USAGE OF *TYPHA ANGUSTIFOLIA* FOR SIMULTANEOUS REMOVAL OF COPPER AND NICKEL IONS FROM WASTEWATER

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In this work, Typha angustifolia plants were used as biosorbent in the process of wastewater phytoremediation. Studies were carried out using Typha angustifolia plants, which were able to remove copper and nickel ions from wastewater with an efficiency of 93.86. The higher number of plants used had a important influence on the phytoremediation process of wastewater. Also, the contact time was an important factor of the wastewater treatment, because we observed that a high efficiency required 40 h.

Keywords: plants, phytoremediation, *Typha angustifolia*, heavy metals, wastewater.

1. Introduction

The presence of heavy metals, such as copper and nickel, at toxic levels is a cause for concern. According to the regulations of NTPA 001/2002, the maximum concentrations of copper and nickel ions in industrial and municipal waters that are discharged to natural receptors are 0.10 and 0.50 mg/L respectively [1]. Once ingested, copper in high concentrations present in the human body will affect the hematological, immunological, reproductive, and cardiovascular systems, lungs, spleen, kidneys, brain, bones, and liver. Nickel, if is ingested, will also affect the human body, especially the gastrointestinal system, skin, lungs, and kidneys [2].

To reduce heavy metal ion concentrations in wastewater, various water treatment methods have been applied, such as flocculation, chemical precipitation, membrane separation and ion exchange [3-5]. These methods have certain limitations and present a high cost of operation. Chemical precipitation, for example, generates a large quantity of sludge needing treatment. Ion exchange and membrane filtration, while effective, demand high maintenance. Thus, an alternative solution should be used [6].

Typha angustifolia is a perennial macrophyte characterized by rapid growth, remarkable resistance to stress and high biomass accumulation. It has been used

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both in nature and in wetlands that have been constructed for wastewater treatment [7]. This perennial aquatic plant provides a large amount of biomass that can be used to treat water containing metal ions. Because of its biomass, it has been commonly utilized in built wetlands as an efficient treatment alternative for septic effluent in tiny villages [8, 9]. In addition, the plant has an important role in removing heavy metals through cation exchange, adsorption, and filtration via plant-induced chemical modifications in the rhizome [10]. It has been reported that this species used in built wetlands achieves 100% removal of copper and zinc and 96% removal of nickel [11]. It has been shown that the root of plants in aquatic environments generally has a greater capacity to uptake these heavy metals than leaves. For example, in cattail roots a lead concentration of 13 mg/kg was found, while in leaves the value was lower, namely 8 mg/kg [12].

The aim of this experimental research is to treat wastewater that contains heavy metal ions, using the most efficient and cheapest method possible. We can affirm that this article provides valuable information on water treatment using *Typha Angustifolia*, removing copper and nickel ions from wastewater.

The experimental research presented in this paper shows the investigation of the removal of copper and nickel ions at the same time from wastewater using *Typha Angustifolia*. In addition, the tested concentrations values of copper and nickel ions studied differ from those reported by other researchers.

2. Materials and methods

Harvesting of *Typha angustifolia* plants (narrow-leaved) was carried out using a harrow from water drainage ditches located on plots of arable land in Oarja Municipality, Arges County. After being harvested, the *Typha Angustifolia* plants had no problems adapting, as if they were already part of the system.

The plant specimens used in the research had all the component parts: root, rhizome, simple, unbranched stem, 2.10 m high, 2 cm thick, cylindrical, upright, filled with pith, usually with leaves (2 cm long, linear, fleshy, vaginate). The unisexual flowers, located at the top of the stem, are grouped into a male spike (at the top) and female spike (at the base).

In order to observe the amount of plant required to remove metal ions from water, 1, 3 and 5 *Typha angustifolia* plants were used in the experimental investigations. The synthetic wastewater contained both copper ions and nickel ions in the same system and was analyzed over time to see which of these heavy metals was retained faster and and in larger quantity from the system using *Typha Angustifolia*. The initial concentrations of copper and nickel ions in wastewater were 1.14 and 0.74 mg/L respectively. The concentrations of copper and nickel ions were obtained by dilutions from standard solutions of 1000 mg/L. The biosorption process was carried out while stirring continuously and the temperature at which

the experiments were carried out was room temperature (24 ^{o}C). The pH of the wastewater used in the experiments was 6. Samples were taken from the studied wastewater every 8 hours and analyzed for determination of wastewater treatment efficiencies.

Three separate study systems were developed in which the concentrations of copper and nickel ions in wastewater were the same (1.14 and 0.74 mg/L for copper ions and nickel ions) and the difference consisted in the number of *Typha Angustifolia* plants studied, namely 1, 3 and 5 plants.

The concentration of metal ions of the wastewater samples collected were analyzed using a photometer. The obtained concentrations were used to determine the wastewater treatment efficiencies using the following calculation formula:

$$\eta(\%) = \frac{C_i - C_f}{C_i} * 100 \quad (1)$$

where: η represents the treatment yield [%];

c_i represents the initial concentration of copper and nickel ions [mg/L];

c_f represents the final concentration of copper and nickel ions [mg/L].

During the experiments, a mechanical stirrer was used for continuously homogenization of the wastewater, a laboratory centrifuge was used to centrifuge the samples collected from time to time, and a PhotoLab S12 photometer was used to determine the concentrations of copper and nickel ions from wastewater. For the reproducibility, the experiments were repeated two times.

3. Results and discussion

The maximum time required to treat wastewater containing copper and nickel ions was 40 hours. Variations of metal ion concentrations and wastewater treatment efficiencies as a function of time are shown in Figures 1, 2 and Figures 3, 4 respectively.

In the case of copper ions removal from wastewater using *Typha Angustifolia*, a rapid decrease of the metal ion concentrations is observed in the first 8 hours of contact time. Thus, the concentrations of copper ions reached 0.45, 0.44 and 0.35 mg/L using 1, 3 and 5 *Typha Angustifolia* plants in 480 minutes. The final concentrations of copper ions in wastewater were 0.20, 0.19 and 0.07 using 1, 3 and 5 *Typha Angustifolia* plants.

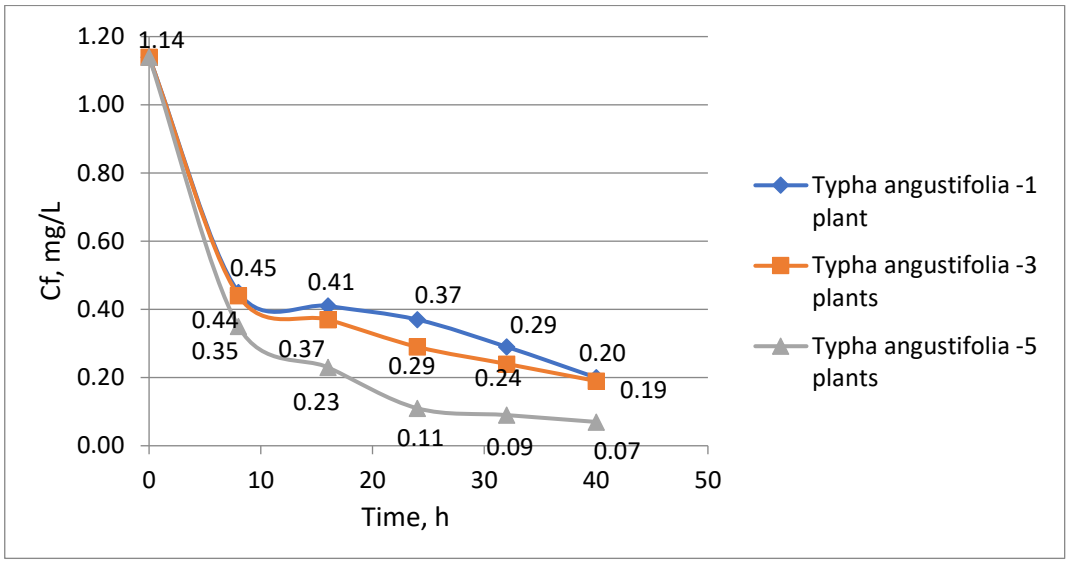

Fig. 1. Variation of copper ions concentrations depending on treatment time.

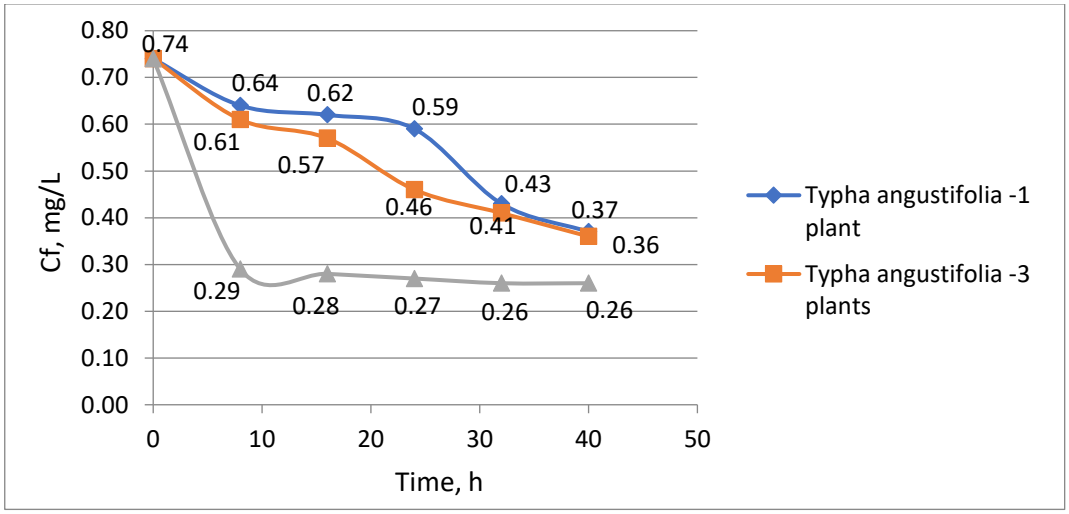

Fig. 2. Variation of nickel ions concentrations depending on treatment time.

In the case of nickel ions removal from wastewater using *Typha Angustifolia*, a rapid decrease in the concentration of metal ions is observed in the first 8 hours of contact time only when using five plants, the concentration reaching 0.29 mg/L. Then, the nickel ion concentration was stabilized, finally reaching a concentration of 0.26 mg/L. When one and three *Typha Angustifolia* plants were

used, nickel ion concentrations in wastewater gradually decreased to concentrations of 0.37 and 0.36 mg/L respectively over a period of 40 hours.

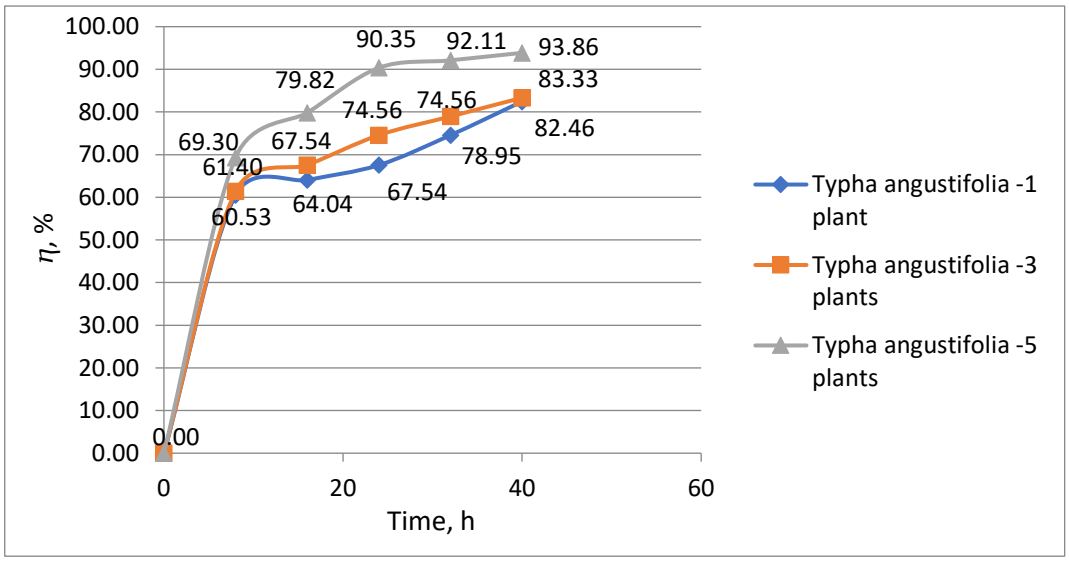

Fig. 3. Variation of wastewater treatment efficiencies for copper ions removal vs. time.

The removal efficiencies of copper ions from wastewater increased rapidly reaching yields of 60.53, 61.40 and 69.30% in the first 8 hours of contact time using 1, 3 and 5 *Typha Angustifolia* plants. At the end of the phytoremediation process, the treatment efficiencies reached 82.46, 83.33 and 93.86 %.

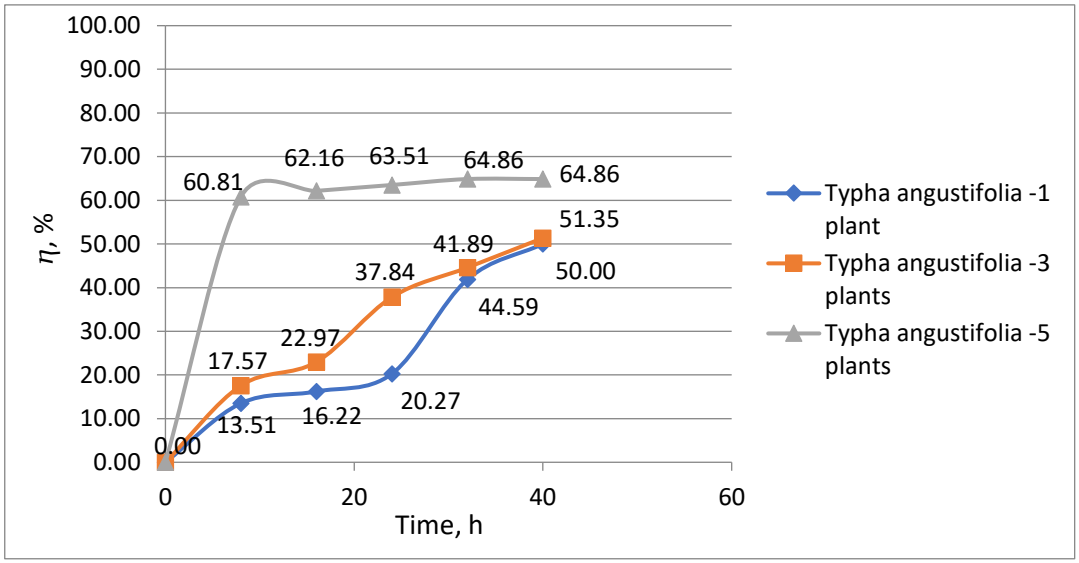

Fig. 4. Variation of treatment efficiencies for the removal of nickel ions from wastewater depending on treatment time

The removal efficiencies of nickel ions from wastewater reached percentages of 50.00, 51.35 and 64.86 respectively using 1, 3 and 5 *Typha Angustifolia* plants. Using 5 plants, a rapid increase in treatment efficiency was observed in the first 8 hours, with the treatment yield slightly exceeding 60%.

The uptake of the two metals from wastewater may be due to the phytoextraction mechanism which involves the uptake of heavy metal ions from the environment and their accumulation in the biomass of the plant [13].

The increased yield of removal cooper ions from wastewater in comparison with that of removal nickel ions on from wastewater may be explained by increased phytotoxicity of nickel ions on *Typha Angustifolia* plant. A similar behavior was observed by other researchers on species belonging to the same genus [14]

6. Future perspectives

In this article were presented the experimental research carried out to study the biosorption of copper and nickel ions from wastewater using *Typha Angustifolia* plant. In the future we can study this plant to observe distribution of copper and nickel ions in the component parts of *Typha Angustifolia*. To investigate that, the roots, stem, and leaves of the plant will be analyzed.

7. Conclusions

Typha Angustifolia is a plant that can be used in phytoremediation process to remove metal ions from wastewater. It is very effective and does not require a high cost for water treatment. In this study, the biosorption of copper and nickel ions from wastewater using *Typha Angustifolia* plants was successfully performed.

Typha angustifolia plants were more efficient in the removal process of copper ions than in the removal process of nickel ions from wastewater, with the highest removal efficiency reaching 93.86%. In contrast, 64.86% was obtained when investigating the removal of nickel ions from wastewater. The required treatment time was 40 hours. In the case of the removal of copper ions from wastewater, the process was fast in the first 480 minutes of contact time.

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