EF Enrichment factor | | | I-geo Geo-accumulation Index | | |
|---|---|---|---|---|---|---|
| | Ni | Cr | Pb | Ni | Cr | Pb |
| **S1** | 0.930 | 0.302 | 2.66 | -0.218 | -1.97 | 1.149 |
| **S2** | 0.811 | 0.21 | 3.32 | -0.416 | -2.495 | 1.469 |
| **S3** | 0.621 | 0.324 | 4.92 | -0.801 | -1.872 | 2.036 |
| **S4** | 1.448 | 0.347 | 4.28 | 0.421 | -1.772 | 1.835 |
| **S5** | 1.259 | 0.384 | 3.915 | 0.22 | -1.627 | 1.706 |
| **Mean** | 1.014 | 0.314 | 3.819 | -0.159 | -1.947 | 1.639 |
| | **Min. Enrich.** | **Defic. Min. Enrich.** | **Moder. Enrich.** | **Unpoll.** | **Unpoll.** | **Moder.y poll.** |

The average value of Igeo for Pb in the sediments of the Erzen River was 1,639, classified in the degree of pollution (1 <Igeo <2). According to the Muller classification, the Igeo values for Pb indicate that the Erzen River sediments are moderately polluted for most sampling sites. According to the sediment quality guidelines, the Erzen River sediments were not highly polluted for the Ni and Cr elements (Table IV).

A contamination factor (CF) was used to determine the contamination status of the Erzen River sediments. The CF calculated for various heavy metals in the Erzen River sediments is shown in Table V.

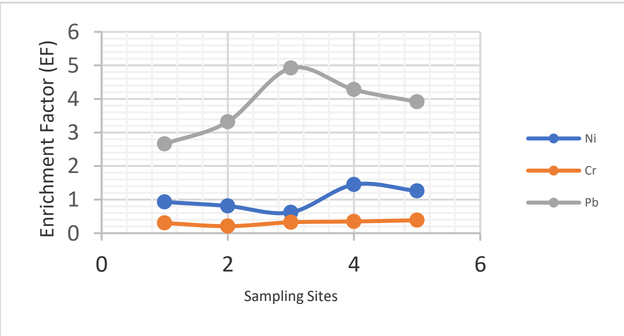



Fig. 2. Enrichment factor (EF) and and geo-accumulation index (I-geo) in Erzen River sediments in July 2020.

The average CF value for Pb in the Erzen River sediments was 4.78. This result presented in Table V, shows that most sampling sites have CF classified in the range 3 ≤ CF <6, with Considerable contamination, according to the [26] classification. While for heavy metal Ni the value of the pollution factor marks 1 ≤ CF <3, indicating average pollution. Significant values of the pollution factor at all stations for Cr marking an average value of 0.41, (CF <1 low pollution).

The maximum value of the degree of Cd contamination is set for Pb metal, 12 ≤Cd <24 significant degrees of contamination. The concentration of nickel metal in the sediments of the Erzeni River is rated at 6 ≤Cd <12, the average degree of contamination. While for Cr metal it marked a low degree of pollution, with Cd <6 low degrees of contamination (Table V).

From these indices, the study area is considered to have high pollution with lead, nickel, and chromium. This is due to the impact of external sources such as industrial activities, agricultural waste, etc.

Pollution load index (PLI) and its variations across stations are determined using the pollution load index. [28] explained that the application of PLI provides a simple way to assess contaminated and non-contaminated sediments. For PLI> 1 contamination in sediment quality is demonstrated [29].

From the obtained results we have that almost all the stations taken in the study, in the Erzen River can be classified as places polluted with heavy metals of Pb, Ni, and Cr.

TABLE V: CONTAMINATION FACTOR (CF), CONTAMINATION DEGREE (CD) AND -POLLUTION LOAD INDEX (PLI) IN ERZEN RIVER SEDIMENTS IN JULY 2020

| | Heavy metals | S1 | S2 | S3 | S4 | S5 | Mean CF | Cd= (ΣCF) | PLI |
|---|---|---|---|---|---|---|---|---|---|
| **CF** | **Ni** | 1.291 | 1.125 | 0.862 | 2.01 | 1.758 | 1.41 moderate contam. | 7.04 average degree of contam. | 1.35 pollution in sediment quality |
| | **Cr** | 0.384 | 0.267 | 0.41 | 0.44 | 0.49 | 0.41 low contamination | 1.99 significant degree contam. | 0.39 present not much pollution |
| | **Pb** | 3.325 | 4.15 | 6.15 | 5.35 | 4.90 | 4.78 considerable contamination | 23.87 high degree of contamination | 4.67 pollution in sediment quality |

The use of plants in the extraction of metals from contaminated sediments is subject to the category of

Deficiency to minimal enrichment.

The following graph presents the ratio of the concentration of nickel (Ni), Chromium (Cr), and Lead (Pb) metals in the samples taken for study in soil and *Salix alba* plants in the Erzen riverbed, in the period July 2020. Heavy metals such as Ni, Cr, and Pb were studied because they are usually more disturbing and have the highest concentration in wastewater sludge [35]. The concern for Pb and Cr arises from its possible entry into the food chain.

The results obtained in these experiments suggest that Cr and Ni were highly absorbed by the plant. The concentration of Pb is higher in the soil solution than absorbed by the plant.

Heavy metals such as Ni, Cr, and Pb were studied because they are usually more disturbing and have the highest concentration in wastewater sludge [36]. The concern for Pb and Cr arises from its possible entry into the food chain.

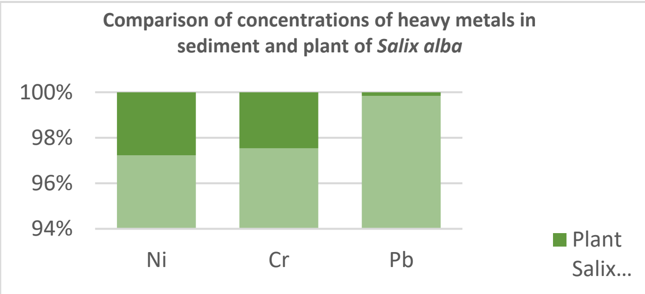


Fig. 3. Comparison of heavy metal concentrations in sediment and plants.

The results obtained in these experiments suggest that Cr and Ni were highly absorbed by the plant. The concentration of Pb is higher in the soil solution than absorbed by the plant.

## IV. Conclusions

In this research, the main purpose was the analysis of heavy metals in the samples of sediments and willow plants in the area of Ndroq, in the Erzen River.

Based on size test analyzes that sediments have the following composition: Clay (9.2%) - Silt (28.7%) - Sand (62.1%) and Gravel (0.0%). Soils were classified as sandy because the percentage of silt was twice the percentage less and clay is less than 30%.

According to the results of heavy metals in plant *Salix alba* and soil it is determined that the content of these contaminants in the study area varies between elements and samples, and those values indicate a potential threat from the industrial sector to the environment.

Based on the data obtained we say that the concentration of heavy metals in sediments is higher than in plants.

Concentrations of chromium, nickel, and lead metals in sediments resulted above standard values. Total concentrations in heavy metal sediment samples are ranked in the order Ni> Pb> Cr.The content of heavy metals in the plant samples was within the permitted limits set by the FAO and are presented in ascending order Ni> Cr> Pb

The use of plants in the extraction of metals from contaminated soils is subject to restrictions on the concentrations of heavy metals achieved in above-ground biomass, as well as the amount of biomass produced by the phytoextraction plant. These soil changes can also serve to fertilize the plant, thus increasing its biomass production. The bioconcentration factor in plants/sediment is <1, indicating that the concentration of metals accumulated in plants is not evenly distributed, but that they aim for their bioaccumulation.

Hyperaccumulation capabilities and pollution prevention characteristics would be essential next step in optimizing phytoremediation and extraction of heavy metals from soil.

The current study shows that effective precautions should be taken by the responsible parties to prevent and mitigate not only the situation but also to significantly protect the well-being of residents along the Erzen River.

## Conflict of Interest

The authors declare no conflict of interest.

## Author Contributions

All authors are involved in sampling, analysis, and site inspection. All authors wrote the manuscript and read and approved the final version of the manuscript.

## References

[1] P. Qiriazi, *The Geography of Albania: Problems and Perspectives*, 1998.

[2] V. Kovaċi, "Assessment of the potential and actual risk of soil erosion for the entire territory of Albania through the geographical information system (GIS) and its combination with the assessment technology according to Corine land cover Albania," 2010.

[3] R. Pandey, V. P. Singh, and S. K. Pandey, "Lead (Pb) accumulation study in plants and vegetables cultivates around coal mines and power plant of singrauli district," *Intl. J. Pharmaceut. Sci. & Res*., vol. 3, no. 12, pp. 5079-5086, 2012.

[4] UNEP, Vleresimi Mjedisor ne Shqiperi pas Konfliktit/Post Conflict Environmental Assessment-Albania, United Nations Environment Programe (UNEP), SMI (Distribution Services) Limited. Stevenage, UK, 2000.

[5] S. L. Raport, "Vlerësimi i pasojave, ndikimit mjedisor problemeve hidrodinamike dhe rehabilitimi i gjëndjes në shtretërit e lumenjve," 2004.

[7] B. D. Ensley and I. Raskin, *Phytoremediation of Toxic Metals: Using Plants to Clean Up the Environment*, John Wiley and Sons, New York, Chichester, 2000.

[7] B. D. Ensley and I. Raskin, *Phytoremediation of Toxic Metals: Using Plants to Clean Up the Environment*, John Wiley and Sons, New york, Chichester, 2000.

[8] N. W. Lepp, "Some relationships between trees and heavy metal pollution," *Arboricultural Journal*, vol. 3, pp. 16-22, 1977.

[9] C. O Nwoko, "Trends in phytoremediation of toxic elemental and organic pollutants," *Afr. J. Biotechnol*., vol. 9, pp. 6010-6016, 2010.

[10] A. J. M. Baker, S. P. McGrath, C. M. D. Sidoli, and R. D. Reeves, "The possibility of in situ heavy metal decontamination of polluted soils using crops of metal accumulating plants," *Resources, Conservation and Recycling*, vol. 11, pp. 41-49, 1994.

[11] C. Newsholme, "Willows: The genus salix," *Batsford*, London, 1992.

[12] G. S. Banuelos and H. A. Ajwa, "Trace elements in soils and plants: An overview," *Journal of Environmental Science and Health*, vol. A34, no. 4, pp. 951-974, 1999.

[13] J. Kirby, W. Maher, and D. Harasti, "Changes in selenium, copper, cadmium, and zinc concentrations in mullet (Mugil Cephalus) from the southern basin of lake Macquarie, Australia, in response to alterations of coal-fired power station fly ash handling procedures," *Arch. Environ. Contam. Toxicol.*, vol. 41, pp. 171-181, 2001.

[14] L. Yun-Guo, Z. Hui-Zhi, Z. Guang-Ming, H. Bao-Rong, and L. Xin, "Heavy metal accumulation in plants on Mn mine tailings," *Pedosphere*, vol. 16, no. 1, pp. 131–136, 2006.

[15] E. Zabludowska, J. Kowalska, L. Jedynak, S. Wojas, A. Sklodowska, and D. M. Antosiewicz, "Search for a plant for phytoremediation — what can we learn from field and hydroponic studies?" *Chemosphere*, vol. 77, pp. 301–307, 2009.

[16] A. Chehregani, M. Noori, and H. L. Yazdi, "Phytoremediation of heavy-metal polluted soils: Screening for new accumulator plants in Angouran mine (Iran) and evaluation of removal ability," *Ecotoxicology and Environmental Safety*, vol. 72, pp. 1349–1353, 2009.

[17] E. Meers, B. Vandecasteele, A. Ruttens, J. Vangronsveld, and F. M. G. Tack, "Potential of five willow species (Salix spp.) for phytoextraction of heavy metals," *Environmental and Experimental Botany*, vol. 60, pp. 57–68, 2007.

[18] A. K. Selenica, "Risk assessment from flooding's in the rivers of Albania. EPOKA University, Tirana, ALBANIA," *International Balkans Conference on Challenges of Civil Engineering*, BCCCE, 2011.

[19] S. Sulçe, "Land and water pollution," UBT, Tiranë, 2005.

[20] WHO (World Health Organization), "Guidelines for drinking-water quality (3rd Ed.)," Geneva: World Health Organization, 2004.

[21] USEPA (United States Environmental Protection Agency), "National recommended water quality criteria," Office of water, Office of Science and Technology (4304T), 2007.

[22] W. Berry, Q. Ketterings, S. Antes, S. Page, J. Russell, R. AnelliRao, and S. DeGloria, "Soil texture. Agronomy fact sheet series of Department of Crop and Soil Sciences, College of Agriculture and Life Science," *Cornell University Cooperative Extension*, 2007.

[23] Y. M. Li, R. Chaney, E. Brewer, R. Roseberg, J. S. Angle, A. Baker, R. Reeves, and J. Nelkin, "Development of a technology for commercial phytoextraction of nikel: Economic and technical considerations," *Plant and Soil*, vol. 249, pp. 107-115, 2003.

[24] G. Muller, "Index of geoaccumulation in sediments of the Rhine River," *GeoJournal*, Vol. 2, No. 3, pp. 108-118, 1969.

[25] D. Acevedo-Figueroa, B. D. Jimenez, and C. J. R. Sierra, "Trace metals in sediments of two estuarine lagoons from Puerto Rico," *Environ. Poll.*, vol. 141, pp. 336-342, 2006.

[26] L. Hakanson, "Ecological risks index for aquatic pollution control sediment logical approaches," *Water Res.*, vol. 14, pp. 975–1001, 1980.

[27] R. L. Rudnick and S. Gao, "Composition of the continental crust," *The Crust 1-64*, Amsterdam-San Diego-Oxford-London, Elsevier, 2005.

[28] D. L. Tomlinson, J. G. Wilson, C. R. Harris, and D. W. Jeffney, "Problems in the assessment of heavy metal levels in estuaries and the formation of pollution index," *Helgol.Wiss. Meeresunters*, vol. 33, pp. 566-572, 1980.

[29] P. S. Harikumar, U. P. Nasir, and M. P. Rahma, "Distribution of heavy metals in the core sediments of a tropical wetland system," *Int. qwJ. Environ. Sci. Tech.*, vol. 6, no. 2, pp. 225-232, 2009.

[30] A. E. Aksu, D. Yasar, and O. Uslu, "Assessment of marine pollution in Izmir Bay: Heavy metal and organic compound concentrations in surficial sediments," *Turk. J. Eng. Environ. Sci.*, vol. 22, pp. 387–416, 1998.

[31] V. B. Gaikwad, "Accumulation and translocation of nickel and cobalt in nutritionally important Indian vegetables grown in artificially contaminated soil of Mumbai, India," *Res. J. Agriculture and Forestry Sci.*, vol. 1, no. 10, pp. 15-21, 2012.

[32] M. Osmani, A. Bani, and B. Hoxha, "The Phyto mining of nickel from industrial polluted site of Elbasan, Albania," *European Academic Researcher*, vol. V, issue 10, January 2018.

[33] S.-H. Han, D.-H. Kim, and S.-J. Shin, "Bioaccumulation and physiological response of five willows to toxic levels of cadmium and zinc," *Soil and Sediment Contamination*, vol. 22, pp. 241–255, 2013.

[34] A. Güne, M. Alpaslan, and L. A. Ina, "Plant growth and fertilizer," *Ankara Univ. Agriculture Pub.*, No. 1539, Ankara, Turkey, 2004.

[35] E. Kucaj and U. Abazi, "Assessment of heavy metals in sediments and phragmites australis in Tirana River, Albania," *European Journal of Physical and Agricultural Sciences (EJPAS), Progressive Academic Publishing*, UK, 2015.

[36] S. Sinex and G. Helz, "Regional geochemistry of trace elements in chesapeak bay sediments," *Environmental Geology*, vol. 3, no. 6, pp. 315-323, doi:10.1007/BF02473521, 1981.



**Enkelejda Kucaj** has finished the Master of Science for Agro environmental and Ecology and in October 2016 defended the Doctorate in Environmental Science. She is a researcher at the Department of Meteorology - Institute of Geosciences, Polytechnic University of Tirana, Albania, and a lecturer at the Department of Environment at POLIS University. Her work experience includes being coordinator of INSTAT, "Bank of Ideas" Foundation, a professor in some private and public universities, and chair organizer of the Scientific Academic Conference and Student Conference. She does research in soil and environmental science, water quality, environmental health and waste management, sustainability management.

**Marilda Osmani** is a lecturer in the Department of Chemistry, Faculty of Natural Sciences. In April 2018 she won the degree of doctor at the Agricultural University of Tirana, Faculty of Agriculture, Department of Agro-Environment and Ecology, Tirana. In the period November 2009 - July 2011. She graduated with the master of science "environmental protection", from the Department of Biology and Chemistry, University of Elbasan "Aleksandër Xhuvani" She is certified for drafting environmental impact reports, to conduct environmental audits. Her current research is focusing on organic chemistry, soil, and water chemistry, as well as technology and environment, environmental and health education.

**Anira Gjoni** is an expert in the Department of Climate and Environment, Institute of Geosciences, Energy, Water and Environment, Polytechnic University of Tirana, Albania from April 2016 - present. She has finished her study for M. Sc., urban environmental management, Faculty of Environment, Polis University, Albania. Now is in process doctorate at Polis University and Ferrara University in Italy. Her interested fields are environmental engineering, meteorology, climatology, urban planning, droughts, fire forests, etc. she participated in various projects that IGEWE had been part, realized in the cadre of: GIZ, CIMA, FAO, WMO, EU, etc.

**Azem Bardhi** has completed his studies at the Faculty of Agronomy at the Agricultural University of Tirana during the period 1983-1988. Also, he is an expert in the agronomy field, who has defended the doctorate degree in the same field. From November 2009 – 2020, he has been a researcher at Polytechnic University of Tirana, Institute of Geosciences, Energy, Water and Environment Lecturer in the Department of Chemistry, Faculty of Natural Sciences. From the period September 2020- until now, he is the head of the Department of Climate and Environment – IGEO. He is member and expert in the WMO Commission for Agricultural Meteorology.

**Besim Kucaj** has finished the master of science in argo environmental and ecology, Agricultural University of Tirana. He is a researcher in the environmental field. Also, his expertise is to be certified for drafting environmental assessment reports, to carry out the audit environment, for drafting expertise on environmental problem and calling as an expert to assess an environmental impact assessment report or the results of an audit and is evaluator for agricultural land, forest land, meadow pastures and barren lands. Currently he is employed in the private sector in drafting reports on environmental impact assessment and real estate assessment.