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ACCUMULATION OF HEAVY METALS BY *CONYZA BONARIENSIS* (L.) CRONQ IN THE UPPER BASIS OF THE RIVER BOGOTÁ

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Abstract

The shedding of wastes along the length of the river Bogotá causes environmental problems and harms the health of the people who live nearby. At the current time, as it passes through the municipality of Chocontá Colombia, it receives discharges of the wastes from the industries in that region which contaminate soils at the same time that they harm agricultural production and therefore the communities who live on the banks of the river. This study analyzes the presence of the metals Cr. Pb. Cd Co and As in specimens of *Conyza bonariensis* (L.) Cronq. gathered along the western bank of the upper basin of the river Bogotá between the towns of Villapinzón and Chocontá, a highly contaminated area due to the presence of tanning industries and in the town of Usme in the environs of the *páramo* (high Andean moor) of Sumapaz (Department of Cundinamarca, Colombia). With the data obtained from soil analyses, we were able to conclude that the chrome in the area of Villapinzón is 457% higher than that found in the soil of Usme. The root and stem of the *Conyza bonariensis* species collected in the region of Villapinzón also showed a higher bio-accumulation of chrome: 6342% and 2682%. respectively, higher than those in the region of Usme. The Pb. Cd. Co and As in the soils were likewise higher in the former by a percentage of between 118% and 148%, as was the bioaccumulation in different organs of the plants (between 111% and 270%), figures which indicate to us that the *Conyza bonariensis* is a species with potential uses for processes involving the phytoremediation of soils.

Keywords: *Conyza bonariensis* (L.) Cronq. heavy metals

Introduction

The contamination of the river Bogotá by the shedding of residual waters and industrial wastes from nearby towns has been an unsolved problem for more than forty years. The basin of the river Bogotá covers an area of 589,143 hectares, ranging from the Department of Boyacá on its northern edge to the Department of Tolima on its southern edge. On the West, it includes the municipalities of Bituima, Guayabal de Síquima, Albán, Sasaima, La Vega, San Francisco, Supatá and Pacho; and on the East, the municipalities of Nilo, Tibacuy, Silvana, Chipaque, Ubaque and Choachí. The river Bogotá is the main watercourse in the basin. Its source lies at 3,300 masl in the town of Villapinzón, in a sub-basin of the river, and it debouches into the river Magdalena in town of Girardot, at an altitude of 280 masl. [1].

The wastes shed into the river Bogotá along its course create environmental and health problems for the people who live near it. When it passes through the town of Villapinzón, it has already received discharges of residual waters from the tanning industries in the nearby towns, a subject which has been studied by many different researchers and entities [2]. Those investigations have shown that the river is highly contaminated, with elements like arsenic (As), cobalt (Co), cadmium (Cd), chrome (Cr), lead (Pb) and a wide variety of potentially toxic organic and inorganic substances. [3-5]

The soils in contact with the contaminated waters of the river Bogotá are affected, because the flow of water moves most of the contaminants and they tend to be absorbed on the surfaces which are present or in liquid phases, remaining trapped in the solid matrix in the soil. The heavy metals may be found in the form of free or available ions, compounds of soluble metal salts or, instead, insoluble or partly miscible compounds like oxides, carbonates and hydroxides [6].

Plants have developed highly specific mechanisms to absorb, shift and accumulate substances. However, some non-essential metals are absorbed, shifted and accumulated in the plant because they show an electrochemical behavior similar to the nutritive elements the plants require. Some are able to accumulate excessive amounts of heavy metals and they are known by the term hyperaccumulator plants. These plants generally have a small biomass since they use more energy in the mechanisms needed to adapt themselves to high concentrations of metal in their tissues [7-8], the *Brassicaceae* family is one of the genera with the most species of hyperaccumulators [9].

Phytoremediation is an alternative technology which is sustainable, low-cost and applicable to a wide variety of contaminants, in order to deal with the effluents and restore the environments. It is based on the use of plants to reduce, in situ, the concentration or danger of organic and inorganic contaminants, like heavy metals, in soils, waters and air. It is accomplished by biochemical processes undertaken by the plants and microorganisms associated with their root systems, which lead to a series of mechanisms to reduce the contaminants [10-11].

Their absorption and subsequent accumulation depend, in the first place, on the movement of the metals from the solution in the soil to the root, stems and leaves of the plant. In plants, the concept of bioaccumulation refers to the aggregation of contaminants: some of them are more apt to be phyto-available than others [8].

The sensitivity of vegetal species to heavy metals varies considerably between the different kingdoms and families: vascular plants are slightly more tolerant [12].

All plants absorb metals from the soil where they grow but in different proportions, depending on the species and family: they likewise adopt different strategies in the presence of metals in their surroundings. Some base their resistance to the metals on an efficient exclusion of metal, restricting the amount which is transported to the aerial part of the plant. Others accumulate the metal in the aerial part in a form which is non-toxic for the plant.

Exclusion is most characteristic in the species which are sensitive to and tolerant of the metals, while accumulation is the most common in species which develop in contaminated soils [6]. The plants´ absorption of heavy metals is generally the first step in their entrance into the food chain and finally turns into a public health problem. Along the course of the river Bogotá, which has been contaminated for decades downriver from the town of Villapinzón, there are species which, since they grow near it, are assumed to have a tolerance to toxic substances. It may either be that they absorb and eliminate them or that they accumulate them. Since many are non-edible plants, they may help to decontaminate the river by means of phytoremediation without causing harms to people. It is important to stress that the water of the river is used to irrigate crops of vegetables (garden produce for the most part), which are located alongside its course and then sold to people who consume those products [13-16]. Heavy metals have the capacity to become bioaccumulated in organisms and biomagnified in the environment, even reaching to foodstuffs. The effects of the ingestion of and/or exposure to these contaminants are related to diseases like cancer, which emerge in the course of time [10, 17].

Conyza bonariensis was described by Cronquist and his study was published in *Phytologia* [18]. This species grows in tropical and subtropical regions as a weed.

It takes the form of a bush and even prospers in cracks in concrete pavements. It can be recognized by its very narrow green-blue foliage, undulated leaves and purple involucral bract. It is an annual herbaceous plant and may reach a height of 1-2 meters. The stems are erect. ramified and have alternative leaves, with florets grouped near the upper end of the branches in the form of loose panicles. Its vulgar names in Colombia include: *Mata negra, cola de caballo, yerba carnicera, yuyo moro, vira vira, coniza* and *rabo de gato.*

Methods

Obtention of the vegetal specimens

The species of *Conyza bonariensis* (L.) Cronq were collected on the right bank of the upper basin of the river Bogotá, between Villapinzón and Chocontá, a region highly contaminated by tanneries, and in Usme, specifically in the environs of the *páramo* (high Andean moor) of Sumapaz (Department of Cundinamarca, Colombia), as an uncontaminated control for metals since there are no industries in that area.

Obtention of the extracts

The plant material of *C. bonariensis* (L.) was dried at room temperature for a week, triturated in a cutter mill until a particle size was obtained which was suitable for the extraction processes. Subsequently, 2 g from each of its organs (leaves, flowers and root) were removed, along with the same amount of the soil where the species grows for digestion by HCL:HNO_3 (1:1), with a subsequent capacity at 25 ml with type-1 water.

Evaluation of the heavy metals

The content of Cr, Pb, Cd, Co and As in the samples were determined by the atomic absorption technique, using a SPECTRA A 240 FS atomic absorption spectrometer, obtaining reference curves with MERCK stock solutions for atomic absorption.

Results and Discussion

Table 1 shows the concentration, in mg, of metal/Kg in the organ (ppm) of the metals detected by the atomic absorption technique in the species of *Conyza bonariensis* (L) Cronq. collected in Villapinzón and Usme.
The species collected in Villapinzón show high levels of Cr, Pb, Cd, Co and As compared to those collected in Usme. The leaves presented increase ratios for Cr. Pb. Cd Co and As of: 1:1; 1:2.70; 1:1.39; 1:1.20; 1:2.24, respectively. For the stems. the ratios for the difference, for Cr, Pb Cd, Co and As, respectively, were: 1:26.28; 1:1.54; 1:1.11; 1:1.52; 1:1.68. For the roots, the ratios for the difference, for Cr, Pb, Cd, Co and As, respectively, were: 1:63.42; 1:2.36; 1:1.10; 1:1.48; and 1:1.65. And for the soil where the species grows the ratio for Cr, Pb, Cd, Co and As, respectively, were: 1:4.57; 1:1.19; 1:1.20; 1:1.48; and 1:1.14.
The accumulation of metals in the specimens of *Conyza bonariensis* (L.) Cronq from Villapinzón were: Cr (415.87), Pb (31.36), Cd (38.36) Co (23.47) and As (1105.01).
The ratios for the transference of the metals in the soil to the organs in the plants in Villapinzón (organ/soil) were, in the case of the leaves: Cr (0.0), Pb (0.42), Cd (0.61), Co (0.40) and As (0.43); for the stems: Cr (2.27), Pb (1.00), Cd (0.73) Co (0.47) and As (0.79); and for the roots: Cr (0.68), Pb (0.45), Cd (0.84), Co (0.69) and As (1.23). The ratios between the whole plant and the soil were: Cr (2.95), Pb (1.87), Cd (2.18), Co (1.56) and As (2.45).
The figures indicate high levels of transference of the metals in the soil to the organ, with ratios ranging from 44% to 222% for the mobility of the metals from the soil to the plant.
In the case of some species of plants like *Zea maiz* L., Sharma and his team report 2538 ppm of Cr accumulation [19]. Dong reports 23 ppm of As in *Pteris vittata* [20]. Israr and his team report 1687 ppm of Cd in *Sesbania drummondi.* [21]. For the roots and shoots of *Vetiveria zizanoides,* Truong [22] reports an accumulation of Cr (ppm) of 1750 and 18; of Cd (ppm) of 14.2 and 0.31; and an accumulation of As (ppm) of 268 and 11.2. [23].
Our study shows that there is a high concentration of heavy metals in the soils in the environs of the Villapinzón, (Cundinamarca, Colombia) sector of the river Bogotá, due to the presence for decades of tanneries there. The *Conyza bonariensis* species registered high levels for the accumulation of arsenic and chrome, which means that it can be categorized as an accumulating species and has a potential use in the recovery of soils contaminated by heavy metals.

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References

1. CAR. Elaboración del Diagnóstico. Prospectiva y Formulación de la Cuenca Hidrográfica del río Bogotá plan de ordenación y manejo de la cuenca hidrográfica del río Bogotá 2006; 104 p.
2. CAR. Adecuación Hidráulica y Recuperación Ambiental del Río Bogotá. La Corporación Autónoma Regional de Cundinamarca – CAR. y la Empresa de Acueducto y Alcantarillado de Bogotá EAAB. 2017; 157 p.
3. Rodríguez O.E., Andrade W., Díaz F.; Celis C., Ortiz-ardila A., Quantification of heavy metals in lichens from the upper basin of the river Bogotá. Pharmacologyonline. 2016; 2: 21-27
4. Barragán O.L., Estudio de diferentes metodologías para determinar la biodisponibilidad de cadmio y arsénico en suelos y su relación con la concentración en plantas. Nova. 2008; 6(9): 35-39.
5. Rodríguez F. A., González J. F., Suárez R., Bioacumulación por metales pesados en el capitán de la sabana (*Eremophilus mutisii*). habitante de la cuenca alta del río Bogotá. Revista Electrónica de Ingeniería en Producción Acuícola. 2017; 3(3):101-115
6. Méndez J., González C.A., Román A.D. & Prieto F., Contaminación y fitotoxicidad en plantas por metales pesados provenientes de suelos y agua. Tropical and subtropical Agroecosystems. 2009: 10(1): 29-44.
7. Vara M., de Oliveira H., Metal hyperaccumulation in plants - Biodiversity prospecting for phytoremediation technology. Electronic Journal of Biotechnology 2003; 6 (3):285-321.
8. Kabata-Pendias A., Pendias H., Trace elements in soils and plants. CRC Press LLC. 3rd Ed. 2001; 403 p
9. Angelova V., Ivanova R., Delibaltova V., Ivanov K., Bio-accumulation and distribution of heavy metals in fibre crops (flax. cotton and hemp). Industrial Crops & Products. 2004; 19(3): 197–205.
10. Cuberos E., Rodriguez A., & Prieto E., Niveles de Cromo y Alteraciones de Salud en una Población Expuesta a las Actividades de Curtiembres en Bogotá. Colombia. Rev. Salud pública. 2009;11 (2): 278-289
11. Navarro-Aviño J.P., Aspectos bioquímicos y genéticos de la tolerancia y acumulación de metales pesados en plantas. . Ecosistemas. 2007; 16(2). 10–25.
12. Rosa C.S., Useof plant tests in the evaluation of textile effluent toxicity. Ecotoxicology Environmental Research. 1999; 2: 56-61.
13. Lora R., Bonilla H., Remediación de un suelo de la cuenca alta del río Bogotá contaminado con los metales pesados cadmio y cromo. Revista UDCA Actualidad & Divulgación Científica 2010; 13 (2): 61-70
14. Ruiz J., Evaluación de tratamientos para disminuir cadmio en lechuga (*Lactuca sativa* L.) regada con agua del río Bogotá. Revista colombiana de ciencias hortícolas. 2011; 5(2): 233-243.
15. González S., Mejía L., Contaminación con cadmio y arsénico en suelos y hortalizas de un sector de la cuenca del río Bogotá. Suelos Ecuatoriales. 1995; 25. 51-56.
16. Miranda D., Carranza C., Rojas C A., Jerez C M., Fischer G., Zurita J., Acumulación de metales pesados en suelo y plantas de cuatro cultivos hortícolas. regados con agua del río Bogotá. Revista Colombiana de Ciencias Hortícolas. 2008; 2(2):180-191.
17. Díaz-Álvarez J.C., Sánchez-Infante C.I., Ramírez-Calderón J.É. Cartagena-Torres É.. Molano-Polanía J., Méndez-Fajardo S. & Lara Borrero J.A, Implementación de estrategias promocionales en salud que contribuyan a la generación de estilos de vida saludable en la población localizada en la planicie aluvial baja del río Bogotá. expuesta a la contaminación por mercurio. plomo y cadmio. Investigación en Enfermería Imagen y Desarrollo. Universidad javeriana. 2009; 11(1):7-31.
18. Cuatrecasas J., Phytologia. *Coniza bonariensis*. 1963; 9(1): 5
19. Sharma D.C., Sharma C.P., Tripathi R.D., Phytotoxic lesions of chromium in *maize*. Chemosphere 2003; 51: 63–68.
20. Dong R., Formentin E., Losseso C., Carimi F., Benedetti P., Terzi M., Lo Schiavo F., Molecular cloning and characterization of a phytochelatin synthase gene. PvPCS1. from Pteris vittata L. J. Ind Microbiol Biotecnol 2005; 32: 527-533.
21. Israr M., Sahi S., Jain J., Cadmium Accumulation and Antioxidative Responses in the *Sesbania drummondii* Callus. Environmental Contamination and Toxicology. 2006; 50(1): 121–127
22. Truong P., Vetiver grass technology for mine rehabilitation. Pacific Rim Vetiver Network Tech. Bull.. 1999; 2: 1-19.
23. Sarma H., Metal Hyperaccumulation in Plants: A Review Focusing on Phytoremediation Technology. Journal of Environmental Science and Technology. 2011; 4(29): 118-138.

Table 1. ppm of metals found in the specimens of *Conyza bonariensis* collected in Usme (Usm) and Villapinzón (Vipz) and their respective differences (Δ)

METALS ACUMULATED IN *CONYZA* BONARIENSIS												
	LEAVES			STEMS			ROOT			SOIL		
METALS	Usm	Vipz	Δ	Usm	Vipz	Δ	Usm	Vipz	Δ	Usm	Vipz	Δ
Cr	-	-	-	12.18	320.04	307.86	1.51	95.83	94.32	30.84	140.90	110.06
Pb	2.58	6.99	4.41	10.90	16.81	5.91	3.20	7.56	4.36	14.12	16.76	2.64
Cd	7.73	10.76	3.04	11.57	12.89	1.32	13.31	14.71	1.39	14.66	17.57	2.91
Co	5.01	6.03	1.02	4.65	7.06	2.41	7.00	10.38	3.39	10.22	15.09	4.87
As	87.36	195.27	107.91	212.36	356.06	143.70	334.99	553.79	218.80	394.65	451.23	56.58

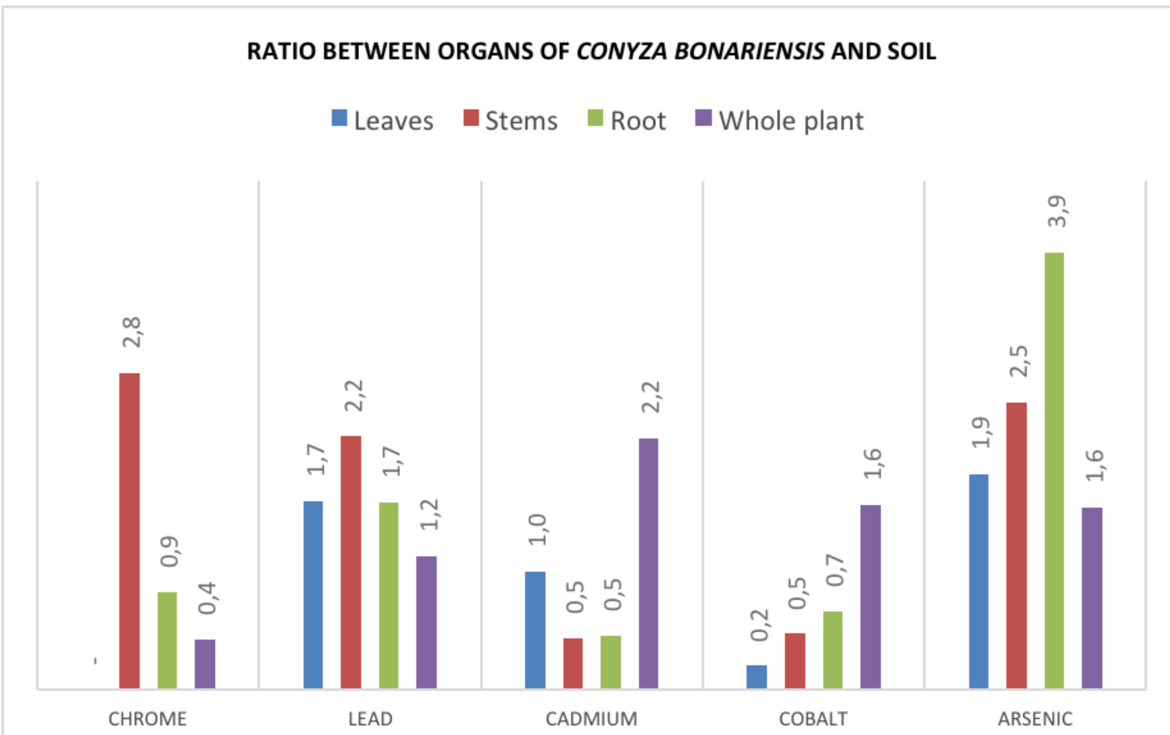

Figure 1. Ratio in ppm of metals found in the specimens of *Conyza bonariensis* collected in Usme and Villapinzón with regard to the increase of metals in the soils

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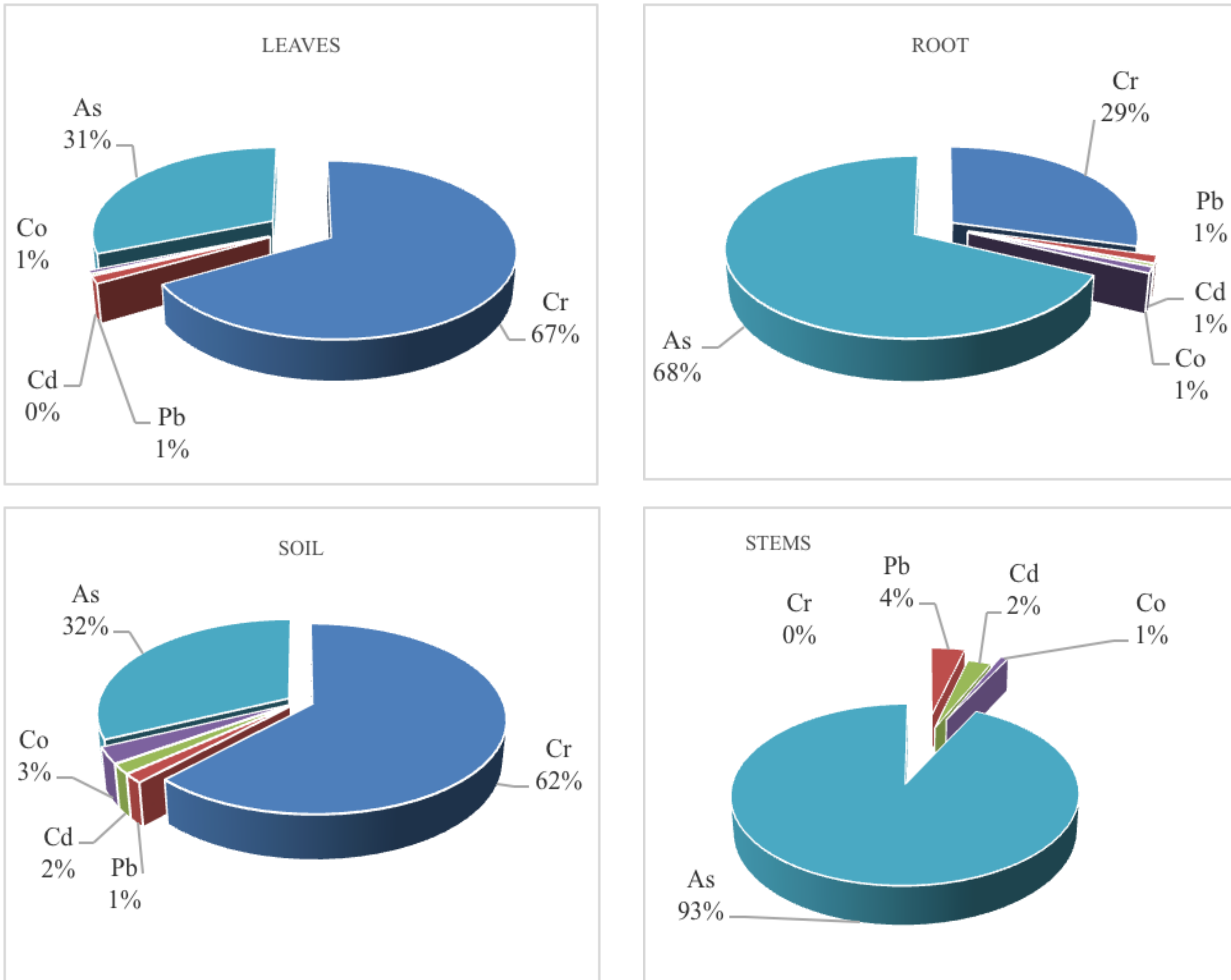

Figure 2. Percentage of increases of metals found in *Conyza bonariensis,* comparing those gathered in Villapinzón with those gathered in Usme