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ICP-MS Quantitative Assessment of Essential and Trace Elements in Traditional Medicinal Plant Tinospora Cordifolia

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Abstract

The inductively coupled plasma mass spectrometry (ICP-MS) approach was employed to quantify the micro-and macro-element contents of traditionally used medicinal herb Tinospora Cordifolia. The analysis reveals that these plant extracts include a total of twenty elements (Li, Al, Be, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Rb, Sr, Ag, Cs, Ba, and Tl). The elemental concentration is expressed in parts per million (ppm). Techniques such as ICP-MS for infusion analytical control can help establish the nutritional value of medicinal plant and how they are used on a daily basis. Using the results of this study, new guidelines for administering herbal medication dosages were established.

Keywords: Tinospora Cordifolia, Medicinal plant, Micro elements, Macro elements, ICP-MS.

INTRODUCTION

The active chemical components found in medicinal plants are formed by trace elements, and these components are what give these plants their therapeutic and poisonous properties[1]. Zinc, iron, copper, chromium, and cobalt are important elements that only become toxic at high amounts, but lead and cadmium have no recognized health benefits and are therefore only dangerous at high concentrations. Metal ions are among the chemical components of

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plants that contribute to both their therapeutic and nutritive qualities as well as their poisonous ones. They function as cofactors for enzymes and are significant trace elements in plant metabolism and biosynthesis[2]. Due to their effectiveness in treating a variety of human disorders, herbal medications are becoming more popular worldwide[3]. The human body absorbs the essential and trace components present in therapeutic plants through the ingestion of herbal medication. Due to the small range between insufficiency and toxicity of different elements in the human body, it is difficult to determine the correct dosage and health guidelines for herbal medicine. The soil's geochemical characteristics govern the accumulation of macro and trace elements in medicinal plants. In addition, the accumulation of elements in plants from their aquatic and atmospheric environments enables some plants to serve as biomonitors[4-8].

Herbal medicine has witnessed a considerable rise in popularity over the last decade due to their low risk of adverse effects, wide availability, and widespread acceptance, particularly in developing nations. People of all ages, including infants and the elderly, can benefit from consuming these plants, which contain both essential and non-essential minerals[9]. The traditional use of medicinal plants has been demonstrated to be effective in the treatment of many human illnesses when studied in an experimental setting. Trace elements are one of the many aspects that contribute to the therapeutic properties of these plants. It has been found that major and trace elements play important roles in the treatment of a wide range of human disorders and diseases[10]. However, it is well-known that trace elements in medicinal plants are responsible for their toxicity when they are present in large concentrations. The pharmacological properties of these medicinal plants need to be looked into because they could affect human health. Knowing how much of these trace elements are in a plant is important for figuring out how well it can treat different diseases and for understanding how it works as a drug. It also makes it easier to understand how traditional knowledge about the healing power of these plants came to be.

Some techniques which are usually used for trace elements analysis present in medicinal herbs, are flame atomic absorption spectrometry[11], energy dispersive X-ray fluorescence (EDXRF)[12], electrothermal atomic absorption spectrometry (ETAAS)[13],

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inductively coupled plasma-atomic emission spectrometry (ICP-AES)[14], inductively coupled plasma-mass spectrometry (ICP-MS)[15,16] and instrumental neutron activation analysis (INAA)[17]. ICP-MS has higher sensitivity than conventional methods and is a trustworthy and efficient approach for determining several elements at the trace level. In this study, the elements in Tinospora Cordifolia medicinal plant were examined using a method known as inductively coupled plasma mass spectrometry (ICP-MS).

MATERIALS AND METHODS

Experimental details[18]

Sampling

Collecting samples of various plant components, including leaves, aerial parts, roots, fruits, and rhizomes, from medicinal plant (Table 1) used traditionally. These samples were extensively cleansed with water, ethanol, and triple-distilled water to eliminate surface contaminants, soil, and foreign particles. The fruits have been peeled. Cut the fruits into small pieces. The fruit pieces were then air-dried under shade in the laboratory before being oven-dried at 40 degrees Celsius and ground. The fragments were crushed mechanically and pulverized into powder. The leaves were also air-dried separately in the shade before being pulverized into a powder. For subsequent investigation, the powdered plant materials were stored at room temperature away from direct sunlight in sealed, dry plastic bags. For analytical purposes, solvents and substances of analytical grade were utilized. Other solvents, chemicals, and reagents were all of pure quality (S.D. fine chemicals or E. Merck India). Whenever water is specified, distilled water is substituted. Table 1 provides the medicinal plant selected for this study, along with its scientific name and plant sections.

Table 1: Medicinal plant and their useful parts.

Local Name	Scientific Name	Part used
Tippateega	Tinospora Cordifolia	Stem, Root, Leaves (1:1:1)

ICP-MS

Analyzing the samples concentrations of various elements with an ICP-MS from the 7700 series (Agilent Technologies, USA). Table 2 summarizes the ICP-MS system's initial

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configuration. The ICP-MS was calibrated with MERCK XVII multi-element ICP-MS calibration standards (Merck KGaA, Germany) diluted with 3% nitric acid (HNO_3).

Table 2: ICP-MS configuration

RF power	1550W
Plasma gas	Argon, 151 min^{-1}
Peristaltic pump speed	0.3 rps
Autosampler	ASX-520 (Agilent)
Measuring mode	Helium and no gas

Digestion Procedure of samples

1 g of each sample (1:1:1 weight ratio of various plant components) was digested in nitric acid/perchloric acid (6:1) using the wet digestion method by slowly heating on a hot plate until white residue was formed. The residue was dissolved in 0.1N nitric acid, and the volume was adjusted to 10 ml. ICP-MS Instrument analysis of the digested sample.

Results and Discussion

The list of macro- and microelements determined by using ICP-MS technique were given in the Table 3. Totally twenty-elements (Li, Be, Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, As, Se, Rb, Sr, Ag, Cs, Ba and Tl) were identified in examined medicinal plant. The concentrations of macro- and microelements that have been determined are presented in Figure 1.

Table 3: Average elemental concentration in ppm.

S.NO	E/SMPL	Tinospora Cordifolia
1	Li	0.0333
2	Be	0.0429
3	Al	1179.7173
4	V	2.0445
5	Cr	2.4831
6	Mn	81.4548
7	Fe	1342.821
8	Co	0.2895
9	Ni	0.5625
10	Cu	5.4537
11	Zn	18.2679
12	Ga	43.0104
13	As	0.1191

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14	Se	0.0915
15	Rb	11.8509
16	Sr	133.3194
17	Ag	0.0219
18	Cs	0.0237
19	Ba	171.7185
20	Tl	0.0318

Chromium, Manganese, Iron and Aluminium

The examination of the table's data indicates that the plant extract has chromium levels of 2.4831 parts per million (ppm), manganese levels of 81.4548 ppm, iron levels of 1342.821 ppm, and aluminum levels of 1179.7173 ppm. Chromium serves as an activator in the majority of enzymes and promotes the metabolism of lipoproteins, carbohydrates, and nucleic acids. A high concentration of chromium damages the kidney, liver, and lungs, whereas a deficit decreases insulin function, which is responsible for an increase in cholesterol and blood sugar levels. Manganese is the second most essential trace element necessary for numerous metabolic activities in plant and animal bodies. Manganese is deposited in the kidney and liver of animals and is needed for appropriate reproductive and central nervous system function[19]. Manganese insufficiency prevents both male and female reproduction. Mn phytotoxicity is characterized by a decrease in biomass and photosynthesis, as well as metabolic disturbances such as oxidative stress[20]. Some studies on the toxicity of manganese and its transfer from soil to plants proved its significance under conditions of low pH and redox potential. Some enzymes[21] include manganese, which is abundant in mitochondria and activates enzymes like as hydrolases, transferases, kinases, and decarboxylases. pyruvate carboxylase is a well-known manganese metalloenzyme that catalysis the conversion of pyruvate to oxaloacetate 2. Other enzymes include arginase, which converts arginine to urea, and mitochondrial superoxide dismutase (SOD). Aluminium hydroxide is used to treat ulcers and renal conditions. Aluminum salts are used in cosmetics, medicine, and to reduce perspiration on the skin. Iron is the most important trace element since it is the central atom of haemoglobin; therefore, it plays an essential role in blood production. Iron is also required for appropriate central nervous system[22] function.

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Cobalt, Nickel, Copper and Zinc

The analysis discovered trace elements, including cobalt, nickel, copper, and zinc, with quantities of 0.2895, 0.5625, 5.4537, and 18.2679 parts per million (ppm) respectively. Cobalt is an essential component of vitamin B-12 and aids in the production of DNA and blood cells[23]. Its lack is detrimental to biological activities. Boron and Molybdenum were lacking from these plants entirely. Copper, Boron, and Molybdenum are necessary for the growth and health of plants and animals. Copper deficiency in animals[24] can result in anaemia, bone abnormalities, and neutropenia. As it is found in DNA and RNA[25], nickel may function as a nucleic acid stabiliser. The high copper concentration in foetal liver is extraordinary. During the last three months of a normal pregnancy, a significant buildup of copper in the liver occurs in the kid. This impact lasts for about four years, after which the liver copper returns to adult levels. This accumulation of copper in the liver guarantees adequate supply for the newborn during the first few months[26].

The increased copper levels in the liver could just be a reflection of the foetus's high copper requirement. However, it should be noted that zinc appears to be more closely associated to neonatal growth rates than copper. All of the elements mentioned above play a critical role in the body's overall function and needs. These critical ingredients are present in both formulations, indicating that they may be valuable to humans in the treatment and prevention of a variety of disorders. Zinc plays a key role in the metabolism of a variety of metabolic events in both animals and plants[27]. Zinc is required for cell-mediated innate immunity, neutrophils, and natural killer cells to grow and function normally[28]. Zinc levels are critical in phagocytosis, cytokine production, T and B cell development and function, DNA synthesis, RNA transcription, and cell activation[29].

Arsenic, Beryllium, Lithium and Silver

Significant quantities of heavy metals and ultra-trace elements, including Arsenic, Beryllium, Lithium, and Silver, were found in Tinospora Cordifolia, with concentrations of 0.1191, 0.0429, 0.0333, and 0.0219 parts per million (ppm) respectively. When ingested by animals, some heavy metals can result in severe health problems. According to the World Health

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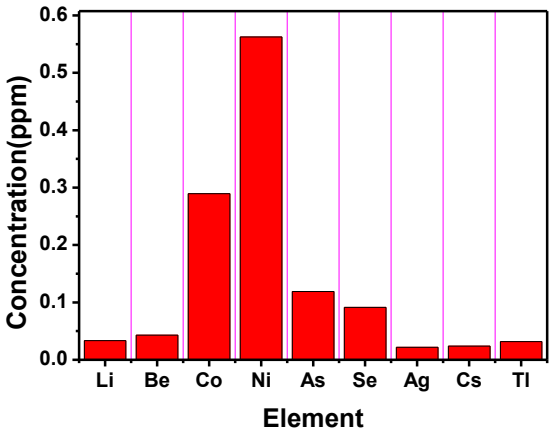
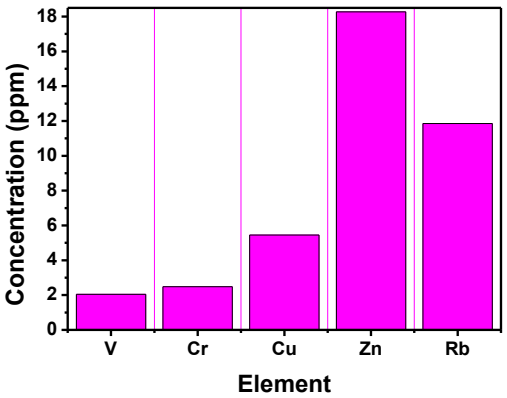
Organization, prolonged exposure to arsenic causes skin cancer. Beryllium is responsible for pneumonia, lung diseases, cardiovascular damage, and allergies. Due to its neuroprotective properties, lithium is the trace mineral most beneficial to mental health; its lack influences prevalent metal diseases and social evils.





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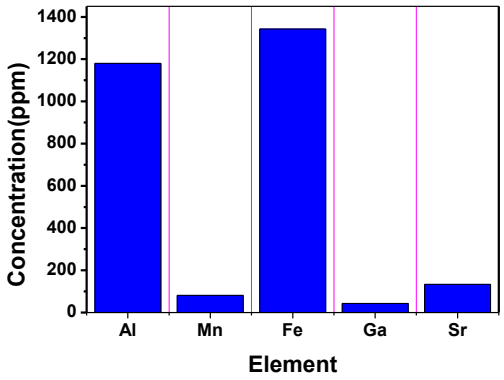

Figure 1. Distribution levels of various elements in ppm

CONCLUSIONS

The Indian medicinal herb Tinospora Cordifolia, was investigated to comprehend the significance of components in pharmacological activities. The correlation between elemental concentration and the medicinal efficacy of these plant have been deemed significant by the researchers. As a result of soil qualities, selective element accumulation capacity of plant, and increased environmental contamination, the plant has been found to contain a wide range of elements, including heavy metals. The plant is capable of absorbing and accumulating heavy metals in the soil. Consequently, this plant is utilized to remove heavy and harmful metals from the soil, thereby reducing soil pollution. According to these findings, the levels of heavy and hazardous metals were below the permissible limit specified by the World Health Organization; as a result, it is possible that it does not represent a threat to the health of humans. The pharmacological characteristics of this plant is supported by the detection of varying concentrations of medicinally significant trace elements. This study demonstrates acceptable elemental concentration, which is useful for demonstrating the medicinal activity and disease-curing potential of this plant. The findings will aid in the development of new herbal medications that may be more effective in the future at controlling and curing a variety of newly emerging, serious health conditions.

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