THE EFFECTS OF IRRIGATION WITH WASTEWATER ON SOIL PROPERTIES, PLANT RESPONSE, AND ACCUMULATION OF HEAVY METALS

A Thesis

by

MESUT OZDEMIR

Submitted to the Graduate and Professional School of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Chair of Committee,	Anish Jantrania
Co-Chair of Committee,	Terry J. Gentry
Committee Members,	June E. Wolfe III
Head of Department,	David D. Baltensperger

December 2021

Major Subject: Soil Science

ABSTRACT

As the world's population has increased, the importance of water sources and wastewater recycling has reached a critical level due to expanding consumption. Concurrently, some available soil is being degraded due to the application of low-quality/polluted water. This has led to water shortages and decreases in usable agricultural lands.

This study investigated the effects of wastewater irrigation on soil, tomato plants, and heavy metal accumulation. The research was carried out from March to June 2021 at Texas A&M University where a hybrid tomato (*Solanum lycopersicum*, "Better Boy") was grown under greenhouse conditions and irrigated with different wastewater types. These included groundwater (i.e., treated tap water used for control), raw sewage wastewater, and membrane-bioreactor treated wastewater. Different formulations of experimental irrigation waters were prepared by mixing treated and untreated wastewaters at proportions of 25%, 50%, 75%, and 100%. A total of six types of irrigation waters were applied to tomato plants grown in pots. In the greenhouse pots were arranged in a completely randomized fashion with 3 replicates of the 6 irrigation water types. A total of 18 plants were grown to harvest. The effects of irrigation water on soil quality and plant growth were examined. The accumulation and distribution of heavy metals in the soil and plant tissues were also examined.

Total irrigation amounts applied to treatments were 87.25 L. Approximately one-third of the total applied irrigation water was not transpired by the plant. Comparing initial

soil conditions to post-experiment conditions, increases in pH, electrical conductivity, nitrogen, phosphorus, and organic matter were observed while decreases were seen in calcium, magnesium, potassium, and sodium. Considering tomato yields, the smallest yields were seen in T_0 (GW), while the highest yields were found in T_1 (MBR) and T_3 (%50 MBR + %50 RWW).

According to the allowable heavy metal limits stipulated by FAO and EPA, 14 elements measured in the applied wastewaters were below acceptable limits. Pre- and post-experiment soil heavy metal concentrations showed decreases in aluminum, beryllium, iron (except T_1), manganese, nickel, and selenium (except T_0). Increases were observed in arsenic, cobalt, chromium, copper, lead, vanadium, and zinc. In plant tissues, the most accumulated heavy metal was aluminum, while the lowest was beryllium. Small amounts of chromium were present, but none was detected in the fruit. Cadmium and selenium were not detected at all. Compared to all other parts of the plant, the fruit showed the smallest heavy metal concentrations, and all were below acceptable levels.

In conclusion, using wastewater for agricultural irrigation of tomatoes may offer a viable alternative to limited freshwater sources because it boosts plant growth and yield through increased fertility (i.e., nitrogen and phosphorus) and the fruit has heavy metal accumulation below acceptable levels for consumption.

DEDICATION

This thesis is dedicated to my family,

my mother Gülizar Özdemir,

my father Muharrem Sefa Özdemir,

my sister Dilek Özdemir,

who cared for me,

and never stopped supporting and believing in me throughout my education,

and never left me alone in a single moment of my life.

I am grateful that I have such an indescribably perfect family.

Bu tez;

benimle ilgilenen,

eğitimim boyunca bana inanmaktan ve desteklemekten asla vazgeçmeyen,

hayatımın hiçbir anında beni yalnız bırakmayan aileme,

annem Gülizar Özdemir'e,

babam Muharrem Sefa Özdemir'e,

ablam Dilek Özdemir'e,

ithaf edilmiştir.

Tarif edilemeyecek kadar mükemmel bir aileye sahip olduğum için şükrediyorum.

ACKNOWLEDGEMENTS

First and foremost, I would like to be grateful the Republic of Turkey Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policies for providing me the opportunity to study abroad and finance my education.

I greatly appreciate my committee chair, Dr. Anish Jantrania, and my committee members, Dr. Terry J. Gentry, and Dr. June E. Wolf III, for their continued advice, encouragement, guidance, toleration, and support throughout my education.

Dr. Jantrania and Dr. Wolfe, I would like to dedicate a separate paragraph to you. You showed up at the right place and at the right time. I would like you to know that I was able to finish this thesis thanks to your touches on me.

I would like to thank my brother from another mother Kaan Sel, who was my roommate for most of my education, stood by me on good and bad days, and never stopped supporting me.

Special thanks also go to my friends, Ahmet Emrecan Elkit, Erdem Uysal, Şerif Ekinci, Yusuf Yiğit, Önder Özal, Mustafa Çilkız, Murat Kaşlı, Yasemin Taşçı, Aleyna Öztürk and colleagues and the department faculty and staff for making my time at Texas A&M University a great experience.

It would be unfair to express my gratitude to my family only here. If I have been able to get to where I am today, it is because of their financial and moral support. Mom and dad, by sacrificing yourself and risking living at lower standards, you struggled against difficulties for my sister and me to live in better conditions. The greatest gift a

child can give to their parents is to make them proud. I hope I was able to do that. If somebody had asked if there is anyone in your life that you take as an example, my answer would be undoubtedly my sister. Because if I had not her support and encouragement, maybe I would be no different from an ordinary person.

Last but not least, I am proud to express my infinitive gratitude to Mustafa Kemal Atatürk, the founder of the Republic of Turkey. Your presence has been a silver lining for us even on the darkest day.

I am a Turk, honest and hardworking. My principle is to protect the younger, to respect the elder, to love my homeland and my nation more than myself. My ideal is to rise, to progress.

Great Atatürk! On the path that you have paved, I swear to walk incessantly toward the aims that you have set.

My existence shall be dedicated to the Turkish existence. How happy is the one who says "I am a Turk!".

CONTRIBUTORS AND FUNDING SOURCES

Contributors

This study was supervised by a thesis committee consisting of Professor Terry J. Gentry of the Department of Soil and Crop Sciences, along with Associate Professor Anish Jantrania and Associate Research Scientist June E. Wolfe III of the Department of Biological and Agricultural Engineering.

Dr. Anish Jantrania and Dr. June E. Wolfe III helped significantly with the research, preparation, writing, and reviewing the manuscripts, which led to the contents of this thesis. Dr. Terry J. Gentry reviewed the manuscripts, which led to the contents of this thesis.

The soil analysis was performed by The Texas A&M AgriLife Extension Service Soil, Water, and Forage Testing Laboratory.

Samples of soil and plant tissue were digested using the facilities in Dr. Julie Howe's laboratory.

All work written and done in this thesis was completed by the student under the advisement of Dr. Anish Jantrania.

Funding Sources

Graduate study was supported by a fellowship from the Republic of Turkey Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policies.

NOMENCLATURE

%	Percentage
°C	Centigrade Degree
Al	Aluminum
ANOVA	Analysis of Variance
As	Arsenic
Be	Beryllium
Ca	Calcium
CB	Centibars
Cd	Cadmium
cm	Centimeter
Co	Cobalt
Cr	Chromium
Cu	Copper
EC	Electrical Conductivity
EPA	Environmental Protection Agency
ESP	Exchangeable Sodium Percentage
ET	Evapotranspiration
FAO	Food and Agriculture Organization
Fe	Iron
g	Gram

GW	Ground Water
HNO_3	Nitric Acid
HSD	Honestly Significant Difference
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
K	Potassium
kg	Kilogram
km^3	Cubic Kilometers
L	Liter
m	Meter
m^3	Cubic Meters
MBR	Membrane Bioreactor Treated Wastewater
Mg	Magnesium
mg	Milligram
ml	Milliliter
mm	Millimeter
Mn	Manganese
Na	Sodium
Ni	Nickel
NO_3-N	Nitrate-Nitrogen
OM	Organic Matter
OSSF	On-Site Sewage Facilities
P	Phosphorus

Pb	Lead
PFAS	Per- and Polyfluoroalkyl Substances
pH	Power Of Hydrogen
RELLIS	Respect, Excellence, Leadership, Loyalty, Integrity, And Selfless Service
RWW	Raw Wastewater
SAR	Sodium Absorption Rate
Se	Selenium
SSPS	Statistical Package for The Social Sciences
TDS	Total Dissolved Solids
USA	United States of America
USDA	United States Department of Agriculture
USSL	United States Salinity Laboratory
V	Vanadium
WSS	Web Soil Survey
Zn	Zinc
µS	Micro Siemens

TABLE OF CONTENTS

Page

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION AND LITERATURE REVIEW

1.1. Water Usage in the World and the United States

The average amount of water extracted per capita from existing world freshwater resources is 3,945 km^3/year (Table 1.1) [1]. Although the amount appears to be relatively high, the primary problem for water availability and accessibility concerns time and place. Around the world, the average amount of available water per capita is 13,541 m^3 [1], [2] However, this value varies considerably from country to country, even between different regions of the same country, depending on its level of development, the water resources it has, the geography, and climate conditions. The per capita water consumption in the world is around 574 m^3/year (Table 1.1) [1].

The utilization rate of the United States for freshwater resources consumed for domestic, industrial, and agricultural purposes is 13%, 46%, and 41%, respectively. For these purposes, the utilization rates worldwide are approximately 12%, 18%, and 70%, respectively (Table 1.1).

Rapid and unconscious consumption of freshwater resources and the contamination of groundwater is a severe problem not only in water-scarce countries but also worldwide. To find a solution to this problem, new and cost-effective treatment methods are needed. However, while the environmental impact of the result is minimized, it should be easily adapted to the infrastructures of the countries and adopted by the local people.

Table 1.1 Freshwater withdrawal and use by continents and the USA in 2013

Continents and the USA	Total Fresh Water Withdrawal	Per Capita Withdrawal	Domestic Use		Industrial Use		Agricultural Use		2010 Pop.
	km^3/yr	m^3/yr	%	m^3/yr	%	m^3/yr	%	m^3/yr	mil.
Asia	2,509	605	9.1	55.3	9.3	56.1	81.6	493.8	4,143
Africa	211	205	12.0	24.5	5.1	10.4	82.9	169.3	1,031
America ^{NC}	630	1,165	13.7	159.4	41.9	486.8	44.4	517.0	541
America ^{S}	177	452	22.5	101.5	11.6	52.5	65.9	297.8	393
Europe	352	481	20.4	98.0	54.2	260.0	25.4	122.1	732
Oceania	66	1,883	16.5	310.2	10.6	197.8	73.9	1390.4	35
Total	3,945	574	11.7	67.3	18.4	105.4	69.9	400.8	6,875
The USA	482	1518	12.7	193	46.0	699	41.3	626	318

^{NC}: North and Central, ^{S}: South, Pop: Population, mil: millions, km^3: cubic kilometer, m^3: cubic meter, yr: year

1.2. Importance of Wastewater

Particularly in nations with arid and semi-arid climates, competition exists between agricultural and urban users due to the increasing need for water. As a result, existing treated wastewater has become an increasingly low-cost and reliable alternative for agricultural irrigation purposes [3]. On the other hand, since wastewater poses health and environmental risks, its direct use without treatment is not without concern [4]. In many developing countries, government policies require that wastewater must be treated before it is released into the environment or used for agricultural irrigation [5]. However, globally, enforcing wastewater treatment standards is difficult in numerous nations because of restricted budgetary assets and institutional limitations [6]. Since the water used in agriculture in developing countries constitutes 4/5 of total water consumption, the treatment and use of wastewater is the best alternative for agriculture [7].

The composition of wastewater varies greatly among different sources and times. While approximately 99% of wastewater is composed of water, the remaining 1% is comprised of colloidal, suspended, and dissolved solids [6]. Because of this, treated wastewater offers many opportunities for recycling water and its suspended and dissolved constituents.

Wastewater is broadly viewed as a water source, thus, it plays an important role as an option to supplement and diversify water supply throughout the year [8], [9]. The accessibility and nourishing properties of water are most valuable in arid and semi-arid regions. Its use may allow higher harvest yields, improve various production cycles, and extend growing seasons [10].

It is imperative to ensure the sustainability of usable water resources, which constitute a small extent of the aggregate sum of world water supplies. According to the United Nations report, 2/3 of the world population, which is expected to reach 8.1 billion in 5 years, will suffer from moderate to high water scarcity, and 2.7 billion people will face water scarcity [11], [12]. Population increase, environmental pollution, inadequate water resource management, and climate changes directly affect the availability of freshwater resources. Although water usage has become more efficient in developed countries, the demand for freshwater continues to increase considering the world population. Research shows that by 2025 more than half of the world will encounter serious water shortages, and half of the world's population will face water access restrictions. The situation is critical in terms of the availability of freshwater resources, especially in North Africa and the Middle East. Almost all freshwater resources in Libya, Palestine, Israel, Jordan, Yemen, Bahrain, Kuwait, Qatar, Oman, United Arab Emirates, and Saudi Arabia have been exploited, and some other nearby countries are expected to face the similar situation. Water shortages also affect temperate zones where abundant water resources are the norm. In these regions, the frequency and duration of drought are increasing. For example, some rivers have dried up in several regions of France, Italy, Spain, and England due to extended drought, and groundwater levels have decreased drastically [13].

It is therefore prudent and even vital to conduct research examining the recycling and reuse of water in order to protect existing resources for future generations. Classical approaches (i.e., the treatment of wastewater by various methods and returning it to the environment) must be reconsidered and transformed into a new approach that reduces discharge to the environment and instead recycles it for different purposes. Using treated wastewater for agricultural irrigation offers a viable and environmentally positive choice if done carefully.

1.3. Advantages and Disadvantages of Reusing Treated Wastewater in Agriculture

Advantages, disadvantages, and possible risks need to be evaluated together when planning to reuse treated wastewater for agricultural irrigation:

The benefits or advantages are:

- ✓ Reduces the cost of tertiary treatment systems necessary to remove excess nutrients.

- ✓ Fertilization costs may be lowered due to the nitrogen and phosphorus content.
- ✓ Provides an irrigation resource for regions suffering seasonal drought.
- ✓ Water scarcity may be lessened.
- ✓ Becomes a constant water source when wastewater is treated in volumes to be discharged according to environmental needs.
- ✓ Improves microbial activity, which is beneficial to agricultural processes [14], [15].

The adverse effects or disadvantages are:

- ✓ Nutrient concentrations that may be harmful to plants and the environment.
- ✓ Pathogenic microorganisms may be present and threaten human and animal health.
- ✓ Irrigation is seasonal, and treated wastewater may require storage when there is no demand.
- ✓ Treated wastewater can cause physical damage to irrigation systems [11], [14].

1.4. Effects of Wastewater on Soil

Although the potential to reuse wastewater is high in irrigation, it poses a danger if it has not been managed attentively. The most significant reason for this is the presence of salts, metals, and chemicals in wastewater. Furthermore, as a result of using wastewater in agricultural activities, it may increase the environmental risk to groundwater and soil. Most recent research has focused on heavy metal and salinity problems caused by wastewater in groundwater and soil [16], [17].

It may be helpful to look at the risks in wastewater as the short term and long term. While short-term risks may vary depending on the contact of animals and people, long-term risks show that the heavy metal accumulation and salinity problems in the soil often occur with increased wastewater usage. Wastewater may cause an increase in the content of sodium (Na) which interacts with exchangeable calcium (Ca), magnesium (Mg), and potassium (K) ratios in the soil and produced salinity and sodicity problems [8].

Plants can be irrigated with treated wastewater from sewers that contain a very high level of heavy metals and nutrients. Contamination of the soil with metals that can cause toxic effects has created a threat in areas that can be used for agriculture. Filtration of these surface pollutants by the soil means soil degradation, and these surface pollutants play a direct role in soil contamination [18].

1.5. Wastewater Use in the World

The municipal and industrial wastewater treatment level of a country is usually a reflection of that country's income level. As the income levels of the countries increase, the rate of treatment of wastewater produced increases. In high income, upper-middle-income, and low-middle-income countries, treatment rates are 70%, 38%, and 28%, respectively. In low-income countries, this is somewhat different, and about 10% can be treated because costs can negatively affect countries' economies [9]. Globally, according to the estimates made by the World Water Development Report, the rate of wastewater discharged directly without treatment is approximately 80% [19].

Although it is prohibited to use untreated wastewater in many countries, it is impossible to prevent it entirely. Low-income countries, which have some problems such as groundwater quality (e.g., saline), transportation costs (e.g., pumping), and water scarcity, use wastewater directly without treatment because their access to alternative water resources is limited. Direct wastewater usage without treatment is common, especially in Africa, Latin America, and South Asia [20].

In some regions of India, it is very costly to supply and deliver water from groundwater sources, so wastewater is taken from sewage and used for agricultural activities [21].

It has been recorded that untreated wastewater is commonly used in Latin America (i.e., Mexico, Colombia, Argentina, and Brazil), the Middle East (i.e., Lebanon, Jordan, Egypt, and Syria), West Africa, and South Asia (i.e., Vietnam, China, and India) [20]. For example, in Beijing, China, 50% of the total wastewater is used for agricultural purposes. Wastewater is also discharged directly into surface waters without any treatment. Wastewater use in vegetable production in Hanoi in Vietnam is about 80%, while in major cities of West Africa, somewhere between 50 and 90% of vegetables in and around the city are irrigated with wastewater [3].

In the Middle East, where the urban population is constantly expanding, and there are insufficient wastewater facilities, the wastewater generated is discharged chiefly into rivers. Farmers frequently use untreated wastewater for irrigation [9].

Regions that frequently use treated wastewater include high-income countries, especially those with arid and semi-arid areas. In the USA, especially in Florida and California, most treated wastewater is used for landscape and agricultural purposes. Approximately 20 different product types are grown in California with treated wastewater, including strawberries, cereals, raw vegetables, and non-food products [22].

In Southern European countries, the rate of projects where wastewater is reused in agricultural irrigation is 44% [9]. For instance, there are reuse projects in Spain (150) and France (30), and the main objectives of these projects are to provide irrigation water for agricultural and environmental services [9], [23]. More than 3,000 hectares in France and approximately 30,000 hectares in Italy are irrigated with treated wastewater [3].

Recently, treated wastewater usage for agricultural purposes has started to become widespread in North Africa and the Middle East. For example, approximately 50% of reclaimed wastewater in the Arabian Gulf region is used for agricultural irrigation [3]. In Kuwait, the rate of wastewater usage for agricultural purposes has reached 35% [24].

Before treatment technologies were applied, wastewater was used for agricultural purposes to prevent pollution of surface water resources in many North American and European cities. In developing countries such as Vietnam, India, Peru, Egypt, Lebanon, Morocco, Mexico, and China, the most valuable crop nutrient source in the last 30 years has been wastewater [25].

Wastewater reuse has been indirectly implemented in Egypt for centuries, and official wastewater reuse was initiated in 1911 in a northeast area of Cairo called El-Gabal El-Asfar [26]. The Nile River is the region's most important source of irrigation water, and wastewater discharged to the Nile River is estimated to be 2-3 billion m^3 annually [23].

Less than 50% of the population in Argentina has access to improved sewage systems, and just a tiny portion of the collected canalization is treated. Since the beginning of the 20th century, there has been an enormous untreated wastewater usage for the horticultural water system in densely populated areas in western regions (i.e., arid regions) [27].

In certain districts of Italy, particularly in the southern parts, farmers use wastewater for agricultural purposes due to insufficient irrigation water [28].

Sweden has a generally enormous measure of freshwater. The elevated water requests in industry, city, and rural requests are 55%, 36%, and 6%, respectively. Nevertheless, agricultural demand in the southeastern regions of Sweden is more prominent, and precipitation is insufficient. In this part of the country, over 40 irrigation projects have been done with treated wastewater [27].

Water scarcity is a concern in Sardinia, where recurrent droughts frequently damage agricultural production. Therefore, the reuse of treated wastewater for agricultural irrigation has been considered a new source of water. For this purpose, the water treated in the "Is Arenas" treatment facility serving the city of Cagliari and its suburbs irrigates approximately 7,900 hectares of land in the Southern Sardinia irrigation zone. This project has been beneficial for solving water shortage and ecological assurance issues [29].

In Pakistan, where wastewater is extensively used, farmers believe that wastewater is nutrient-rich, particularly in Faisalabad. The reason behind why farmers use untreated wastewater is that the groundwater is excessively salty [20], [25], [30]. The main products grown in these areas in Pakistan are vegetables, fodder crops, and wheat [27], [31].

In Quetta, Pakistani farmers wanted to make wastewater usage costs 2.5 times more than clean water, as they obtained more products with wastewater use [4]. In Pakistan, approximately 25% of vegetables are grown using wastewater, and approximately 75% of vegetables are produced by mixing wastewater with freshwater [32].

Oman, another drought country, has been using 90% of treated wastewater for agricultural irrigation since 1987. There are also official regulations on the reuse of treated wastewater for irrigation [27].

Israel takes the lead in the use of wastewater for agricultural irrigation, and in 2012, the ratio of treated wastewater to total clean water is estimated to be almost equal [33]. Approximately 75% of the total wastewater is treated and utilized for agricultural purposes [34]. By 2040, it is estimated that the water to be used for agricultural purposes will consist entirely of treated wastewater in Palestine and Israel [35].

Kuwait is another country suffering due to insufficient water resources. In recent years, forage plants (mostly clover) have been cultivated in a 1,600-hectare area using tertiary treated wastewater [36].

Approximately 78% of the wastewater collected in Tunisia, recognized as a pioneer in the wastewater of North Africa, is reused to irrigate fruit trees such as landscape irrigation, feed, and industrial crops production, cereal cultivation, and vineyards [44], [46].

Since Japan suffers from insufficient water due to frequent and severe droughts and rapid population growth, treated wastewater is reused in large cities. In recent years, the use of treated wastewater in recreation areas, agricultural irrigation, toilet systems, snow melting, and industry has become widespread [40].

As part of the reuse of wastewater, in Cyprus, the majority of wastewater, which reaches approximately 25 million m^3, is treated for use in agricultural activities, and these waters irrigate around 40,000 hectares [3].

In summary, the primary reasons for water reuse in different parts of the world show that they suffer from water problems due to urbanization, population growth, and climate changes. The purpose of water reuse is to protect freshwater resources and to respond to increasing water demand.

1.6. Using Wastewater for Tomato Cultivation

In the study of Al-Lahham, four types of water application (i.e., 100% wastewater, 1:3 wastewater, 1:1 wastewater, and clean water) in two types of tomatoes were carried out under Jordan conditions. They looked at parameters such as weight and water-soluble dry matter [41]. However, the difference between the tomato varieties was significant. No significant difference was found between water-soluble dry matter and fruit hardness. Considering the fruit diameter and fruit weight parameters, it was observed that fruit diameter and fruit weight increased with wastewater applications. Wastewater ratio with no clean water added resulted in the highest microbial contamination and bacterial count compared to the cases with clean water mixed with wastewater. On the other hand, all wastewater types showed a low level of fecal coliform due to the chlorination that existed in wastewater, which shows that chlorination had a beneficial effect. Chlorination does not affect the pollution on fruit surfaces. As a result, microbial accumulation in fruits has been found to be below standards, and it has been emphasized that wastewater can be used in tomato cultivation.

However, heavy metals are a potential problem. The recommended maximum concentration levels of heavy metals and toxic elements in irrigation water are given in Table 1.2.

Table 1.2 Recommended maximum concentration levels of heavy metals and toxic elements for irrigation waters

Elements	Maximum recommended limit for short term (μg/L)	Maximum recommended limit for long term (μg/L)
Aluminum (Al)	20,000	5,000
Arsenic (As)	2,000	100
Beryllium (Be)	500	100
Cadmium (Cd)	50	10
Cobalt (Co)	5,000	50
Chromium (Cr)	1,000	100
Copper (Cu)	5,000	200
Iron (Fe)	20,000	5,000
Manganese (Mn)	10,000	200
Nickel (Ni)	2,000	200
Lead (Pb)	10,000	5,000
Selenium (Se)	20	20
Vanadium (V)	1,000	100 ^{FAO} - 200 ^{EPA}
Zinc (Zn)	10,000	2,000

EPA: Environmental Protection Agency [42]
FAO: Food and Agriculture Organization [43]

Najafi [44] applied urban treated wastewater to tomato plants under Iran-Isfahan conditions with different irrigation strategies. Irrigation applications were created as furrow irrigation with municipal water (T_1), surface drip irrigation with wastewater (T_2), subsurface drip irrigation with wastewater at a depth of 15 cm (T_3), subsurface drip irrigation wastewater at a depth of 30 cm (T_4), and furrow irrigation with wastewater at 75 cm width (T_5). Study results showed that while the most efficiency was obtained from the second irrigation application, the maximum water usage efficiency was obtained from the third water application. Looking at the heavy metal content of the tomato plant, it was determined that Fe, Zn, Cu, and Mn values were primarily seen in plants irrigated with the fifth application. Considering the nematode amount in tomatoes, most nematodes were detected in tomatoes irrigated with T_5. Also, the T_5 and T_2 treatments contained the most fecal coliform bacteria, respectively. As a result, it was determined that the microbiological quality of the tomato plant is best in sub-surface drip irrigation with wastewater at a depth of 15 cm. Additionally, sub-surface drip application of wastewater minimized soil surface contamination. The sub-surface drip irrigation method was recommended when using wastewater.

In a study conducted in Jordan, the tomato plant was grown by irrigating four different water to wastewater ratios, including 100% wastewater, 1:3, 1:1 wastewater, and clean water. Tomato fruit, soil, and water were examined for detecting the heavy metal concentrations [45]. Heavy metal concentration, EC, and pH changes of soil were measured. Results showed that wastewater applications increased soil salinity. The increase in soil pH before and after the experiment was found to be insignificant. However, it was observed that the pH value increased as the soil depth increased. When heavy metals were examined in soil, Cd and Pb did not accumulate in the soil. However, Mn, Zn, and Cu concentrations increased. The highest heavy metal content was observed in the 100% wastewater application. When heavy metal concentrations in the fruit were examined, the values were found below the JS 41:1997 standards. As a result, it has been determined that tomato cultivation using wastewater is possible without heavy metal contamination risks.

Aiello et al. [46] investigated the effect of urban treated wastewater on the fruit quality of tomatoes and the hydrological behavior of the soil. In a 2004 study, tomato plants were irrigated by superficial and subsurface drip irrigation methods. Different drippers and laterals, distribution uniformity, filtering techniques were tested, and emitter distribution, flow reduction, and filter performance calculations were examined to determine the most suitable irrigation technology. The hydraulic properties of the soil and microbial contamination were also determined before and after treated wastewater applications. During the trials, tomato fruit quality and microbial contamination in plants were measured. Results showed that microbial contamination was present on the soil surface. A decreased tendency in water retention and hydraulic conductivity was observed in soil porosity. The study concluded that microbial contamination in the fruit might be negligible, and that wastewater can be used as beneficial alternative water in the irrigation of tomato plants.

Rai and Tripathi [47] conducted monthly analyzes of the effects of wastewater upon soil and vegetables. Treated and untreated wastewater was used to irrigate radish, turnip, spinach, tomato, carrot, cabbage, onion, brinjal, and potato. Results showed heavy metal (i.e., Cd, Cr, Cu, and Zn) buildup in the soil and higher concentrations in turnips, cabbage, and radishes.

In a study examining tomatoes (variety “TITANO M) grown under greenhouse conditions, three different water applications (i.e., clean water, wastewater with fertilizer, and wastewater without fertilizer) were applied [48]. Results showed that wastewater increased electrical conductivity, exchangeable Mg, exchangeable sodium percentage (ESP), and Zn content in the soil. Pots containing tomatoes were separated into three even layers, A-Top, B-Middle, C-Bottom. Layer A showed a three-fold increase in carbon content. Sodium and Mg increased in both A and B layers, while Ca was found only in the B layer. A decrease was observed in Fe concentrations. Manganese, Cu, and Zn concentrations were not affected by wastewater usage. The water usage efficiency and the mass weight of the plant were found to be higher in wastewater applications. As a result, it was emphasized that wastewater could be used both as a water source and inorganic fertilizer for agriculture in conditions where water is limited.

Abdelrahman et al. [49] examined the effects of water source and amount on salt buildup in the soil. Fresh water and thrice treated wastewater were applied at different quantities (i.e., 0.6, 1.0, and 1.4 ETo), while salt and moisture content were regularly monitored in the soil. Results showed that the soil moisture content was higher in soils irrigated with fresh water. Moisture content was found to decrease as soil depth increased. Results also showed that salts build up in was present in soil irrigated with treated wastewater. The pH of the soil decreased with both fresh water and treated wastewater applications. The sodium absorption rate (SAR) was found to be low for both applications. In maize crops, there were no considerable effects on the chemical composition between the two applications except for the nitrogen content. Nitrogen concentrations were higher in plants irrigated with treated wastewater. The authors concluded that corn may be irrigated with treated wastewater in the Oman region.

Kahlaoui et al. [50] investigated the yield and fruit quality of tomato plants (variety - Rio Grande) grown using subsurface drip irrigation (SSDI) and surface drip irrigation (SDI) methods. Irrigation methods followed three different water regimes (i.e., 100%, 85%, and 70%). In the SDI (70%) application, it was observed that soil salinity increased, and there were decreases in the number of flowers, number of fruits, fruit length, and yield. The authors also found titration acidity, total soluble solids content, and fruit pH decreased in the SDI method and irrigation regimes. Final results reported that the tomato yield was higher with SSDI applications, and the method was recommended for the region.

In a study conducted in Italy, tomato and eggplant were irrigated with wastewater by applying different irrigation strategies [51]. Potable water and wastewater were used to irrigate plants using superficial and subsurface drip irrigation. Results showed that the efficiency of plants grown with wastewater applications increased by 20% in tomato plants and 22% in eggplant plants compared to potable irrigation water. Additionally, it was emphasized that water usage efficiency could be increased with applications such as planting with plastic and mulching. The study also suggested that microbial contamination may occur in plants at minimum levels.

Alrajhi et al. [52] grew tomato crops with three different water qualities: tap water, recycled wastewater, and a mix of recycled wastewater and stormwater. Five different irrigation strategies were imposed: 100% full irrigation, 75% partial root-zone drying (PRD), 50% deficit irrigation (DI), 75% PRD, and 50% DI. Results showed that salt accumulation in the top layer of soil was determined in at least 75% PRD applications. In wastewater applications, total nitrogen and total carbon increased in the soil by 4% and

7%, respectively, compared to the 100% clean water irrigation application. However, irrigation strategies and water resources in sodium adsorption ratio (SAR) did not differ significantly. In wastewater PRD applications with high SAR values, SAR was determined to be less than DI applications. The study concluded that PRD applications with wastewater have the potential to reduce soil salinity and have applicability in regions where water resources are limited.

Chunfang et al. [53] grew tomatoes under greenhouse conditions to examine the effect of treated wastewater application on soil nutrients and enzymes. They determined that NO_3, P, K uptake was enhanced through soil urease and acid phosphatase, which helps increase enzyme activities in soils irrigated with clean water. In addition, catalase activity, soil urease, nitrate-nitrogen, total N, and total P content increased in the application using treated wastewater. These results suggest that treated wastewater for irrigation is a safe and effective strategy for farmland management.

1.7. Research Questions, Hypotheses, and Objectives

Due to the shrinking availability of freshwater resources, investigating alternative irrigation water sources is becoming essential. Wastewater offers a potential resource that can augment or replace limited freshwater irrigation resources. In addition to the water component, wastewater often contains valuable nutrients, including nitrogen (N) and phosphorus (P), and may offer positive benefits by augmenting crop fertilization requirements. Conversely, wastewater also may contain undesirable pollutants, including heavy metals. This study investigated the use of raw and treated wastewater as an alternative irrigation water source for agricultural purposes. Several questions related to this topic were addressed. Each topic is accompanied by a hypothesis (H_0) and alternates.

Research Question 1: Do the nutrients present in wastewater sources improve or degrade soil quality?

H_0: The organic matter percentage and nitrogen, phosphorus, and potassium content of the soil will increase when raw wastewater is applied regularly over a crop growing cycle.

H_1: The organic matter percentage and nitrogen, phosphorus, and potassium content of the soil will decrease when raw wastewater is applied regularly over a crop growing cycle.

H_2: The organic matter percentage and nitrogen, phosphorus, and potassium content of the soil will remain the same when raw wastewater is applied regularly over a crop growing cycle.

Research Question 2: Do the heavy metals present in irrigation waters accumulate in the soil or crop (tomato)?

H_0: The accumulation of heavy metals in the crop (tomato) irrigated with raw wastewater will be higher than crops irrigated with other types of water.

H_1: The accumulation of heavy metals in the crop (tomato) will be more than in the soil when irrigation waters are applied.

H_2: The accumulation of heavy metals in the soil, crop (tomato) will be the same when irrigation waters are applied.

Research Question 3: Do the extra nutrients in raw wastewater sources improve or degrade crop (tomato) total biomass and fruit yield?

H_0: Wastewater will increase crop (tomato) total biomass and fruit yield.

H_1: Wastewater will decrease crop (tomato) total biomass and fruit yield.

H_2: Wastewater will not affect crop (tomato) total biomass and fruit yield.

Objective 1: Measure the effects of different water types on the soil properties.

Objective 2: Measure heavy metal concentration levels in each water type.

Objective 3: Compare tomato yield grown under irrigation with different water types.

Objective 4: Measure heavy metal concentrations uptake by soil and crops irrigated with raw and treated wastewater.

2. MATERIAL AND METHODS

2.1. Material

2.1.1. Study Areas

This study was conducted in Brazos County, Texas (Figure 2.1). Plant cultivation was carried out from March to June 2021 under controlled conditions at Texas A&M University, Southern Crop Improvement Greenhouse facilities. Six different water sources applied to meet the water demands of the plants were the On-Site Sewage Facilities (OSSF) Center at The Texas A&M University System RELLIS Campus.

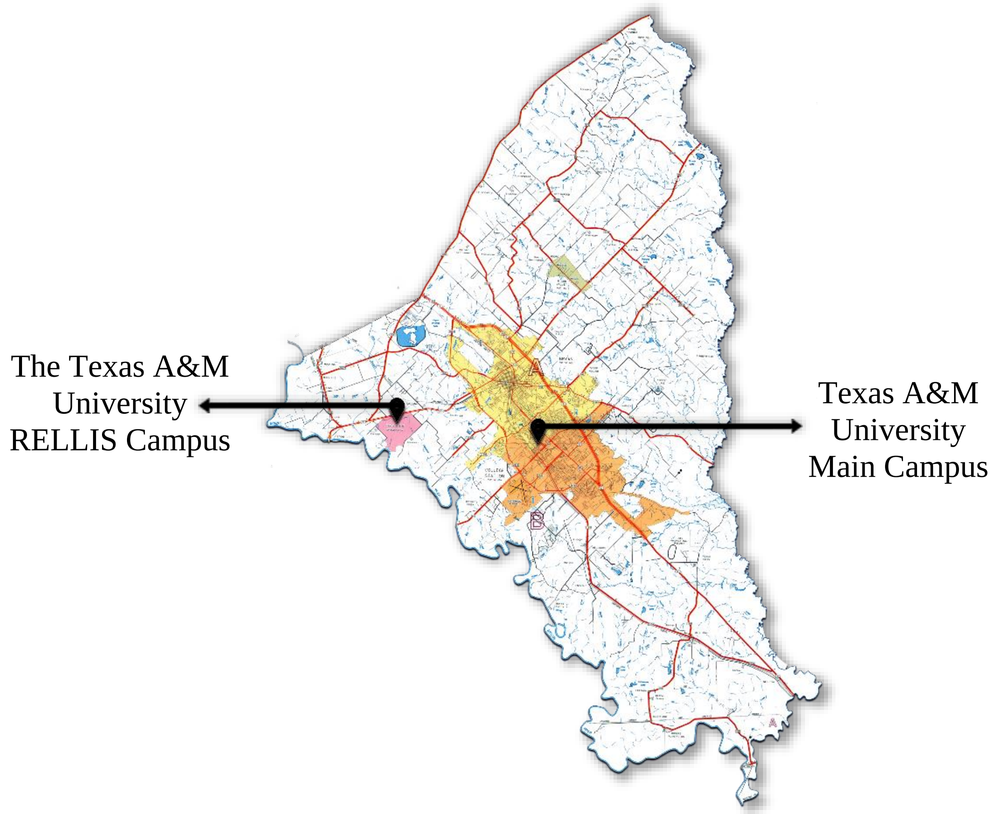

Figure 2.1 Geographic location of this study's regions in Brazos County, Texas

The soil used in this study was obtained from Texas A&M University farmland in Burleson County. The soil type was determined as Weswood Silt Loam through the United States Department of Agriculture's (USDA) Web Soil Survey (WSS) [54]. Soil properties are shown in Table 2.1. The soil was excavated to a depth of 30 cm. The first 15 cm layer was discarded, and the 15-30 cm layer was prepared for use in the greenhouse. The foreign matter was removed by sieving the soil through an 11-mm screen before filling pots. Pot volume was 26.5 L, and 20 kg of prepared soil was used in each for plant cultivation. A sample was collected from the prepared soil and analyzed by the Texas A&M AgriLife Extension Service Soil, Water, and Forage Testing Laboratory (Table 2.2).

The soil texture was determined to be loam, and the ratio of sand, silt, and clay was 38%, 38%, and 24%, respectively. The electrical conductivity (EC) value of the soil was 324 μS/cm, organic matter content was 1.56%. Soil analysis indicated that the soil had no salinity problems and was not rich in organic matter. Additionally, it was slightly alkaline with a pH of 7.5.

Soil moisture sensors (WaterMark - Irrometer, Riverside, CA) were used to observe daily moisture changes in the soil before and after each irrigation application. Each sensor was placed at a depth of 10 cm and 5 cm from the pot edge. The sensor range was 0-200 Centibars (CB), and soil moisture conditions were described using recommendations by the manufacturer (Table 2.3) [55]. Soil moisture was recorded at set intervals (e.g., minutes, hours, days) for eight pots in this study. An additional ten sensor connections were monitored manually using a handheld meter during irrigation events.

Table 2.1 Soil Properties of Weswood Silt Loam

Typical Profile	
Surface layer	
0 to 25 cm	Brown, moderately alkaline silt loam
Subsoil	
25 to 135 cm	Light brown or light reddish-brown, moderately alkaline, silt loam
135 to 150 cm	Pink, moderately alkaline, very fine sandy loam
150 to 185 cm	Light brown, moderately alkaline, silt loam
185 to 205 cm	Reddish-brown, moderately alkaline, silty clay loam
Soil Properties	
Drainage class	Well-drained
Water table	None within a depth of 185 cm
Permeability	Moderate
Available water capacity	High
Natural soil fertility	High
Shrink-swell potential	Low
Hazard of water erosion	Slight
Composition	
Weswood soil and similar inclusions	90%
Contrasting inclusions	10%

Table 2.2 Values of the physical and chemical properties of the soil before starting cultivation

Properties	Analysis	Results	Units
Physical	Sand	38	%
	Silt	38	%
	Clay	24	%
	Textural Class	Loam	
Chemical	pH	7.5	
	EC	324	µS/cm
	Organic Matter	1.56	%

Table 2.3 Recommended tension ranges for commonly grown plants [55]

Range	Water
0-10 CB	Saturated soil
10-20 CB	Soil is adequately wet
30-60 CB	The usual range for irrigation (except heavy clay soils)
60-100 CB	The usual range for irrigation in heavy clay soils
100-199 CB	Soil is becoming dangerously dry for maximum production

2.1.2. Plant Properties and Planting

The optimum temperature requirement for tomato plant cultivation is generally between 20-30 °C, although different temperature intervals are reported in the literature. The fruiting set is weak, above 30 °C and below 10 °C. The plant is very sensitive to freezing and may die below 0 °C. Considerable temperature changes between day and night also affect fruit yield adversely. Therefore, interior air temperature in the greenhouse was maintained between 20 and 30 °C.

The hybrid tomato variety "Better Boy" (*Solanum Lycopersicum* Better Boy) was used for this study. This variety was adapted to the ecological conditions of the region. Plants were supplied through the Bonnie Plants Company. The average seedling height was 15 cm on 1st March. The growth characteristic of the variety suggests that this variety reaches maturity within 75 days after planting grows to an average height of 1.8 - 2.4 m. A total of 18 plants were grown on a table in the greenhouse.

2.1.3. Water Sources, Irrigation Types, and Quality Measurement

The irrigation water used for this study was obtained from 3 different sources:

1) Groundwater (GW),

2) Raw wastewater (RWW),

3) Membrane bioreactor (MBR) treated wastewater. All waters were supplied from the On-Site Sewage Facilities (OSSF) Center on RELLIS Campus.

RWW used in this study came from Texas A&M University RELLIS campus offices, classrooms, and teaching laboratories. RWW was collected using an ISCO 3700 automated water sampler (Figure 2.2).

The membrane bioreactor treatment system consisted of 3 parts: trash tank, treatment tank, and pump tank. The raw wastewater received primary treatment through the MBR system. Subsequently, the MBR effluent was treated to ozone treatment. After the raw wastewater passed through the MBR treatment system, it was collected for use in tomato plant cultivation, called MBR in this study. MBR-treated water was collected through a tap before the ozone treatment system.

Figure 2.2 A) Taking water from the raw wastewater tank through ISCO 3700, B) Taking water from the MBR treatment system (B)

RWW and MBR waters collected at the RELLIS Campus were transported to the greenhouse in 19L buckets. The water transported to the greenhouse was prepared according to the determined water needs of the plants.

The amount of irrigation water needed by the plant was calculated according to the equation (Eq.1) below.

$$IWA_i = PWR \times REP \times PV_i \qquad \text{(Eq.1)}$$

where;

IWA: Irrigation water amount $[mm]$,

PWR: Plant water requirement $[mm]$,

REP: Replication

PV: Percentage value [%],

i: Irrigation type index, i.e., T_0, T_1, T_2, T_3, T_4, T_5

Physical water quality measurements of irrigation water to the plants were taken with a multiparameter water meter (HI98194 – HANNA Instruments, Smithville, RI) before each irrigation application. Measurement of pH, EC, and total dissolved solids (TDS) was used to describe water quality.

2.1.4. Heavy Metal Measurement

Figure 2.3 shows the points where the heavy metal concentration level was detected. The heavy metal concentration level was measured for plant parts (i.e., root, crown, lower stem, upper stem, leaf, truss, and fruit) and soil (i.e., at 0-10, 10-20 cm depth, and the soil collected in the saucer). In order to determine the accumulated amount of heavy metal in the soil and plants, samples were first dried and weighed. Dried samples were digested by a microwave digestor (MARS6 - CEM, Matthews, NC) and subsequently analyzed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS). In order to digest soil and plant samples, all samples were oven-dried at 80 °C for 48 hours [56]. Dried soils were passed through 2-mm sieves, and plant parts were ground to a powder [57]. 0.5 g of each sample (i.e., soil, plant parts) were weighed separately and poured into separate 50 ml centrifuge tubes, along with 10 ml of nitric acid. (HNO_3) [58]. The tubes were tightly capped, placed in the microwave holder, and then prepared for digestion using the MARS6.

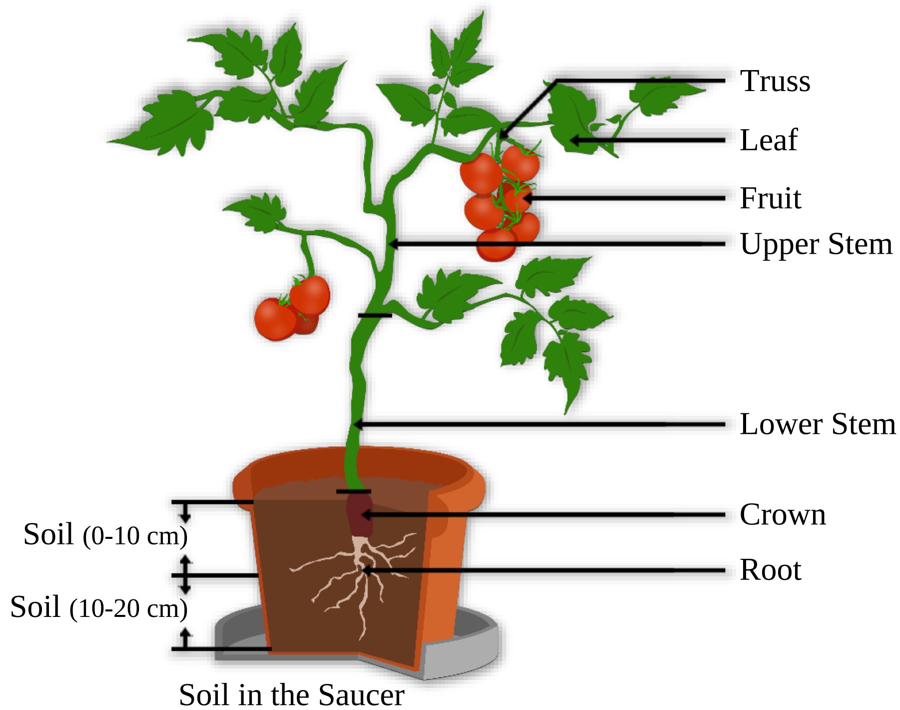

Figure 2.3 Sample points for heavy metal analysis

2.1.5. Type of Irrigation Water

The water required for tomato cultivation was obtained from 3 sources: 1) ground water (GW) from the Texas A&M RELLIS campus tap, 2) raw wastewater (RWW) from the Texas A&M RELLIS campus, and 3) membrane bioreactor treated wastewater (MBR) from the OSSF on the Texas A&M RELLIS campus. Water was collected every five days from each of the three water sources and used to irrigate the experimental tomato crop. Water was collected from each source on 23 dates over the 115-day irrigation period (Table A.1). Additionally, three irrigation water solutions were prepared by mixing RWW and MBR waters at various proportions of 25%, 50%, 75% with GW water. The three source waters and mixtures yielded six distinct irrigation water treatments (Table 2.4).

Table 2.4 Contents of irrigation treatments applied to tomato plants

Treatment	GW	MBR	RWW
T_0	100%	-	-
T_1	-	100%	-
T_2	-	75%	25%
T_3	-	50%	50%
T_4	-	25%	75%
T_5	-	-	100%

GW: Ground Water, MBR: Membrane Bioreactor Treated Wastewater, RWW: Raw Wastewater

2.1.6. Experimental Design

Tomatoes were grown in pots under greenhouse conditions. Six irrigation treatments with three replications were examined. Pots (i.e., treatments) were randomized within the available greenhouse space (Figure 2.4). Each plant was attached to a string suspended from the greenhouse roof to support vertical growth and fruiting. Branches and fruiting structures were tied at additional support locations vertically along the suspended string as needed, depending upon plant growth.

This study was carried out on a table with a dimension of 8.5 m x 1.8 m. Pots were spaced as far apart as possible to minimize growth interference among the plants. Available table space allowed two rows of 9 pots spaced 1.0 m apart with a 0.6 m gap configuration between each pot within each row (Figure 2.4).

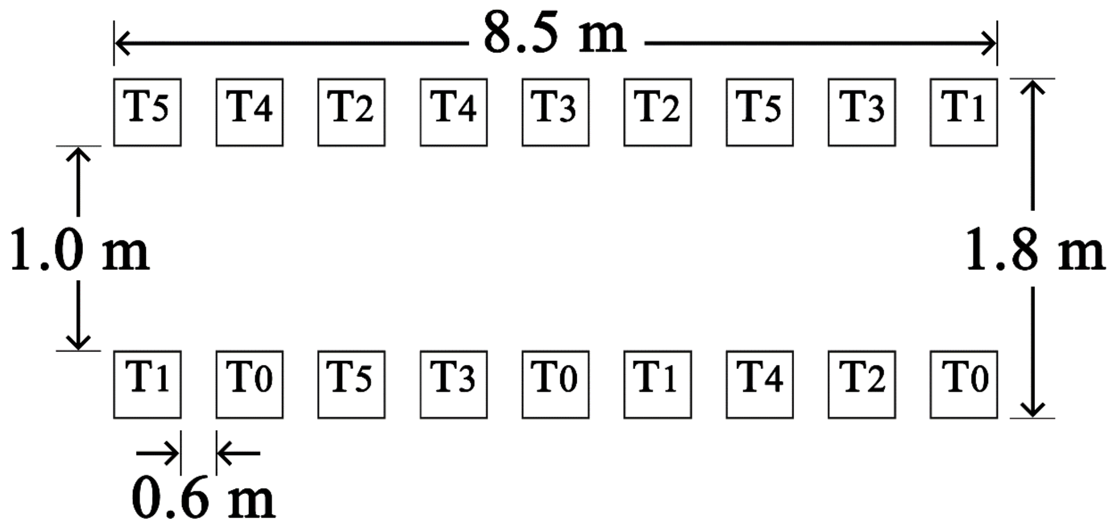

Figure 2.4 The randomized design scheme of pots in the greenhouse

2.1.7. Pot Preparation

Tomatoes were container-grown in plastic pots (~30L volume, 30x20x20 cm dimensions). One tomato seedling was planted in each pot containing a final volume of 20 kg of soil per plant. The pots were of solid construction; five 2-cm holes were drilled to provide drainage, one at the center bottom and four on the sides at the bottom. A saucer was placed under each pot in order to capture water draining from the soil. This helped the waters drained from the soil to be reused by plants.

2.1.8. Monitoring Soil Moisture

Soil moistures change over time was measured in each pot throughout the experiment using soil moisture sensors (Watermark, Irrometer, Riverside, CA). One sensor was installed in each pot. A data logger was used to record soil moisture levels every hour. Only eight of the 18 pots were monitored with the automated datalogger due to an instrument limitation (i.e., only two dataloggers were available, and each had four sensors input channels). The remaining ten sensors were read manually using a handheld meter once a day when the plants were irrigated. Soil moisture conditions were used to determine the daily water requirement for each plant. The amount of irrigation water per plant (i.e., ~1 liter per plant) was applied based on soil moisture readings.

2.1.9. Plant Water Consumption

Plant water consumption was determined by mass balance. Subtracting water losses (i.e., drainage, soil evaporation, and crop transpiration) from water applications (i.e., irrigation water) yields the quantity of water consumed by the plant [59].

$$W_C = W_{IR} - (W_D + E_s + T_c) \quad \text{(Eq.2)}$$

$$ET = E_s + T_c \quad \text{(Eq.3)}$$

$$W_C = W_{IR} - (W_D + ET) \quad \text{(Eq.4)}$$

where;

W_C: Plant water consumption $[mm]$,

W_{IR}: Irrigation water $[mm]$,

W_D: Drain water $[mm]$,

E_S: Soil evaporation $[mm]$,

T_C: Crop transpiration $[mm]$,

ET: Evapotranspiration $[mm]$,

The experiments were carried out under greenhouse conditions in order to control irrigation water quality (i.e., differing wastewater treatments) and quantity (e.g., exclude precipitation). Additionally, irrigation drainage (W_D) was controlled through the use of saucers placed under the pots. Water captured in the saucers acted as reservoirs from which the plants were able to draw when needed. When irrigating, water addition was stopped when the drainage saucer was filled to capacity.

Soil evaporation (E_S) and crop transpiration (T_C) were the two sources of water loss from the experimental plant/pot systems. This can be estimated by calculating an evapotranspiration (ET) value which approximates the sum of these two values. Daily plant ET was estimated by the pan evaporation method following FAO recommended procedures (Figure 2.5) [60].

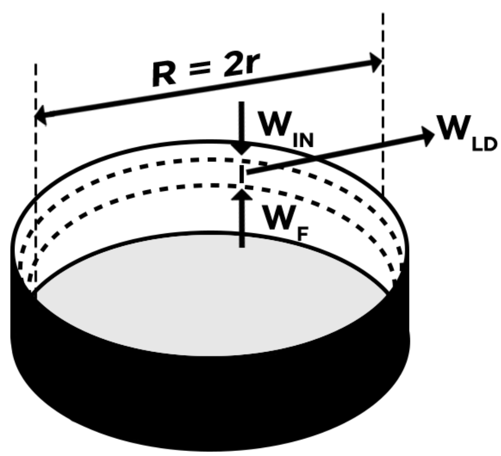

Figure 2.5 The Class A Evaporation Cylinder

$$W_{LD} = W_F - W_{IN} \quad \text{(Eq.5)}$$

$$W_{LD,N} = W_{F,N} - W_{F,N-1} \quad \text{(Eq.6)}$$

$$A_i = \pi r_i^2 \quad \text{(Eq.7)}$$

$$V_{i,N} = A_i \times W_{LD,N} \quad \text{(Eq.8)}$$

$$ET = \pi r_X{}^2 \times W_{LD,N} \times \frac{V_{Y,N}}{V_{X,N}} \quad \text{(Eq.9)}$$

where;

W_{LD}: Water level difference $[mm]$,

W_F: Final reading of water level $[mm]$,

W_{IN}: Initial reading of water level $[mm]$,

N: Day index,

$W_{LD,N}$: Water level difference between two consecutive days on *N*th day $[mm]$,

i: Evaporation index, i.e., Y: The Class A Evaporation cylinder, X: Pot

A: Surface area of the cylinder $[mm^2]$,

r_i: Radius of the *i*-th cylinder $[mm]$,

$V_{i,N}$: Volume of the *i*-th cylinder between two consecutive days on *N*th day $[mm^3]$,

The amount of consumed water by the plant W_C was estimated using (Eq. 10.

$$W_C = W_{IR} - \left(W_D + \left(\pi {r_X}^2 \times W_{LD,N} \times \frac{V_{Y,N}}{V_{X,N}} \right) \right) \qquad \text{(Eq. 10)}$$

2.1.10. Plant Observation and Measurements

Plant height measurements were carried out once a week, starting with the beginning of the planting to judge the overall plant condition and growth rate. A meter stick was used to measure plant height from the soil surface to the tip of the plant in the horizontal direction.

2.1.11. Fruit Measurement

The plants were harvested every week, and the weight, height, and width of the collected fruits (tomatoes) were measured. Precision scales were used to weigh fruit weights (in grams), and digital calipers were used for other measurements (in millimeters).

2.1.12. Soil Analysis

Following plant harvest, the soil was removed from each pot in two 10-cm layers (i.e., 0-10 and 10-20 cm). To remove the remaining moisture, all soil sub-layers were oven-dried at 80 °C for 48 hours [56]. Following drying, the samples were sieved to 2-mm to homogenize and remove roots [57]. A 1 kg sample from each soil layer was taken to the Texas A&M AgriLife Extension Service Soil, Water, and Forage Testing Laboratory for pH [61], EC [62], and microelements [63] analysis.

2.1.13. Heavy Metal Analysis

2.1.13.1. Plant and Fruit Sample Collection and Preparation

Ripe fruits were harvested weekly; counted, washed, weighed, and cut into small pieces to facilitate drying. Following air-drying for five days, the samples were dried at 50 °C for 24 hours to remove any remaining moisture. Samples were ground fine using a Wiley Mill and sieved through a 2-mm mesh to remove any non-plant material and homogenize. Samples were stored at laboratory room temperature in labeled plastic bags until further analysis.

2.1.13.2. Soil Sample Collection and Preparation

The majority of the plant roots were separated from the soil by simple pulling and shaking. After the plant's root was eliminated from the soil, soil samples were collected from the layers at a depth of 0-10 and 10-20 cm. Large clods were reduced in size using a mallet. After air-drying for five days, the sample was further dried in an oven at 50 °C to remove the remaining moisture. Following the drying process, the dried soil was sieved with a 2mm size mesh and sub-sampled for heavy metal analysis.

2.1.13.3. Sample Digestion Procedures for Heavy Metal Analysis

Sample digestion prior to heavy metal analysis was accomplished using the microwave method [58], [64]. A 0.5g dried and homogenized sample was placed in a high-pressure vessel. Ten mL of HNO_3 was added, and the sample was digested at 180˚C for 45 minutes. Following digestion samples were filtered through a 5µm filter. Filtered solutions received a 10x dilution with 2-3% HNO_3. Heavy metal concentration determination was carried out by Inductively Coupled Plasma Mass Spectrometry (ICP-MS, Agilent's 7700 Series, Santa Clara, CA) using Method 200.8 [65].

2.1.14. Statistical Analysis

All statistical calculations were made using SSPS software (Version 26.0. Armonk, NY: IBM Corp). One-way ANOVA was used to compare sample means and means separation were determined with Tukey post-hoc multiple comparisons. All statistical analyses were determined at the 95% and 99% confidence levels.

3. RESULTS AND DISCUSSION

3.1. Water Consumption

Plants were irrigated between March and June with six water treatments of groundwater (GW), membrane bioreactor (MBR) treated wastewater, raw wastewater (RWW), and mixtures. Water was drawn from the sources (GW, RWW, MBR) 23 times over the 115-day irrigation period. Total irrigation amounts applied to treatments were 1,235 mm (87.25 L). Approximately one-third of the total applied irrigation water (427 mm) was not used by the plant. Table A.1 shows daily irrigation applied, evapotranspiration, and the plant's water consumption. Irrigation was applied to all plants as 7.08 mm (500 ml) for the first 42 days, 10.62 mm (750 ml) for the next 27 days, and 14.15 mm (1,000 ml) for the following next 46 days.

The total water consumption of the tomato plants in this study may be high compared to other similar studies. Shrivastava [66] found the water consumption of tomato plants grown in India as 566 mm. Singandhupe [67] found it to be 503 mm in the study took place in Italy. Kirda [68] found it to be 456 mm in the study in Turkey. Tarantino [69] found it to be 616 mm in the study in Italy. Therefore, it is speculated, according to different research results, that the changes in water consumption are caused by climatic conditions and regional differences.

3.2. Water Quality Parameters

The applied irrigation water for tomato cultivation in the experiment was supplied from Texas A&M University RELLIS Campus collected on 23 different days. Certain quality parameters were measured before the water was applied. While Table 3.1

illustrates the statistical description of the applied irrigation water pH, EC, and TDS measurements, the values of applied irrigation water pH, EC, and TDS measurements are shown in Tables A.2, A.3, A.4, and Figure 3.1.

pH is used to indicate the basicity or acidity of a solution [70]. For tomatoes, it is recommended that the pH of irrigation water falls within the range of 6.5 to 8.4; however, this may vary depending on soil type [71]. Table 3.1 and Figure 3.1-A show the average pH values of treatments varied between 8.25 and 9.19, implying that the water used in this study was slightly basic. However, considering the collected days of the water used, the largest fluctuations were seen in wastewater, which had the highest pH of 12.32 (T_5), and the lowest pH of 7.39 (T_5). The high pH in T_2, T_3, T_4, T_5 were not within the recommended pH range and there could be a number of related problems. For example, a pH value out of the recommended range may cause nutritional imbalance [72], [73]. Bauder [74] stated that when the upper limit pH value is exceeded, clogging problems in irrigation systems increase due to the presence of carbonate and bicarbonate.

The parameters used to express the salinity levels are electrical conductivity (EC) and total dissolved solids (TDS). These two parameters are related and are usually calculated on a simple equation ($EC\left(\frac{\mu s}{cm}\right) k \ x \ TDS\left(\frac{mg}{L}\right)$) [75]. The coefficient, k, used in the equation varies according to the type of water and salinity (e.g., drinking water, groundwater, ocean water). A multiparameter water meter was used to measure these parameters. The multimeter used the k coefficient as 0.5 [76].

The treatments included six irrigation water qualities. Table 3.1 and Figure 3.1-B show that average EC values of treatments ranged between 916 and 1,822 μS/cm. EC was highest with MBR-treated wastewater irrigation (T_1 Irrigation water was taken from the sources (i.e., GW, MBR, RWW) simultaneously, every five days. The MBR treated wastewater reflects the treatment of a previously introduced RWW (i.e., ~24-hour treatment of lag time to process). Therefore, water samples, although collected at the same time, reflected different EC contents, and no relationship between EC of MBR treated wastewater and raw wastewater was observed. According to the United States Salinity Laboratory (USSL) [77], EC values for waters below 750 μS/cm are generally satisfactory for irrigation, as this value suggests the salt content is below plant-toxic levels. However, salt-sensitive crops may be adversely affected by the application of these waters. Waters in the range of 750 to 2250 μS/cm EC values are frequently applied, and satisfactory crop growth may only be obtained under good management and favorable drainage conditions. Otherwise, soil salinity may increase if leaching and drainage are inadequate. The waters applied in this study were considered to be of medium salinity and did not pose any major problems for the soil and the plant [78].

Table 3.1 Measured quality parameters of irrigation water supplied and prepared from Texas A&M University RELLIS Campus sources and applied in tomato plant cultivation expressed by descriptive statistics

Analyte	T	Mean	SD	SE	Min	Max
pH						
	T_0	8.51	0.20	0.04	8.10	8.97
	T_1	8.25	0.19	0.04	7.96	8.65
	T_2	8.78	0.66	0.14	8.04	10.90
	T_3	8.97	0.84	0.18	8.00	11.71
	T_4	9.10	0.97	0.20	7.72	12.09
	T_5	9.19	1.09	0.23	7.39	12.32
EC						
(µS/cm)	T_0	916	66	14	827	1,029
	T_1	1,822	290	61	1,325	2,281
	T_2	1,777	281	59	1,250	2,402
	T_3	1,733	387	81	1,175	2,879
	T_4	1,708	553	115	1,072	3,381
	T_5	1,642	723	151	765	3,888
TDS						
(mg/L)	T_0	458	33	7	414	514
	T_1	911	146	30	663	1,141
	T_2	889	141	29	625	1,201
	T_3	867	194	40	588	1,440
	T_4	854	276	58	536	1,689
	T_5	821	361	75	384	1,942

T: Treatment, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, EC: Electrical Conductivity, TDS: Total Dissolved Solids

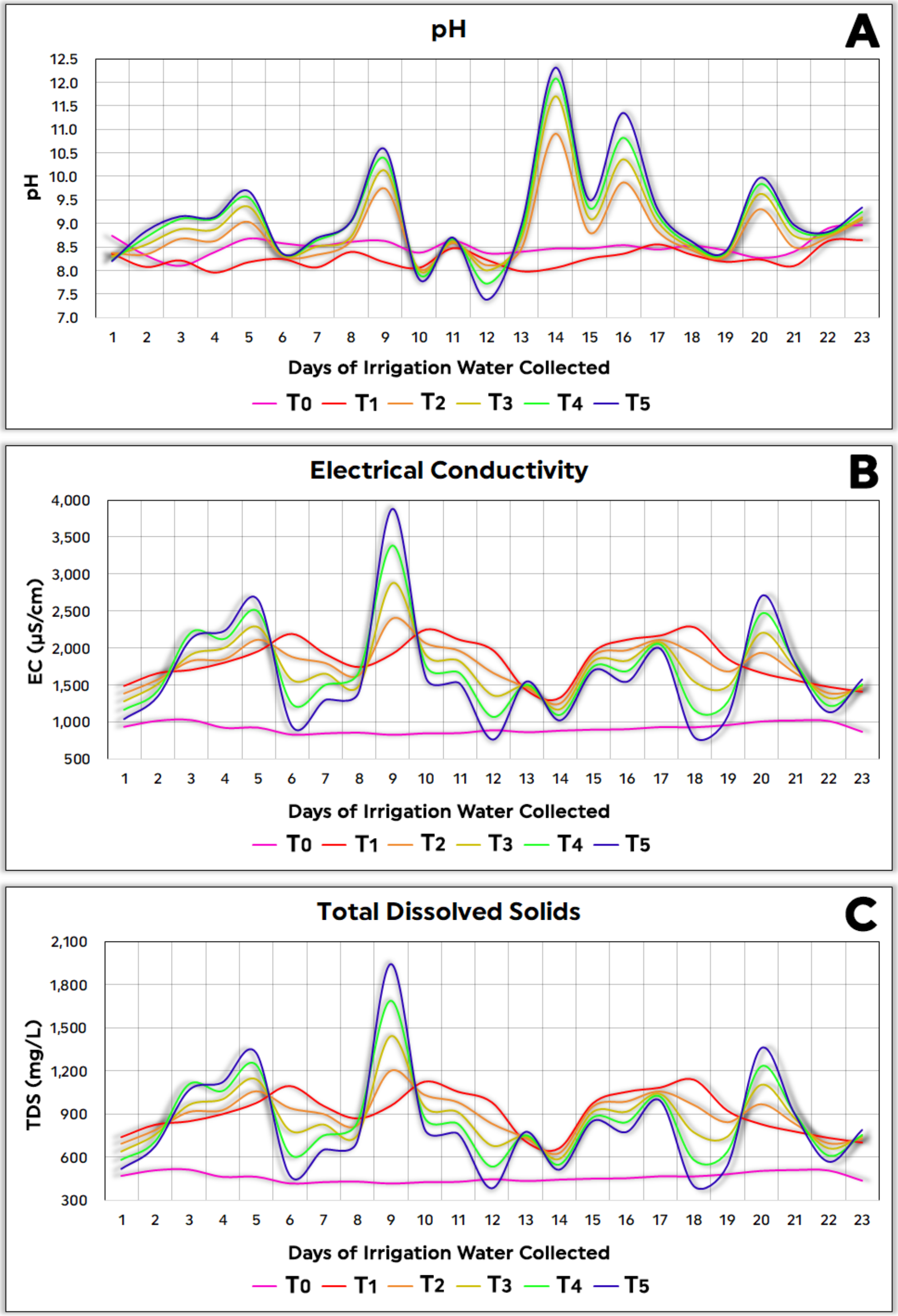

Figure 3.1 Changes in measured quality parameters of irrigation water supplied from Texas A&M University RELLIS Campus and applied in tomato plant cultivation

3.3. Soil Properties

Tables 3.3, 3.4, and 3.5 show summary statistics for soil pH, electrical conductivity (EC), nitrate-nitrogen (NO_3-N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), exchangeable sodium percentage (ESP), and organic matter (OM). One-way ANOVA results for soil pH, EC, NO_3-N, P, K, Ca, Mg, Na, ESP, and OM are given in Tables 3.6 and 3.7. Analysis results of initial and final physical-chemical characteristics of soil used in this study are given graphically in Figures 3.2 and 3.3.

Soil pH values shifted in each irrigation treatment according to the initial value after four months of cultivation. For example, pH in T_1 (8.17) increased over time while T_2 (8.03) only slightly increased. T_3 (8.23) and T_5 (8.43) significantly increased compared to the initial value (7.50). Table 3.3 and Figure 3.2-A shows soil pH changes for all treatments. According to the soil pH results, average soil pH values varied between 7.97 and 8.43 and were classified as “moderately alkaline” [79]. It has been reported that low-quality water such as wastewater may cause increases in soil pH [80]. It was observed that as the treatment ratio of the water applied to the soil decreases, the soil pH values increase. This is important for subsequent crops and cropping cycles. Due to high concentrations of ammonium in wastewater, soils that are irrigated with it also tend to have high concentrations of ammonium. The accumulation of ammonium in soils over time, as well as nitrification, which is a source of hydrogen ions, may cause an increase in pH [81], [82]. A comparison of soil pH using one-way ANOVA indicated no statistically significant difference among treatments ($F_{5, 12}$ = [2.526], P = 0.087, Table 3.6).

The soil electrical conductivity (EC) before and after tomato cropping is given in Table 3.3. Analyzed soil samples showed that EC was affected by water treatments. The maximum EC was 1620 µS/cm, the minimum EC was 345 µS/cm, which are at levels not harmful to tomatoes. According to the soil salinity classification, EC values of the soils in this study were classified as "normal" (0-4,000 µS/cm, pH < 8.50) [83], [84]. Three observations can be made from the data in Table 3.3 and Figure 3.2-B. First, relatively high levels of salinity exist in the soils where the treatment concentration was low. Second, according to the results, a one-way ANOVA revealed a significant difference in mean soil EC results between at least five groups ($F_{5, 12}$ = [5.445], P = 0.008, Table 3.6). Tukey's HSD test for multiple comparisons found that the mean values of soil EC were significantly different between T_0 and T_4 (p = 0.019, 95% C.I. = [-1,651.27, -132.06], 99% C.I. = [-1867.30, 83.96]) and T_1 and T_4 (p = 0.022, 95% C.I. = [-1,628.61, -109.39], 99% C.I. = [-1844.63, 106.63], Table C.2). Third, the future applicability of irrigating the soil with water, as saline as T_3 and T_4 treatments, should be considered. Furthermore, many studies reveal that low-quality and salty water such as wastewater significantly affect the properties of soils and increase the salt content of soils, similar to the results obtained in this study [85], [86], [87], [88].

Nitrate-nitrogen (NO_3-N) contents in the analyzed soils range from 44 to 146 mg/kg. It can be seen from the data in Table 3.3 and Figure 3.2-C that GW (T_0) and MBR (T_1) irrigation have no notable effect on the NO_3-N contents of the soil, which was a finding consistent with Arcak [90] and Saltali [91]. However, the NO_3-N contents are higher in the soils irrigated with T_2, T_3, T_4, and T_5 than T_0 and T_1. One of the main reasons for the presence of NO_3-N in the soil was that the wastewater source was industrial and contains plenty of nitrogen [89], [90]. Moreover, the content of NO_3-N in T_0 soil was remarkable as the only treatment with a decrease compared to T_I among treatments. Additionally, comparing soil NO_3-N contents using ANOVA, no statistically significant differences were detected ($F_{5, 12}$ = [2.483], P = 0.091, Table 3.6).

Phosphorus (P) contents of the soil used in this study are shown in Table A.1 and ranged from 374 to 433 mg/kg. As shown from Table 3.3 and Figure 3.2-D, phosphorus content was approximately 13.5% lower in T_4 and T_5 treatment compared to T_0 treatment; however, this difference was less than 5% in T_1 treatment.

The main sources of phosphorus in wastewater are human feces, household detergents containing phosphorus, and some industrial and commercial wastes [90]. Phosphorus, a nutritional factor, may contribute to the degradation of surface and groundwater resources. In addition, since the wastewater used in this study was industrial, the amount of soil phosphorus increased as a result of all treatments compared to its initial condition. The content of phosphorus increases as the treated water concentration in the applied water increases. Additionally, no statistically significant difference was detected through the ANOVA comparison ($F_{5, 12}$ = [0.257], P = 0.928, Table 3.6).

Calcium (Ca) not only protects plants against heat stress but also affects fruit quality and significantly reduces phosphorus availability [91]. Furthermore, it may prevent the soil structure from being damaged by replacing the adsorbed sodium. The most common symptoms of calcium deficiency are leaf tip burns and fruit damage.

Table A.1 and Figure 3.2-E show that the exchangeable calcium content in this study ranged from 4.827 to 5.061 mg/kg. Comparing the calcium content present in the soil before planting with the calcium content at the end of this study, the content of calcium in all treatments decreased between 31.2 % and 34.4 %. There were no significant differences between the treatments. No statistically significant difference was detected in the mean content of exchangeable Ca through the ANOVA comparison ($F_{5, 12}$ = [1.305], P = 0.325, Table 3.6).

Magnesium (Mg), which is necessary for the leaves to take on their green color, is the power required for photosynthesis in plants [92]. In magnesium deficiency, leaves may often appear purple, red, or brown in color. If there is a high potassium (K) content in the soil, plants may absorb it instead of magnesium, leading to a deficiency. Eventually, if the deficiency might not be eliminated and controlled, the leaves and the plant may die.

Table A.1 and Figure 3.2-F show that the content of exchangeable magnesium varied between 161 and 199 mg/kg. It can be seen from the data in Table A.1 that the highest decrease in the soil was in the RWW (T_0) with 34.8 %, while the lowest decrease was in the GW (T_0) with 19.4 % at the end of this study. There were no significant differences observed between the treatments. Additionally, there was no statistically significant difference in the mean content of exchangeable Mg through the ANOVA comparison ($F_{5, 12}$ = [2.598], P = 0.081, Table 3.6). Furthermore, Tukey's HSD test for multiple comparisons found that the mean content of exchangeable magnesium was significantly different between T_0 and T_5 (p = 0.045, 95% C.I. = [0.72, 75.95], 99% C.I. = [-9.98, 86.65], Table C.6)

Potassium (K), necessary for plant growth, helps plants use water, resist drought, and improve fruits and vegetable quality [93]. It also encourages well-developed flowers and strong stems. Plant growth, root development, and seed-fruit development are generally reduced in potassium-deficient plants. The most apparent symptoms are the curling of the leaf tips or the appearance of purple spots on the undersides of the leaves.

Exchangeable potassium contents varied from 119 to 144 mg/kg. It can be seen from the data in Table A.1 and Figure 3.3-G that the highest content of exchangeable K was measured in the T_4 treatment with 144 mg/kg, and the T_3 treatment was very approximate to the T_4 treatment with 143 mg/kg among the treatments. Additionally, while T_2 treatment had the least content of K with 119 mg/kg, it was found to be less than T_4 by 12.5%. Considering the mean content of exchangeable K, no statistically significant difference was detected through the ANOVA comparison ($F_{5, 12}$ = [2.113], P = 0.134, Table 3.7).

Sodium (Na) ions are generally considered as waste ions that plants might not require [94]. However, some studies show that plants may use this element, albeit in small contents. Studies also state that Na may be used as a partial substitute for K in some plants. An excess of Na, similar to micronutrient toxicities, occurs as necrosis or scorch on the leaf tips and margins.

Table A.1 and Figure 3.3-H show that the content of exchangeable Na varied between 7.7 and 11.7 mg/kg. It can be seen from the data in Table A.1 that the highest decrease in the soil was in the RWW (T_0) with 34.8 %, while the lowest decrease was in the GW (T_0) with 19.4 % at the end of this study. Considering the exchangeable Na content before the planting started, the decrease in the exchangeable Na content shows that the plants use Na, parallel to other studies [94]. There were no significant differences between the treatments. Additionally, there was no statistically significant difference in the mean content of exchangeable Mg through the ANOVA comparison ($F_{5, 12}$ = [0.630], P = 0.681, Table 3.7). The exchangeable sodium percentage (ESP) value in the soil used varied 14.6-21.7 % (Table 3.5 and Figure 3.3-I). The highest ESP value was determined in the T_0 treatment and the lowest in the T_3 treatment. There was no statistically significant difference in mean values of ESP through the ANOVA comparison ($F_{5, 12}$ = [0.624], P = 0.685, Table 3.7).

Examining the contents of Ca, Mg, K, and Na in the soil used in this study, there were no significant differences between the treatments. According to the FAO classification [95], exchangeable calcium contents in the soil were in the “high” group in all treatments, exchangeable magnesium contents were in the “medium” group in all treatments, exchangeable potassium contents were in the “medium” group in T_3 and T_4 applications, while other treatments (i.e., T_0, T_1, T_2, T_5) were in the “low” group (Table 3.4).

Some studies show that the content of potassium in the soil has decreased compared to the initial condition of soils [96], [97], [98].

Demirtas [99] indicated in his studies that the content of potassium in the soil was sufficient when the municipal wastewater was applied as irrigation water, and there were no statistically significant differences. The exchangeable sodium content increased compared to the initial condition of soils, and accordingly, it was observed that ESP increased. However, a decrement in sodium contents and ESP values was observed in the second year of this study. Abdelrahman et al. [49] found that the content of exchangeable sodium decreased, and ESP decreased accordingly. Moreover, they observed that wastewater causes a decrement in the contents of Ca, Mg, and K in the soil. On the other hand, Cicek [100] stated that wastewater has an effect on the exchangeable Ca, Mg, K, and Na of soils and increases the contents of these macronutrients in the soil.

Table 3.2 Food and Agricultural Organization (FAO) classification of macronutrient contents (in mg/kg) in five classes

Class		Potassium	Calcium	Magnesium
1	Very Low	< 50	< 380	< 50
2	Low	50 - 140	380 - 1150	50 - 160
3	Medium	141 - 370	1151 - 3500	161 - 480
4	High	371 - 1000	3501 - 10000	481 - 1500
5	Very High	> 1000	> 10000	> 1500

Considering the organic matter content of the soil, it can be seen from the data in Table A.1 and Figure 3.3-J that organic matter varies between 1.76 and 2.37%. According to the organic matter content of the soil, the soils used for T_0 and T_1 treatments were classified as "moderate" while the other treatments (i.e., T_2, T_3, T_4, and T_5) were classified as "low" [101]. It has been determined that the content of organic matter in soils irrigated with wastewater for many years has increased [96]. A one-way ANOVA revealed that there was a statistically significant difference in mean values of soil organic matter content between at least five groups ($F_{5, 12}$ = [3.377], P = 0.039, Table 3.7). Additionally, Tukey's

HSD test for multiple comparisons found that the mean value of soil organic matter content was significantly different between T_0 and T_5 ($p = 0.036$, 95% C.I. = [0.000, 0.012], 99% C.I. = [-0.001, 0.014], Table C.10).

Table 3.3 Analysis results of pH, EC (µS/cm), NO_3-N (mg/kg), and P (mg/kg) of soil used in this study expressed by descriptive statistics

Analyte	T	Mean	SD	SE	Min	Max
pH						
	T_0	7.97	0.12	0.07	7.90	8.10
	T_1	8.17	0.15	0.09	8.00	8.30
	T_2	8.03	0.15	0.09	7.90	8.20
	T_3	8.23	0.15	0.09	8.10	8.40
	T_4	8.17	0.32	0.19	7.80	8.40
	T_5	8.43	0.06	0.03	8.40	8.50
EC						
	T_0	401	70	41	345	480
	T_1	424	69	40	350	488
	T_2	891	212	122	701	1,120
	T_3	1,148	478	276	664	1,620
	T_4	1,293	292	169	988	1,570
	T_5	1,015	303	175	705	1,310
NO_3-N						
	T_0	44	15	8	29	58
	T_1	60	17	10	41	71
	T_2	124	31	18	90	151
	T_3	135	43	25	88	172
	T_4	146	95	55	77	254
	T_5	110	20	12	87	122
P						
	T_0	433	23	13	411	456
	T_1	412	7	4	406	419
	T_2	399	92	53	322	501
	T_3	400	84	49	307	472
	T_4	374	116	67	245	471
	T_5	375	76	44	316	461

T: Treatment, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, EC: Electrical Conductivity, NO_3-N: Nitrate Nitrogen, P: Phosphorus

Table 3.4 Analysis results of Ca (mg/kg), Mg (mg/kg), K (mg/kg), and Na (mg/kg) of soil used in this study expressed by descriptive statistics

Analyte	T	Mean	SD	SE	Min	Max
Ca						
	T_0	5,053	228	131	4,791	5,201
	T_1	5,061	142	82	4,975	5,225
	T_2	4,890	165	95	4,715	5,042
	T_3	5,021	79	46	4,970	5,112
	T_4	4,903	162	94	4,768	5,083
	T_5	4,827	43	25	4,781	4,865
Mg						
	T_0	199	25	14	174	224
	T_1	173	3	2	170	176
	T_2	171	11	6	158	179
	T_3	176	10	6	165	184
	T_4	172	15	9	157	187
	T_5	161	7	4	153	167
K						
	T_0	136	24	14	112	160
	T_1	123	5	3	120	129
	T_2	119	15	9	107	136
	T_3	143	4	3	140	148
	T_4	144	4	2	139	147
	T_5	132	2	1	130	133
Na						
	T_0	8	4	2	4	12
	T_1	10	4	3	7	15
	T_2	8	2	1	6	10
	T_3	12	4	2	8	15
	T_4	10	2	1	8	11
	T_5	9	3	2	7	12

T: Treatment, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, Ca: Calcium, Mg: Magnesium, K: Potassium, Na: Sodium

Table 3.5 Analysis results of ESP (%) and OM (%) of soil used in this study expressed by descriptive statistics

Analyte	T	Mean	SD	SE	Min	Max
ESP						
	T_0	0.146	0.069	0.040	0.079	0.216
	T_1	0.187	0.083	0.048	0.133	0.283
	T_2	0.147	0.038	0.022	0.120	0.191
	T_3	0.217	0.062	0.036	0.151	0.275
	T_4	0.185	0.032	0.018	0.154	0.217
	T_5	0.176	0.053	0.031	0.136	0.236
OM						
	T_0	0.024	0.005	0.003	0.020	0.029
	T_1	0.020	0.002	0.001	0.019	0.022
	T_2	0.019	0.002	0.001	0.017	0.021
	T_3	0.018	0.001	0.000	0.018	0.019
	T_4	0.018	0.001	0.000	0.018	0.019
	T_5	0.018	0.001	0.000	0.017	0.018

T: Treatment, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, ESP: Exchangeable Sodium Percentage, OM: Organic Matter

Table 3.6 One-way ANOVA results of pH, EC, NO_3-N, P, Ca, and Mg of soil used in this study

Analyte		Sum of Squares	dF	Mean Squares	F	Sig
pH	Between G	0.40	5	0.080	2.526	0.087
	Within G	0.38	12	0.032		
	Total	0.78	17			
EC	Between G	2,088,589	5	417,718	5.445	0.008**
	Within G	920,560	12	76,713		
	Total	3,009,149	17			
NO_3-N	Between G	26,152	5	5,230	2.483	0.091
	Within G	25,281	12	2,107		
	Total	51,432	17			
P	Between G	7,602	5	1,520	0.257	0.928
	Within G	70,961	12	5,913		
	Total	78,562	17			
Ca	Between G	145,204	5	29,041	1.305	0.325
	Within G	267,105	12	22,259		
	Total	412,309	17			
Mg	Between G	2,443	5	489	2.598	0.081
	Within G	2,257	12	188		
	Total	4,701	17			

df: Degree of Freedom, Sig: Significance, G: Group EC: Electrical Conductivity, NO_3-N: Nitrate-Nitrogen, P: Phosphorus, Ca: Calcium, Mg: Magnesium
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table 3.7 One-way ANOVA results of K, Na, ESP, and OM of soil used in this study

Analyte		Sum of Squares	dF	Mean Squares	F	Sig
K	Between G	1,520	5	304	2.113	0.134
	Within G	1,727	12	144		
	Total	3,248	17			
Na	Between G	32	5	6	0.630	0.681
	Within G	122	12	10		
	Total	154	17			
ESP	Between G	0.01	5	0.002	0.624	0.685
	Within G	0.04	12	0.003		
	Total	0.05	17			
OM	Between G	0.000081	5	0.000016	3.377	0.039*
	Within G	0.000057	12	0.000005		
	Total	0.000138	17			

df: Degree of Freedom, Sig: Significance, G: Group K: Potassium, Na: Sodium, ESP: Exchangeable Sodium Percentage, OM: Organic Matter
*, ** significant at 0.05 and 0.01 probability levels, respectively.

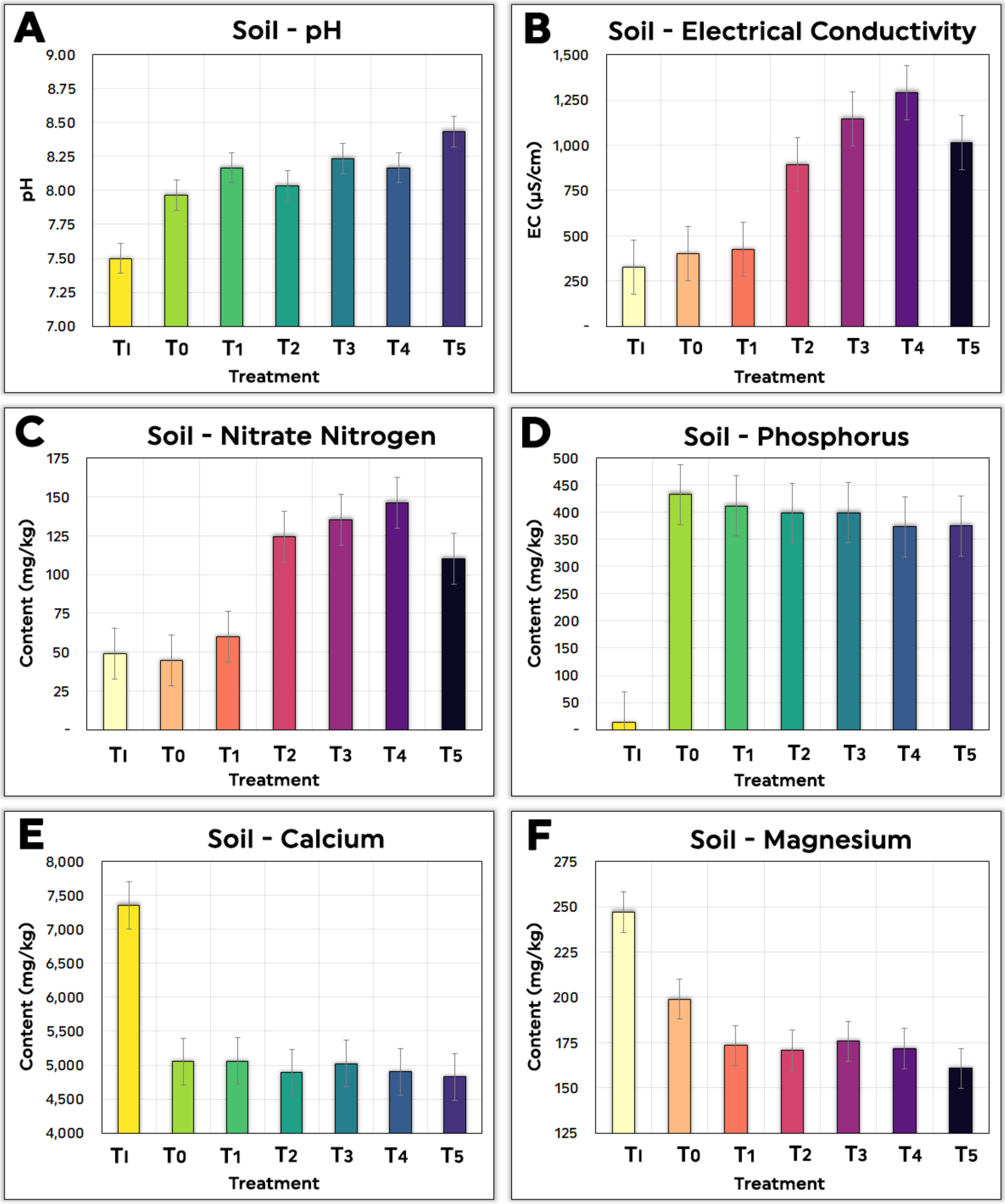

Figure 3.2 Analysis results of initial and final physical-chemical characteristics of soil used in this study. A) pH, B) Electrical Conductivity, C) Nitrate-Nitrogen, D) Phosphorus, E) Calcium, F) Magnesium

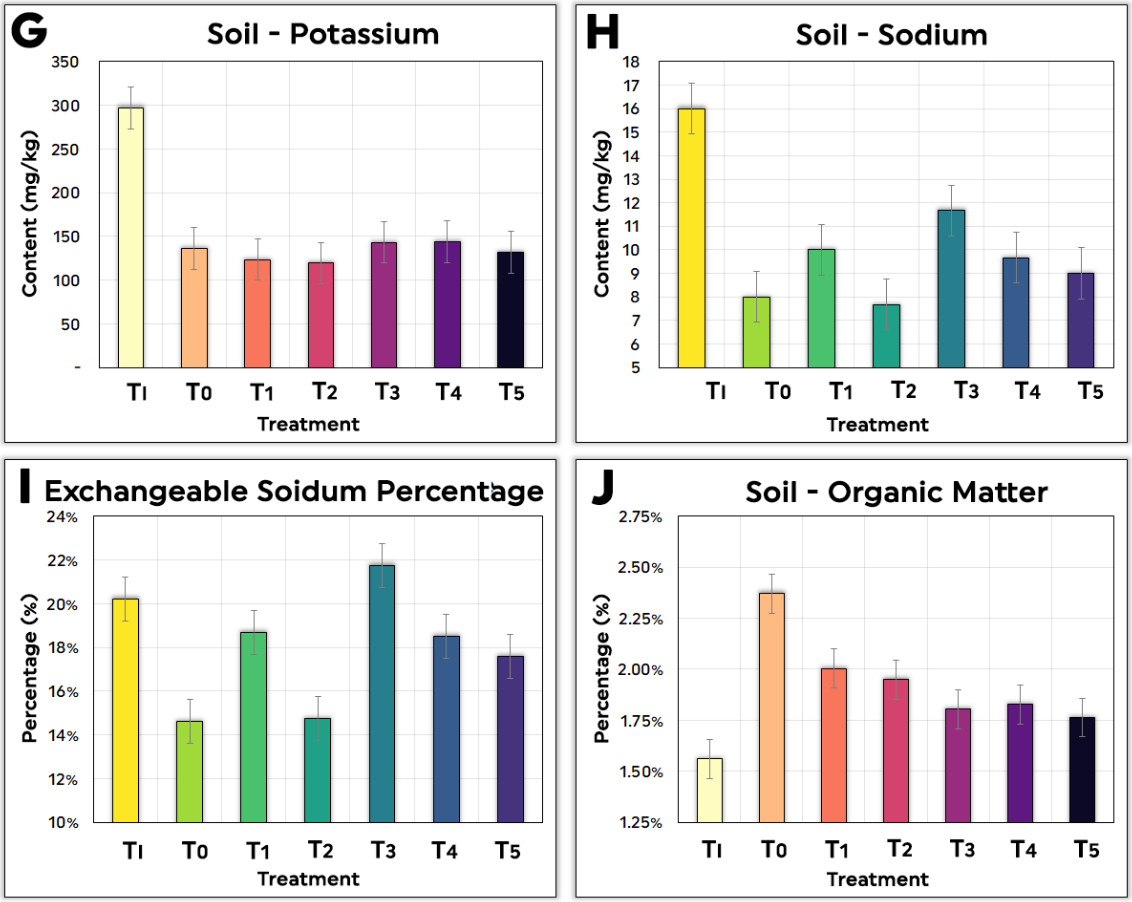

Figure 3.3 Analysis results of initial and final physical-chemical characteristics of soil used in this study. G) Potassium, H) Sodium, I) Exchangeable Sodium Percentage, J) Organic Matter

3.4. Plant Measurement

3.4.1. Plant and Fruit Measurements

Many studies show that wastewater applications have positive effects on the yield and quality parameters of plants [46], [51], [102]. Zavadil [103] reported that the vegetable yield decreases as the treatment level increases using wastewater as irrigation at different treatment levels. Shahalam [85] obtained the highest yield of tomato in wastewater with fertilization application, secondly in clean water with fertilization application, and in third and fourth place from wastewater and clean water applications, respectively.

During and after this study carried out between March and June, average fruit wet-dry weight, average fruit length-width, harvested fruit number and weight per plant, plant parts' (i.e., root, crown, lower stem, upper stem, leaf, truss) dry-wet weight and plant height were determined (Tables A.7, A.8, A.9, A.10, A.11, A.12, A.13, A.14, A.15, and A.16). Tables 3.8, 3.9, 3.10, 3.11, and 3.12 illustrate the statistical description of average fruit wet-dry weight, average fruit length-width, harvested fruit number and weight per plant, plant height, plant parts' (i.e., root, crown, lower stem, upper stem, leaf, truss) dry-wet weight. One-way ANOVA results are given in Tables 3.13, 3.14, and 3.15. Additionally, all results are shown graphically in Figures 3.4, 3.5, and 3.6.

In this study, average wet fruit weights vary 58.4 - 83.7 g, while average dry fruit weights vary 4.52 - 5.96 g (Table 3.8). The highest average wet-dry weights were observed in the T_5 treatment, and the lowest average wet-dry weights were observed in the T_1 treatment. No statistically significant difference in mean values of average wet weights and average dry weights were detected through the ANOVA comparison (for average wet weights $F_{5, 12}$ = [1.649], P = 0.221, for average dry weights $F_{5, 12}$ = [1.113], P = 0.404, Table 3.13). Ozkan [104] reported the average fruit wet weight between 90.47 - 136.14 g. Ates [105] found the average wet fruit weight between 111 - 209 g in his study. Al-Lahham et al. [41] stated the highest tomatoes were in wastewater applications considering the wet weight in tomatoes, and this could be caused by plant nutrients found in wastewater.

It can be seen from the data in Table 3.8 that the average fruit length varies 44.4 - 49.7 mm, while the average fruit width varies 49.7 - 55.6 mm. The highest average fruit length and width were found in T_0 and T_4 treatments, respectively, and the lowest average fruit length and width were found in T_1 and T_2 treatments, respectively (Figure 3.4-C and 3.4-D). There was no statistically significant difference in mean values of average fruit length and average fruit width through the ANOVA comparison (for average fruit length $F_{5, 12}$ = [0.888], P = 0.519, for average fruit width $F_{5, 12}$ = [1.845], P = 0.178, Table 3.13). Ates [105] found the average fruit width between 62.0 - 93.0 mm in his study. Ozkan [104] determined the average fruit width between 32.7 - 51.3 mm. Al-Lahham et al. [41], Maurer et al. [106], and Neilsen et al. [107] reported that wastewater increased fruit width in plants. Ates [105] determined the fruit length between 47.6 - 60.0 mm in his study. Ozkan [104] found the fruit length between 42.4 - 63.5 mm.

The average tomato yield and tomato fruit weight per plant for this study are given in Table 3.9. Tomato yield was not significantly different among treatments (Figure 3.4-E and 3.4-F). Among treatments, the average tomato yield order was $T_1 = T_3 > T_2 = T_4 > T_5 > T_0$. The fruit per plant varies between 8 to 15. The most harvested plants were in T_1 and T_3 treatments with 15 fruits, while the least harvested plants were in T_0 treatment with eight fruits. The fruit weight per plant varies 568.8 - 1142.7 g, the highest fruit weight was found in the T_4 treatment, and the lowest fruit weight was found in the T_0 treatment. There was no statistically significant difference in mean values of average fruit per plant and average fruit weight per plant through the ANOVA comparison (for fruit per plant $F_{5, 12}$ = [0.533], P = 0.747, for fruit weight per plant $F_{5, 12}$ = [0.643], P = 0.672, Table 3.13). Ates

[105] found that treated wastewater increased the number of fruits more than clean water in all applications in his study. It was stated that this increase was due to the higher plant growth parameters in applications irrigated with treated wastewater. Additionally, the number of fruits per plant was between 12 - 50 in his study.

Plant height values are given in Table 3.12 and are graphically displayed in Figure 3.6-Q. The results show that the average final plant heights for all treatments were 152.2, 161.7, 165.9, 179.9, 161.7, 171.5 cm for T_0, T_1, T_2, T_3, T_4, and T_5, respectively. The tallest plant height was in the T_5 treatment (210.8 cm), while the shortest plant height occurred in the T_1 treatment (134.6 cm). The effects of wastewater on growth characteristics were found significant at treatments. The increase in wastewater ratio increased the growth characteristics of all plants compared to plants' growth in groundwater (T_0). There was no statistically significant difference in the mean values of plant height through the ANOVA comparison ($F_{5, 12}$ = [0.494], P = 0.775, Table 3.15).

When the wet weights of the parts of the plants were compared to the control treatment (T_0), an increment of 116% and 57% were observed in the root part with T_1 and T_5 treatments, respectively, while a 20% decrement was observed with T_3 treatment (Table 3.9 and Figure 3.5-G). Additionally, the highest increase in the crown (121 %) and truss (211 %) parts were recorded with the T_4 treatment (Table 3.10 and 3.12, Figure 3.5-I), the highest growth in the upper stem (36 %) and leaf (21 %) parts were recorded with the T_3 treatment (Table 3.11, Figures 3.6-M, and 3.6-O). A decrement in the lower stem part was observed in all treatments, except T_2 (0.04 %). The highest decrease was observed with T_4 (35.77 %) treatment (Table 3.10 and Figure 3.5-K). There was no statistically significant difference in mean values of root wet weight, lower stem wet weight, upper stem wet weight, leaf wet weight, and truss wet weight (for root wet weight $F_{5, 12}$ = [2.520], P = 0.088, for lower stem wet weight $F_{5, 12}$ = [2.573], P = 0.083, for upper stem wet weight $F_{5, 12}$ = [2.344], P = 0.105, for leaf wet weight $F_{5, 12}$ = [0.795], P = 0.605, for truss wet weight $F_{5, 12}$ = [NA], P = NA, Tables 3.14 and 3.15).

Comparing the dry weights of the parts of the plants to the control treatment (T_0), an increment of 36%, 7%, and 6% were observed in the root part with T_1, T_5, and T_4 treatments, respectively, while 18% decrement was observed with T_3 treatment (Table 3.9 and Figure 3.5-H). Moreover, the highest increase in the crown (91 %) and truss (210 %) parts were recorded with the T_4 treatment (Tables 3.10 and 3.12, Figure 3.5-J). Additionally, the highest increase in the upper stem part (27 %) was recorded with the T_3 treatment, and the highest growth in the leaf part (13 %) was observed with the T_5 treatment (Table 3.11, Figure 3.6-N and 3.6-P). An increment in the lower stem part was observed in all treatments, except T_4 (13 %). The highest increase was observed with T_3 (19.2 %) treatment (Table 3.14 and Figure 3.5-L). There was no statistically significant difference in mean values of root wet weight, lower stem dry weight, upper stem dry weight, leaf dry weight, and truss dry weight (for root dry weight $F_{5, 12}$ = [1.280], P = 0.335, for lower stem dry weight $F_{5, 12}$ = [1.396], P = 0.294, for upper stem dry weight $F_{5, 12}$ = [1.469], P = 0.270, for leaf dry weight $F_{5, 12}$ = [0.795], P = 0.573, for truss dry weight $F_{5, 12}$ = [NA], P = NA, Table 3.14 and 3.15).

A one-way ANOVA revealed a statistically significant difference in mean values of crown part of plants’ wet-dry weight between at least five groups (for wet weigh $F_{5, 12}$

= [3.134], P = 0.049 for dry weight $F_{5, 12}$ = [4.048], P = 0.022, Table 3.14). Additionally, Tukey's HSD Test for multiple comparisons found the mean values of crown part of plants' wet weight to be significantly different between T_0 and T_4 (p = 0.038, 95% C.I. = [-6.28, -0.16], 99% C.I. = [-7.16, 0.72], Table C.19). Moreover, Tukey's HSD Test for multiple comparisons found the mean values of crown part of plants' dry weights to be significantly different between T_0 and T_4 (p = 0.020, 95% C.I. = [0.-2.67, -0.20] 99% C.I. = [-3.02, 0.15], Table C.20) and T_0 and T_5 (p = 0.047, 95% C.I. = [-2.48, 0.01], 99% C.I. = [-2.83, 0.34], Table C.20)

Kacar [108] stated that the higher height, stem diameter, and the number of leaves of the plants irrigated with treated wastewater applications may be due to the excess nitrogen and phosphorus content in the treated wastewater. Since nitrogen and phosphorus increase the growth and development of plants, it helps accelerate the plant's vegetative development.

Ekici [109] determined the amount of dry weight of tomato plants according to different periods and reported that the dry weight changed in each period. While the amount of dry weight in the leaf of the tomato plant varied between 9-14 % in the study conducted by De-Konning [110], it varied between 7.7-12.9 % in the study of Heuvelink [111]. Furthermore, Harssema [112] reported that seasonal changes were effective in addition to the application of wastewater on the changes in dry weight in tomato plants.

Table 3.8 Average fruit wet-dry weights (g), average fruit length-width measurements (mm) expressed by descriptive statistics

Analyte	Treatment	Mean	SD	SE	Min	Max
Average Fruit Wet Weight	T_0	70.5	3.27	1.89	66.8	73.1
	T_1	58.4	9.56	5.52	51.0	69.2
	T_2	64.8	8.86	5.12	55.7	73.4
	T_3	64.2	16.25	9.38	47.0	79.3
	T_4	81.5	6.05	3.49	76.8	88.3
	T_5	83.7	25.25	14.58	59.4	109.8
Average Fruit Dry Weight	T_0	5.06	0.36	0.21	4.66	5.34
	T_1	4.52	0.55	0.32	4.01	5.10
	T_2	4.89	1.05	0.61	4.23	6.10
	T_3	4.67	0.81	0.47	3.74	5.21
	T_4	5.79	0.81	0.47	4.86	6.29
	T_5	5.96	1.69	0.98	4.43	7.78
Average Fruit Length	T_0	49.7	2.38	1.37	47.9	52.4
	T_1	44.4	4.41	2.55	39.5	48.1
	T_2	48.1	1.87	1.08	46.6	50.2
	T_3	47.8	3.87	2.24	43.7	51.4
	T_4	49.4	4.35	2.51	45.2	53.9
	T_5	49.5	4.40	2.54	45.0	53.8
Average Fruit Width	T_0	50.4	1.67	0.96	49.1	52.3
	T_1	50.0	4.08	2.36	46.9	54.6
	T_2	49.7	2.94	1.70	46.5	52.3
	T_3	50.7	3.36	1.94	47.0	53.6
	T_4	55.6	0.57	0.33	55.1	56.2
	T_5	55.5	6.00	3.46	49.5	61.5

SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum

Table 3.9 Harvested fruit number and weight per plant (g), root dry-wet weight (g) expressed by descriptive statistics

Analyte	Treatment	Mean	SD	SE	Min	Max
Fruit Per Plant	T_0	2.67	1.15	0.67	2.00	4.00
	T_1	5.00	3.00	1.73	2.00	8.00
	T_2	4.67	3.06	1.76	2.00	8.00
	T_3	5.00	-	-	5.00	5.00
	T_4	4.67	0.58	0.33	4.00	5.00
	T_5	4.00	2.65	1.53	1.00	6.00
Weight Per Plant	T_0	189.6	89.1	51.4	133.6	292.3
	T_1	296.0	174.3	100.6	102.1	439.8
	T_2	284.7	150.9	87.1	146.9	446.0
	T_3	320.8	81.2	46.9	235.1	396.5
	T_4	380.9	62.2	35.9	317.2	441.5
	T_5	299.3	190.6	110.0	109.8	490.9
Root Wet Weight	T_0	2.34	0.28	0.16	2.02	2.57
	T_1	5.05	2.19	1.26	2.99	7.35
	T_2	2.40	0.71	0.41	1.79	3.18
	T_3	1.87	0.78	0.45	1.30	2.75
	T_4	2.89	1.27	0.73	1.46	3.88
	T_5	3.68	1.44	0.83	2.02	4.59
Root Dry Weight	T_0	1.81	0.26	0.15	1.56	2.08
	T_1	2.46	0.65	0.38	1.96	3.20
	T_2	1.62	0.24	0.14	1.42	1.89
	T_3	1.49	0.47	0.27	1.16	2.03
	T_4	1.93	0.73	0.42	1.13	2.55
	T_5	1.94	0.55	0.32	1.48	2.55

SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum

Table 3.10 Crown and lower stem dry-wet weight (g) expressed by descriptive statistics

Analyte	Treatment	Mean	SD	SE	Min	Max
Crown Wet Weight	T_0	2.66	0.74	0.43	2.03	3.48
	T_1	4.17	0.56	0.32	3.74	4.80
	T_2	4.24	1.14	0.66	3.08	5.36
	T_3	4.77	1.65	0.95	2.94	6.15
	T_4	5.88	0.73	0.42	5.16	6.61
	T_5	5.49	1.44	0.83	3.84	6.46
Crown Dry Weight	T_0	1.58	0.10	0.06	1.46	1.65
	T_1	2.17	0.36	0.21	1.79	2.50
	T_2	2.12	0.31	0.18	1.82	2.43
	T_3	2.51	0.53	0.31	1.90	2.91
	T_4	3.02	0.63	0.36	2.30	3.46
	T_5	2.83	0.55	0.32	2.24	3.34
Lower Stem Wet Weight	T_0	8.21	1.30	0.75	7.14	9.66
	T_1	8.02	1.15	0.66	6.77	9.02
	T_2	8.21	0.24	0.14	7.98	8.45
	T_3	7.96	1.86	1.07	6.74	10.10
	T_4	5.27	0.73	0.42	4.70	6.10
	T_5	7.92	1.46	0.84	6.48	9.39
Lower Stem Dry Weight	T_0	2.31	0.46	0.27	2.03	2.84
	T_1	2.41	0.44	0.25	2.00	2.87
	T_2	2.74	0.24	0.14	2.48	2.96
	T_3	2.75	0.43	0.25	2.29	3.15
	T_4	2.01	0.40	0.23	1.55	2.26
	T_5	2.71	0.59	0.34	2.29	3.38

SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum

Table 3.11 Upper stem and leaf dry-wet weight (g) expressed by descriptive statistics

Analyte	Treatment	Mean	SD	SE	Min	Max
Upper Stem Wet Weight	T_0	375.7	108.8	62.8	254.5	465.1
	T_1	409.8	54.3	31.3	366.7	470.7
	T_2	447.7	42.0	24.2	402.1	484.7
	T_3	511.0	36.2	20.9	469.7	536.9
	T_4	448.0	11.3	6.5	435.2	456.5
	T_5	382.5	41.1	23.7	353.5	429.5
Upper Stem Dry Weight	T_0	72.7	18.80	10.85	51.0	84.0
	T_1	76.9	10.96	6.33	66.2	88.1
	T_2	82.0	4.98	2.88	78.0	87.6
	T_3	92.7	1.34	0.78	91.7	94.2
	T_4	84.8	4.54	2.62	81.9	90.0
	T_5	83.6	7.67	4.43	78.3	92.4
Leaf Wet Weight	T_0	247.7	97.16	56.09	139.7	328.0
	T_1	254.2	22.99	13.27	240.3	280.7
	T_2	234.0	14.82	8.56	224.4	251.1
	T_3	299.0	35.89	20.72	258.3	326.0
	T_4	229.9	11.09	6.40	222.3	242.6
	T_5	262.3	58.89	34.00	206.3	323.7
Leaf Dry Weight	T_0	46.2	3.51	2.03	42.3	49.1
	T_1	44.2	3.29	1.90	42.2	48.0
	T_2	46.9	1.65	0.95	45.0	48.0
	T_3	50.4	1.97	1.14	48.6	52.5
	T_4	46.9	7.27	4.20	38.5	51.7
	T_5	52.1	10.53	6.08	40.2	60.1

SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum

Table 3.12 Truss dry-wet weight (g) and plant height expressed by descriptive statistics

Analyte	Treatment	Mean	SD	SE	Min	Max
Truss Wet Weight	T_0	2.23	NA	NA	2.23	2.23
	T_1	5.19	NA	NA	5.19	5.19
	T_2	5.54	NA	NA	5.54	5.54
	T_3	4.33	NA	NA	4.33	4.33
	T_4	6.94	NA	NA	6.94	6.94
	T_5	2.21	NA	NA	2.21	2.21
Truss Dry Weight	T_0	0.49	NA	NA	0.49	0.49
	T_1	1.12	NA	NA	1.12	1.12
	T_2	1.43	NA	NA	1.43	1.43
	T_3	1.18	NA	NA	1.18	1.18
	T_4	1.52	NA	NA	1.52	1.52
	T_5	0.52	NA	NA	0.52	0.52
Plant Height	T_0	152.2	9.0	5.2	146.7	162.6
	T_1	161.7	32.8	18.9	134.6	198.1
	T_2	165.9	15.5	9.0	152.4	182.9
	T_3	179.9	25.1	14.5	157.5	207.0
	T_4	161.7	7.4	4.3	156.2	170.2
	T_5	171.5	34.6	20.0	146.1	210.8

SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum

Table 3.13 One-way ANOVA results of average fruit wet-dry weight, average fruit length-width measurements, fruit and weight per plant

Analyte		Sum of Squares	dF	Mean Squares	F	Sig
Average Fruit Wet Weight	Between G	1,537.9	5	307.6	1.649	0.221
	Within G	2,237.7	12	186.5		
	Total	3,775.7	17			
Average Fruit Dry Weight	Between G	5.3	5	1.1	1.113	0.404
	Within G	11.4	12	1.0		
	Total	16.7	17			
Average Fruit Length	Between G	60.7	5	12.1	0.888	0.519
	Within G	164.0	12	13.7		
	Total	224.6	17			
Average Fruit Width	Between G	116.3	5	23.3	1.845	0.178
	Within G	151.4	12	12.6		
	Total	267.7	17			
Fruit Per Plant	Between G	12.0	5	2.4	0.533	0.747
	Within G	54.0	12	4.5		
	Total	66.0	17			
Weight Per Plant	Between G	57,820.7	5	11,564.1	0.643	0.672
	Within G	215,743.0	12	17,978.6		
	Total	273,563.7	17			

df: Degree of Freedom, Sig: Significance, G: Group

*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table 3.14 One-way ANOVA results of root, crown, and lower stem wet-dry weight

Analyte		Sum of Squares	dF	Mean Squares	F	Sig
Root Wet Weight	Between G	20.3	5	4.1	2.520	0.088
	Within G	19.3	12	1.6		
	Total	39.6	17			
Root Dry Weight	Between G	1.7	5	0.3	1.280	0.335
	Within G	3.2	12	0.3		
	Total	4.9	17			
Crown Wet Weight	Between G	19.6	5	3.9	3.134	0.049*
	Within G	15.0	12	1.2		
	Total	34.5	17			
Crown Dry Weight	Between G	4.1	5	0.8	4.048	0.022*
	Within G	2.4	12	0.2		
	Total	6.5	17			
Lower Stem Wet Weight	Between G	19.7	5	3.9	2.573	0.083
	Within G	18.4	12	1.5		
	Total	38.1	17			
Lower Stem Dry Weight	Between G	1.3	5	0.3	1.396	0.294
	Within G	2.3	12	0.2		
	Total	3.6	17			

df: Degree of Freedom, Sig: Significance, G: Group
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table 3.15 One-way ANOVA results of upper stem, leaf, and truss wet-dry weight and plant height

Analyte		Sum of Squares	dF	Mean Squares	F	Sig
Upper Stem Wet Weight	Between G	38,431.9	5	7,686.4	2.344	0.105
	Within G	39,344.9	12	3,278.7		
	Total	77,776.9	17			
Upper Stem Dry Weight	Between G	709.3	5	141.9	1.469	0.270
	Within G	1,159.1	12	96.6		
	Total	1,868.4	17			
Leaf Wet Weight	Between G	9,348.3	5	1,869.7	0.745	0.605
	Within G	30,132.6	12	2,511.0		
	Total	39,480.9	17			
Leaf Dry Weight	Between G	128.2	5	25.6	0.795	0.573
	Within G	387.0	12	32.2		
	Total	515.2	17			
Truss Wet Weight	Between G	17.9	5	3.6	NA	NA
	Within G	NA	NA	NA		
	Total	17.9	5			
Truss Dry Weight	Between G	1.0	5	0.2	NA	NA
	Within G	NA	NA	NA		
	Total	1.0	5			
Plant Height	Between G	1,347.8	5	269.6	0.494	0.775
	Within G	6,549.7	12	545.8		
	Total	7,897.5	17			

df: Degree of Freedom, Sig: Significance, G: Group, NA: Not Available
*, ** significant at 0.05 and 0.01 probability levels, respectively.

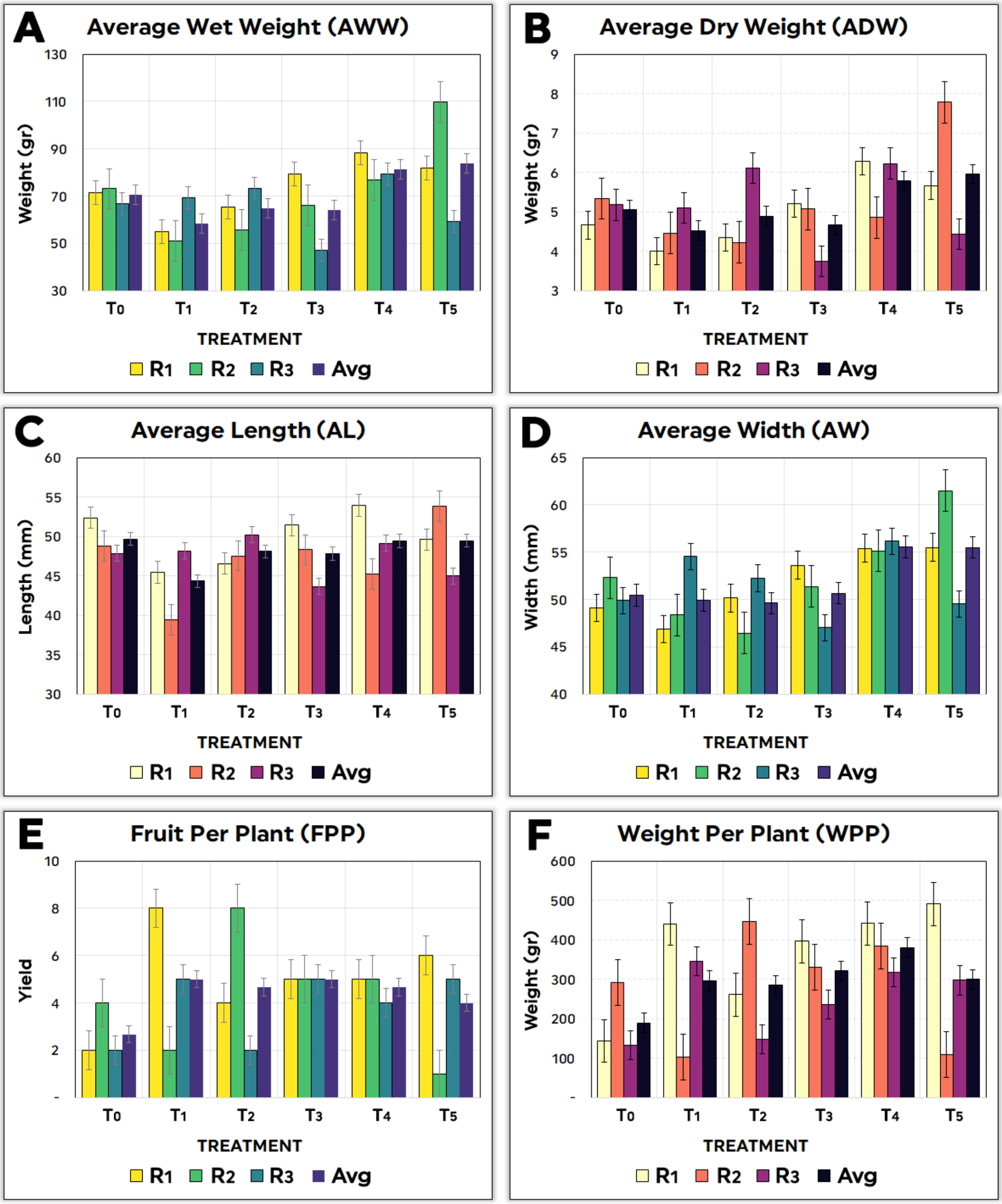

Figure 3.4 Fruit and plant parts measurements. A) Average fruit wet weights (AWW), B) Average fruit dry weights (ADW), C) Average fruit length (AL), D) Average fruit width (AW), E) Fruit per plant (FPP) F) Wet Weight per plant (WWPP)

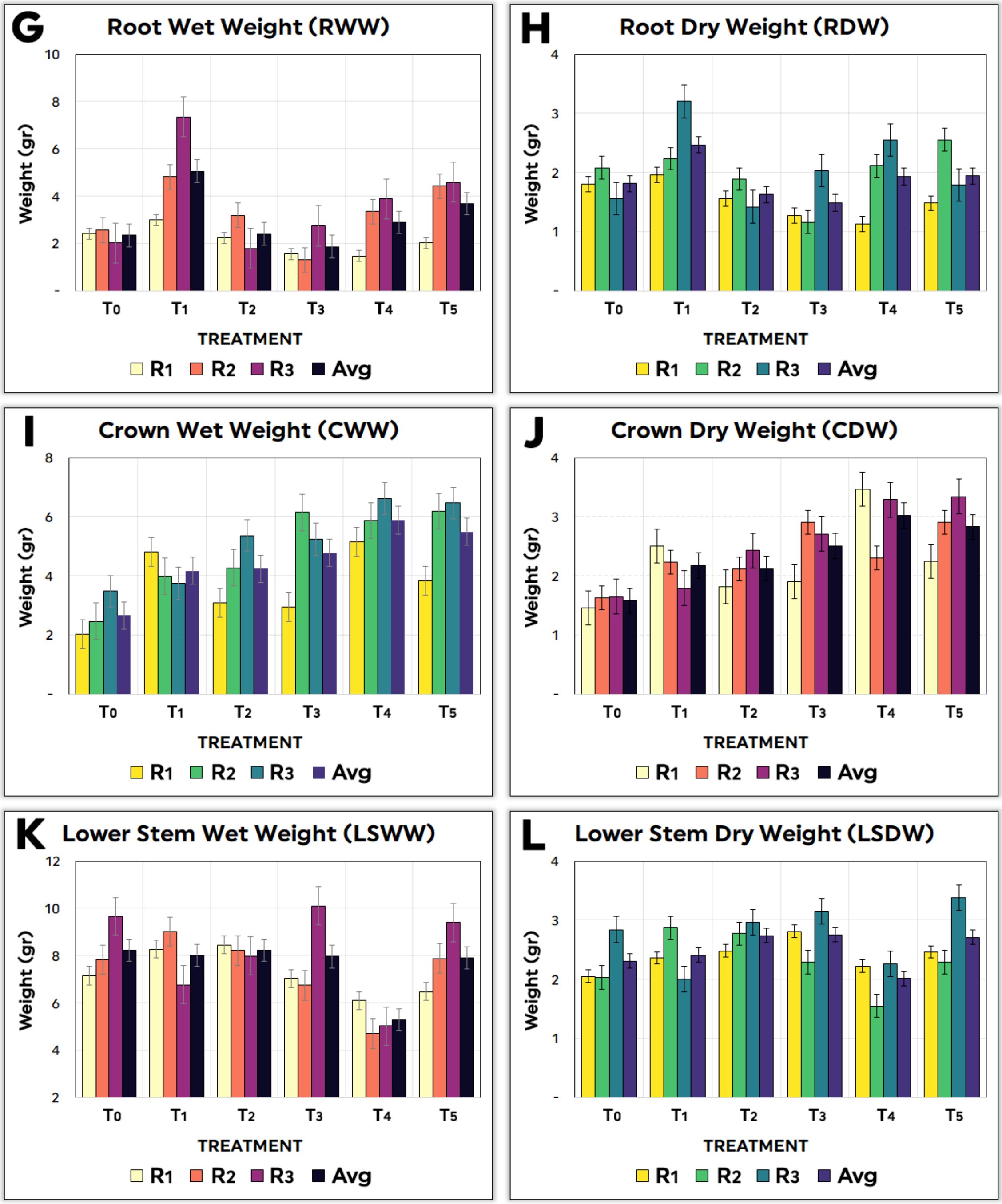

Figure 3.5 Plant parts measurements. G) Root wet weight (RWW), H) Root dry weight (RDW), I) Crown wet weight (CWW), J) Crown dry weight (CDW), K) Lower stem wet weight (SLWW) L) Lower stem dry weight (LSDW)

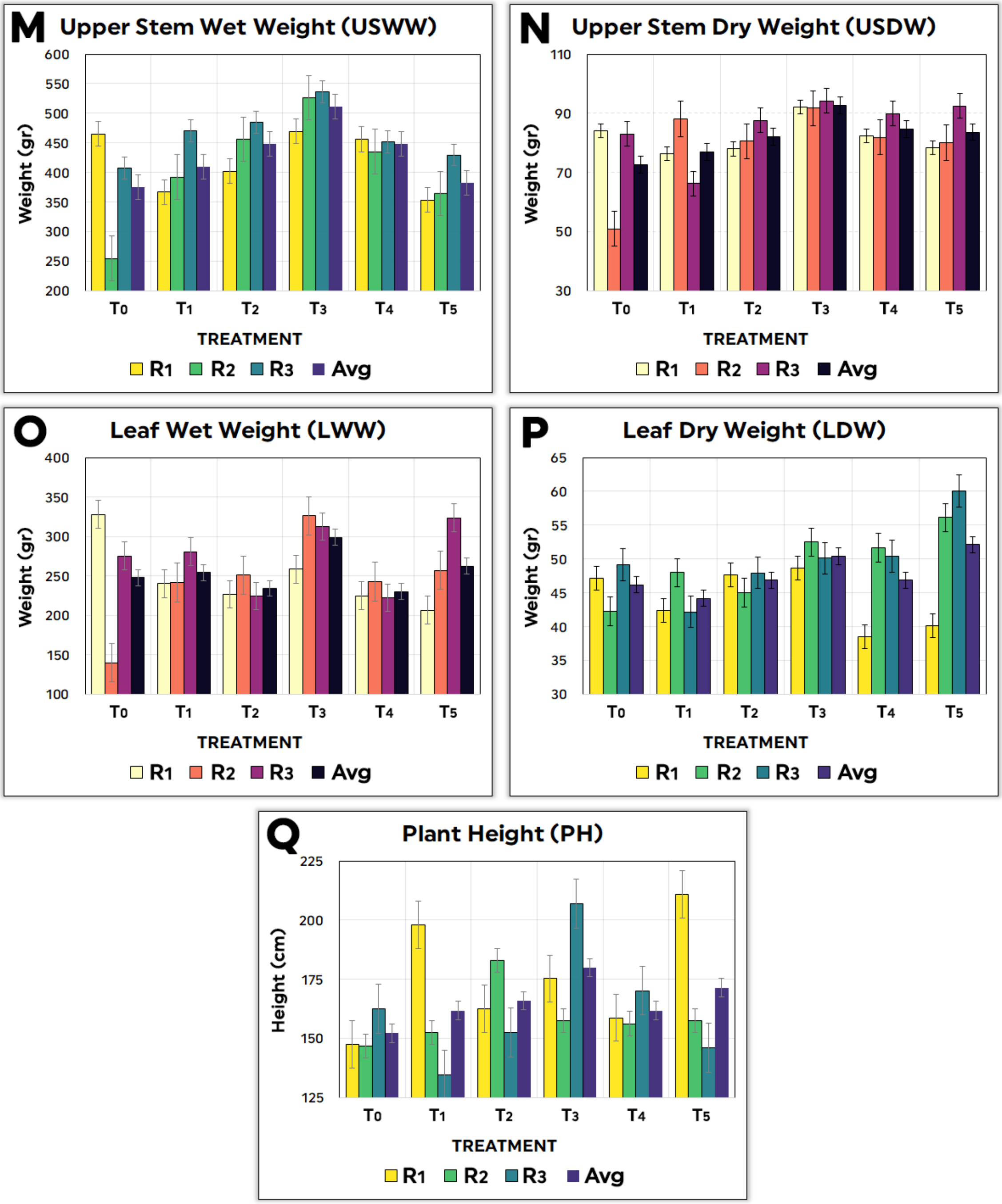

Figure 3.6 Plant parts measurements. M) Upper stem wet weight (USWW), N) Lower stem dry weight (LSDW), O) Leaf wet weight (LWW), P) Leaf dry weight (LDW), Q) Plant height (PH)

3.5. Heavy Metals

3.5.1. Heavy Metal Concentration Level in Water

Table 3.16 shows the permissible concentration levels of heavy metals for agricultural purposes that have been stipulated by EPA and FAO and measured heavy metal concentration levels of water applied. Moreover, Table 3.17 illustrates the statistical description of measured heavy metals concentration levels of treatment water. One-way ANOVA results of measured heavy metals concentration levels of water treatments are given in Table 3.18. Additionally, Figures 3.7, 3.8, and 3.9 show graphically the concentration levels of heavy metals in water samples collected from Texas A&M University RELLIS Campus.

For all the treatments, beryllium, cadmium, chromium, nickel, and selenium heavy metals were not detected. Cobalt was detected in five treatments, but not in T_0 treatment.

It can be seen from Table 3.16 that the recommended maximum limit for the long term of aluminum concentration is 5,000 μg/L (FAO/WHO); the aluminum concentration level of the water applied was detected between 18.38 - 92.61 μg/L (Figure 3.7-A), which shows that the level was considerably below the permissible limit. The increase in the raw wastewater content of the water was directly proportional to the aluminum concentration level. A one-way ANOVA revealed that there was a statistically significant difference in mean values of aluminum between at least five groups ($F_{5, 132}$ = [3.159], P = 0.010, Table 3.18). Additionally, Tukey's HSD test for multiple comparisons found that the mean value of aluminum was significantly different between T_0 and T_5 (p = 0.010, 95% C.I. = [-136.49, -11.95], 99% C.I. = [-148.24, -0.21], Table C.28).

Arsenic and cobalt concentration levels were measured noticeably below the permissible maximum limit (i.e., for arsenic 100 μg/L, for cobalt 50 μg/L). Arsenic concentration levels ranged between 0.22 and 5.99 μg/L (Figure 3.7-B), and cobalt concentration levels were detected between 0.16 and 0.52 μg/L (Figure 3.7-C). The concentration level of arsenic increased as the raw wastewater ratio increased, such as aluminum; contrarily, the concentration level of cobalt increased as the raw wastewater level decreased. There was no statistically significant difference in mean values of arsenic, whereas there was a statistically significant difference in mean values of cobalt between at least five groups (for arsenic $F_{5, 132}$ = [0.952], P = 0.450, cobalt $F_{5, 132}$ = [29.317], P = 0.000, Table 3.18). Additionally, Tukey's HSD test for multiple comparisons found that the mean value of cobalt was significantly different between T_0 and T_1 (p = 0.000, 95% C.I. = [-0.66, -0.38], 99% C.I. = [-0.69, -0.35]), T_0 and T_2 (p = 0.000, 95% C.I. = [-0.57, -0.29], 99% C.I. = [-0.59, -0.26]), T_0 and T_3 (p = 0.000, 95% C.I. = [-0.48, -0.20], 99% C.I. = [-0.51, -0.17]), T_0 and T_4 (p = 0.000, 95% C.I. = [-0.39, -0.11], 99% C.I. = [-0.42, -0.08]), T_0 and T_5 (p = 0.020, 95% C.I. = [-0.30 -0.02], 99% C.I. = [-0.33, 0.01]), T_1 and T_3 (p = 0.000, 95% C.I. = [0.04, 0.32], 99% C.I. = [0.01, 0.35]), T_1 and T_4 (p = 0.005, 95% C.I. = [0.13, 0.41], 99% C.I. = [0.10, 0.44]), T_1 and T_5 (p = 0.000, 95% C.I. = [0.22, 0.50], 99% C.I. = [0.19, 0.53]), T_2 and T_4 (p = 0.000, 95% C.I. = [0.04, 0.32], 99% C.I. = [0.01, 0.35]), T_2 and T_5 (p = 0.000, 95% C.I. = [0.13, 0.41], 99% C.I. = [0.10, 0.44]), and T_3 and T_5 (p = 0.005, 95% C.I. = [0.04, 0.32], 99% C.I. = [0.01, 0.35], Table C.30).

The copper concentration level for all applications was measured to be the closest to the permissible maximum limit (200 μg/L) for long term in comparison to other heavy metal concentration levels. The copper concentration level was detected between 6.34 and 165.05 μg/L (Figure 3.8-D); the copper concentration level in the groundwater (T_0, 115.61 μg/L) was approximately 18 times higher than the concentration level of the MBR-treated water (T_1, 6.34 μg/L). Moreover, iron concentration level, ranged between 2.30-160 μg/L (Figure 3.8-E), was detected as significantly below the permissible maximum limit (5,000 μg/L). There was a statistically significant difference in mean values of copper between at least five groups ($F_{5, 132}$ = [5.857], P = 0.000, Table 3.18). Additionally, Tukey's HSD test for multiple comparisons found that the mean value of copper was significantly different between T_0 and T_1 (p = 0.018, 95% C.I. = [12.22, 206.31] , 99% C.I. = [-6.09, 224.62]), T_1 and T_4 (p = 0.007, 95% C.I. = [-216.07, -21.99] , 99% C.I. = [-234.38, -3.68]), T_1 and T_5 (p = 0.000, 95% C.I. = [-255.75, -61.66] , 99% C.I. = [-274.06, -43.36]), and T_2 and T_5 (p = 0.007, 95% C.I. = [-216.07 -21.99], 99% C.I. = [-234.38, -3.68], Table C.31).

The iron concentration level in groundwater (T_0, 2.30 μg/L) was relatively low compared to other treatments (i.e., for T_1, T_2, T_3, T_4, and T_5, 160.34, 142.75, 125.17, 107.58, and 90.00 μg/L, respectively). There was a statistically significant difference in mean values of iron between at least five groups ($F_{5, 132}$ = [5.494], P = 0.000, Table 3.18). Furthermore, Tukey's HSD test for multiple comparisons found that the mean value of iron was significantly different between T_0 and T_1 (p = 0.000, 95% C.I. = [255.73, -60.34], 99% C.I. = [-274.16, -41.91]), T_0 and T_2 (p = 0.001, 95% C.I. = [-238.14, -42.76], 99% C.I. = [-256.57, -24.33]), T_0 and T_3 (p = 0.005, 95% C.I. = [-220.56, -25.17], 99% C.I. = [-238.99, -6.74]), and T_0 and T_4 (p = 0.027, 95% C.I. = [-202.97 -7.59], 99% C.I. = [-221.40, -10.84], Table C.32).

The manganese concentration levels were found between 1.07 and 9.43 μg/L (Figure 3.8-F), lead concentration levels were ranged between 164.34 and 236.76 μg/L (Figure 3.9-G). There was a statistically significant difference in mean values of copper and lead between at least five groups (for manganese, $F_{5, 132}$ = [4.365], P = 0.001, for lead, $F_{5, 132}$ = [2.761], P = 0.021, Table 3.18). Moreover, Tukey's HSD test for multiple comparisons found that the mean value of manganese was significantly different between T_0 and T_1 (p = 0.016, 95% C.I. = [-13.29, -0.84], 99% C.I. = [-14.47, 0.34]), T_0 and T_2 (p = 0.010, 95% C.I. = [-13.62, -1.16], 99% C.I. = [-14.79, 0.02]), T_0 and T_3 (p = 0.006, 95% C.I. = [-13.94, -1.48], 99% C.I. = [-15.12, -0.31]), T_0 and T_4 (p = 0.004, 95% C.I. = [-14.27, -1.81], 99% C.I. = [-15.44, -0.63]), and T_0 and T_5 (p = 0.002, 95% C.I. = [-14.59, -2.13], 99% C.I. = [-15.76, -0.95], Table C.33). Also, Tukey's HSD test for multiple comparisons found that the mean value of lead was significantly different between T_0 and T_1 (p = 0.017, 95% C.I. = [-136.43, -8.41], 99% C.I. = [-148.51, 3.66]), T_0 and T_2 (p = 0.038, 95% C.I. = [-130.17, -2.14], 99% C.I. = [-142.24, 9.93], Table C.34). While copper, manganese, and lead concentration levels decreased as the ratio of treated wastewater increased, iron concentration levels increased. Additionally, manganese and lead concentration levels were determined noticeably below the permissible maximum limit (i.e., for manganese 200 μg/L, for lead 5,000 μg/L).

The vanadium concentration level was detected ranged between 0.04 and 5.23 μg/L (Figure 3.9-H), the concentration level of groundwater (T_0, 0.04 μg/L) was found to be relatively low comparing to the other treatments (i.e., for T_1, T_2, T_3, T_4, and T_5, 5.23, 4.47, 3.71, 2.96, and 2.20 μg/L, respectively). Moreover, the zinc concentration level was varied between 3.54 and 21.69 μg/L (Figure 3.9-I). Vanadium and zinc were detected as another heavy metal significantly below the permissible limit (i.e., for vanadium 100 μg/L, for zinc 2,000 μg/L). There was a statistically significant difference in mean values of vanadium and zinc between at least five groups (for vanadium $F_{5, 132}$ = [46.623], P = 0.000, zinc $F_{5, 132}$ = [3.722], P = 0.003, Table 3.18). Additionally, Tukey's HSD test for multiple comparisons found that the mean value of vanadium was significantly different between T_0 and T_1 (p = 0.000, 95% C.I. = [-6.29, -4.08], 99% C.I. = [-6.49, -3.87]), T_0 and T_2 (p = 0.000, 95% C.I. = [-5.53, -3.33], 99% C.I. = [-5.74, -3.12]), T_0 and T_3 (p = 0.000, 95% C.I. = [-4.77, -2.57], 99% C.I. = [-4.98, -2.36]), T_0 and T_4 (p = 0.000, 95% C.I. = [-4.02, -1.81], 99% C.I. = [-4.23, -1.60]), T_0 and T_5 (p = 0.000, 95% C.I. = [-3.26, -1.06], 99% C.I. = [-3.47, -0.85]), T_1 and T_3 (p = 0.002, 95% C.I. = [0.41, 2.62], 99% C.I. = [0.20, 2.82]), T_1 and T_4 (p = 0.000, 95% C.I. = [1.17, 3.37], 99% C.I. = [0.96, 3.58]), T_1 and T_5 (p = 0.000, 95% C.I. = [1.92, 4.13], 99% C.I. = [1.71, 4.34]), T_2 and T_4 (p = 0.002, 95% C.I. = [0.41, 2.62], 99% C.I. = [0.20, 2.83]), T_2 and T_5 (p = 0.000, 95% C.I. = [1.17, 3.37], 99% C.I. = [0.96, 3.58]), and T_3 and T_5 (p = 0.002, 95% C.I. = [0.41, 2.62], 99% C.I. = [0.20, 2.82], Table C.35). Moreover, Tukey's HSD test for multiple comparisons found that the mean value of zinc was significantly different between T_0 and T_1 (p = 0.003, 95% C.I. = [-31.99, -4.30], 99% C.I. = [-34.60, -1.69]), T_0 and T_2 (p = 0.009, 95% C.I. = [-30.47, -2.78], 99% C.I. = [-33.09, -0.17]), and T_0 and T_3 (p = 0.024, 95% C.I. = [-28.95, -1.26], 99% C.I. = [-31.56, 1.35], Table c.36).

Table 3.16 Measured average heavy metal concentration levels (μg/L) of water applied and the recommended maximum limit for the short and long term (RMLST and RMLLT; μg/L) of heavy metals

Heavy Metals	Al	As	Be	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Se	V	Zn
T_0	18.38	0.22	-	-	-	-	115.61	2.30	1.07	-	164.34	-	0.04	3.54
T_1	39.31	4.41	-	-	0.52	-	6.34	160.34	8.14	-	236.76	-	5.23	21.69
T_2	52.63	4.81	-	-	0.43	-	46.02	142.75	8.46	-	230.49	-	4.47	20.17
T_3	65.96	5.20	-	-	0.34	-	85.70	125.17	8.79	-	224.23	-	3.71	18.65
T_4	79.28	5.60	-	-	0.25	-	125.37	107.58	9.11	-	217.96	-	2.96	17.13
T_5	92.61	5.99	-	-	0.16	-	165.05	90.00	9.43	-	211.69	-	2.20	15.60
RMLST [113]	20,000	2,000	500	50	5,000	1,000	5,000	20,000	10,000	2,000	10,000	20	1,000	10,000
RMLLT [42], [43]	5,000	100	100	10	50	100	200	5,000	200	200	5,000	20	100 FAO 200 EPA	2,000

T: Treatment, RMLST: Recommended maximum limit for the short term, RMLLT: Recommended maximum limit for the long term, Al: Aluminum, As: Arsenic, Be: Beryllium, Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc, “-“: Not Detected

Table 3.17 Measured heavy metals concentration levels (μg/L) of treatment water expressed by descriptive statistics

HM	Treatment	Mean	SD	SE	Min	Max
Al	T_0	18.38	0.95	0.20	16.98	20.15
	T_1	39.31	55.67	11.61	16.00	279.44
	T_2	52.63	62.21	12.97	19.80	286.65
	T_3	65.96	74.29	15.49	22.58	293.86
	T_4	79.28	89.70	18.70	23.54	320.70
	T_5	92.61	107.01	22.31	24.50	390.78
As	T_0	0.22	0.43	0.09	0.00	1.40
	T_1	4.41	1.54	0.32	1.91	7.27
	T_2	4.81	4.81	1.00	1.44	25.71
	T_3	5.20	9.30	1.94	0.96	46.83
	T_4	5.60	13.87	2.89	0.48	67.95
	T_5	5.99	18.47	3.85	0.00	89.06
Co	T_0	0.00	0.00	0.00	0.00	0.00
	T_1	0.52	0.15	0.03	0.25	0.92
	T_2	0.43	0.13	0.03	0.21	0.71
	T_3	0.34	0.15	0.03	0.17	0.72
	T_4	0.25	0.20	0.04	0.09	0.77
	T_5	0.16	0.25	0.05	0.00	0.82

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum,
Al: Aluminum, As: Arsenic, Co: Cobalt
Beryllium (Be), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Selenium (Se) were not detected.

Table 3.17 Continued

HM	Treatment	Mean	SD	SE	Min	Max
Cu	T_0	115.61	77.54	16.17	9.20	301.82
	T_1	6.34	5.42	1.13	0.00	17.90
	T_2	46.02	48.20	10.05	0.96	167.55
	T_3	85.70	97.35	20.30	1.91	331.94
	T_4	125.37	146.59	30.57	2.87	496.32
	T_5	165.05	195.86	40.84	3.83	660.71
Fe	T_0	2.30	5.75	1.20	0.00	22.57
	T_1	160.34	178.51	37.22	0.00	558.64
	T_2	142.75	137.80	28.73	2.38	432.44
	T_3	125.17	104.52	21.79	4.75	310.00
	T_4	107.58	87.62	18.27	2.40	337.18
	T_5	90.00	96.15	20.05	0.00	374.29
Mn	T_0	1.07	0.96	0.20	0.00	2.76
	T_1	8.14	9.78	2.04	0.00	32.01
	T_2	8.46	7.42	1.55	0.00	24.01
	T_3	8.79	6.25	1.30	0.00	19.46
	T_4	9.11	6.92	1.44	0.00	23.54
	T_5	9.43	9.02	1.88	0.00	29.81

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum,
Cu: Copper, Fe: Iron, Mn: Manganese
Beryllium (Be), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Selenium (Se) were not detected.

Table 3.17 Continued

HM	Treatment	Mean	SD	SE	Min	Max
Pb	T_0	164.34	78.18	16.30	64.06	320.32
	T_1	236.76	96.56	20.14	106.77	469.80
	T_2	230.49	70.07	14.61	122.79	379.05
	T_3	224.23	54.92	11.45	138.81	363.04
	T_4	217.96	60.37	12.59	117.45	373.71
	T_5	211.69	82.43	17.19	85.42	405.74
V	T_0	0.04	0.09	0.02	0.00	0.42
	T_1	5.23	0.80	0.17	4.20	6.77
	T_2	4.47	0.71	0.15	3.35	5.79
	T_3	3.71	1.09	0.23	2.42	7.37
	T_4	2.96	1.64	0.34	1.49	8.95
	T_5	2.20	2.24	0.47	0.34	10.54
Zn	T_0	3.54	6.00	1.25	0.00	23.89
	T_1	21.69	15.24	3.18	1.41	52.35
	T_2	20.17	13.38	2.79	2.07	44.82
	T_3	18.65	14.75	3.07	1.38	63.09
	T_4	17.13	18.64	3.89	0.69	82.19
	T_5	15.60	23.86	4.97	0.00	101.28

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum,
Pb: Lead, V: Vanadium, Zn: Zinc
Beryllium (Be), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Selenium (Se) were not detected.

Table 3.18 One-way ANOVA results of measured heavy metals concentration levels (μg/L) of treatment water

Analyte		Sum of Squares	dF	Mean Squares	F	Sig
Al	Between G	84,213	5	16,843	3.159	0.010**
	Within G	703,692	132	5,331		
	Total	787,906	137			
As	Between G	512	5	102	0.952	0.450
	Within G	14,207	132	108		
	Total	14,719	137			
Co	Between G	4.05	5	0.81	29.317	0.000**
	Within G	3.64	132	0.03		
	Total	7.69	137			
Cu	Between G	379,230	5	75,846	5.857	0.000**
	Within G	1,709,227	132	12,949		
	Total	2,088,457	137			
Fe	Between G	360,459	5	72,092	5.494	0.000**
	Within G	1,732,121	132	13,122		
	Total	2,092,579	137			

df: Degree of Freedom, Sig: Significance, G: Group
Al: Aluminum, As: Arsenic, Co: Cobalt, Cu: Copper, Fe: Iron
Beryllium (Be), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Selenium (Se) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table 3.18 Continued

Analyte		Sum of Squares	dF	Mean Squares	F	Sig
Mn	Between G	1,164	5	233	4.365	0.001**
	Within G	7,042	132	53		
	Total	8,207	137			
Pb	Between G	77,777	5	15,555	2.761	0.021*
	Within G	743,651	132	5,634		
	Total	821,428	137			
V	Between G	390	5	78	46.623	0.000**
	Within G	221	132	2		
	Total	611	137			
Zn	Between G	4,906	5	981	3.722	0.003**
	Within G	34,795	132	264		
	Total	39,701	137			

df: Degree of Freedom, Sig: Significance, G: Group
Mn: Manganese, Pb: Lead, V: Vanadium, Zn: Zinc
Beryllium (Be), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Selenium (Se) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

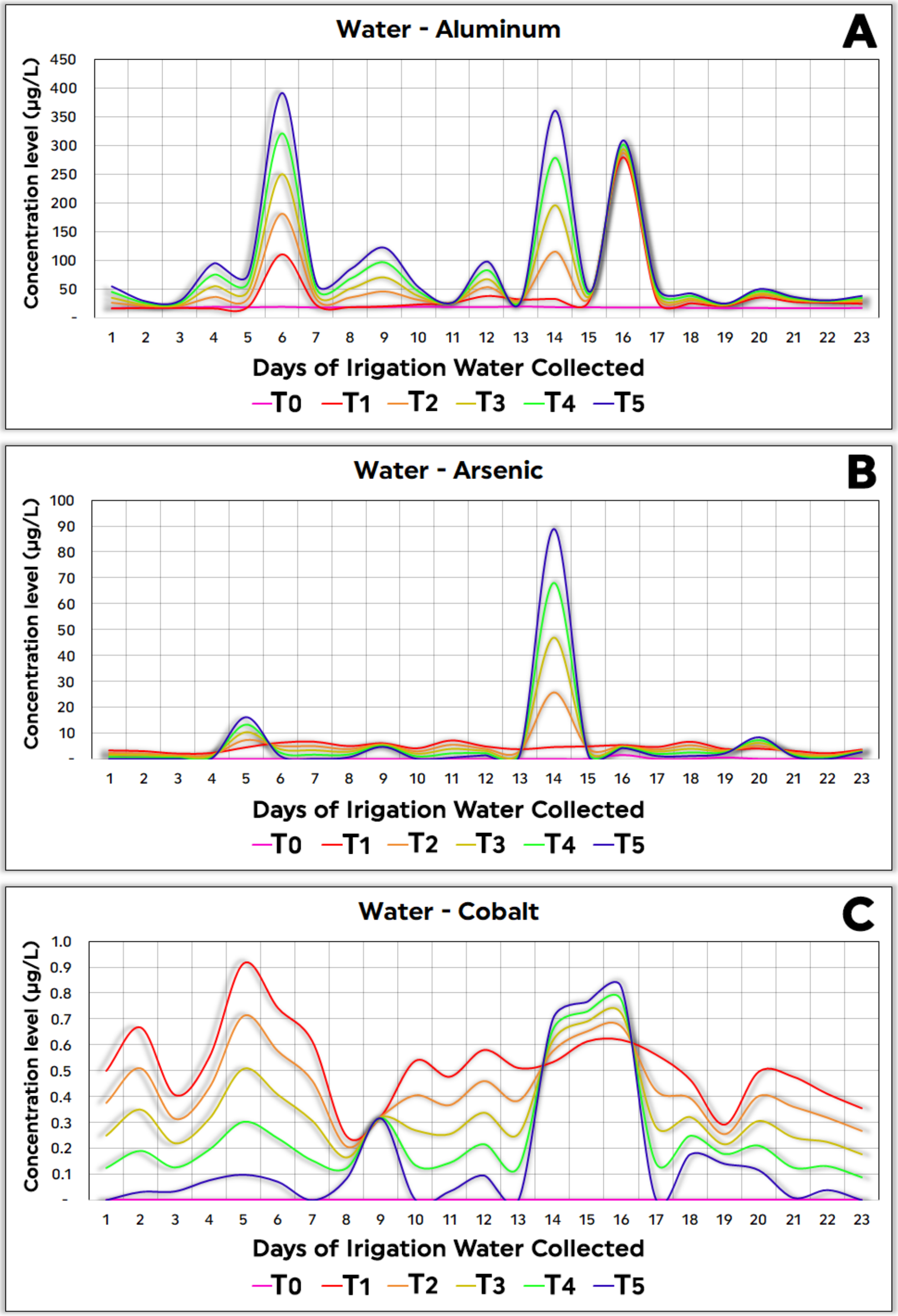

Figure 3.7 Concentration levels of heavy metals (µg/L) in water samples collected from Texas A&M University RELLIS Campus. A) Aluminum, B) Arsenic, C) Cobalt

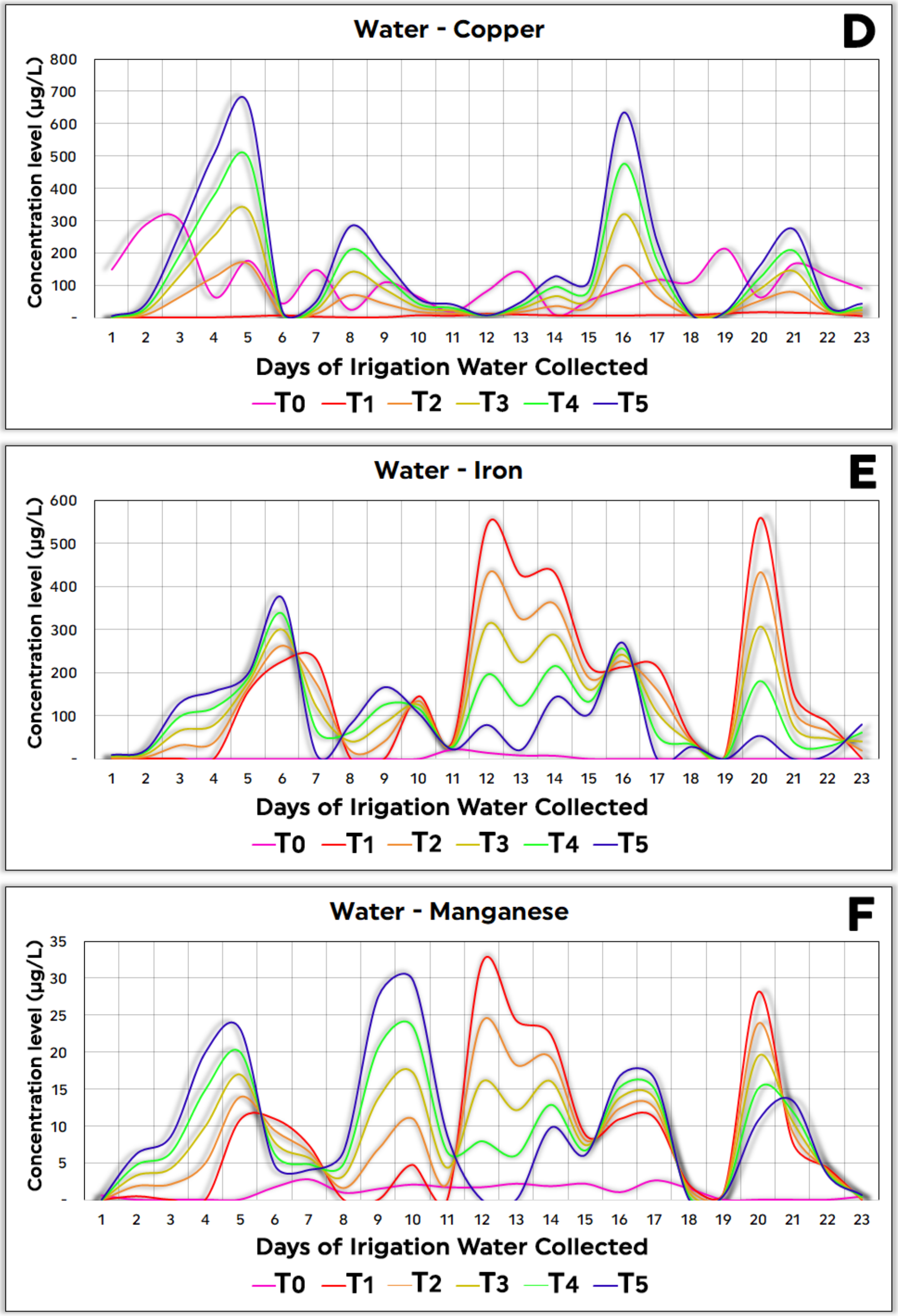

Figure 3.8 Concentration levels of heavy metals (µg/L) in water samples collected from Texas A&M University RELLIS Campus. D) Copper, E) Iron, F) Manganese

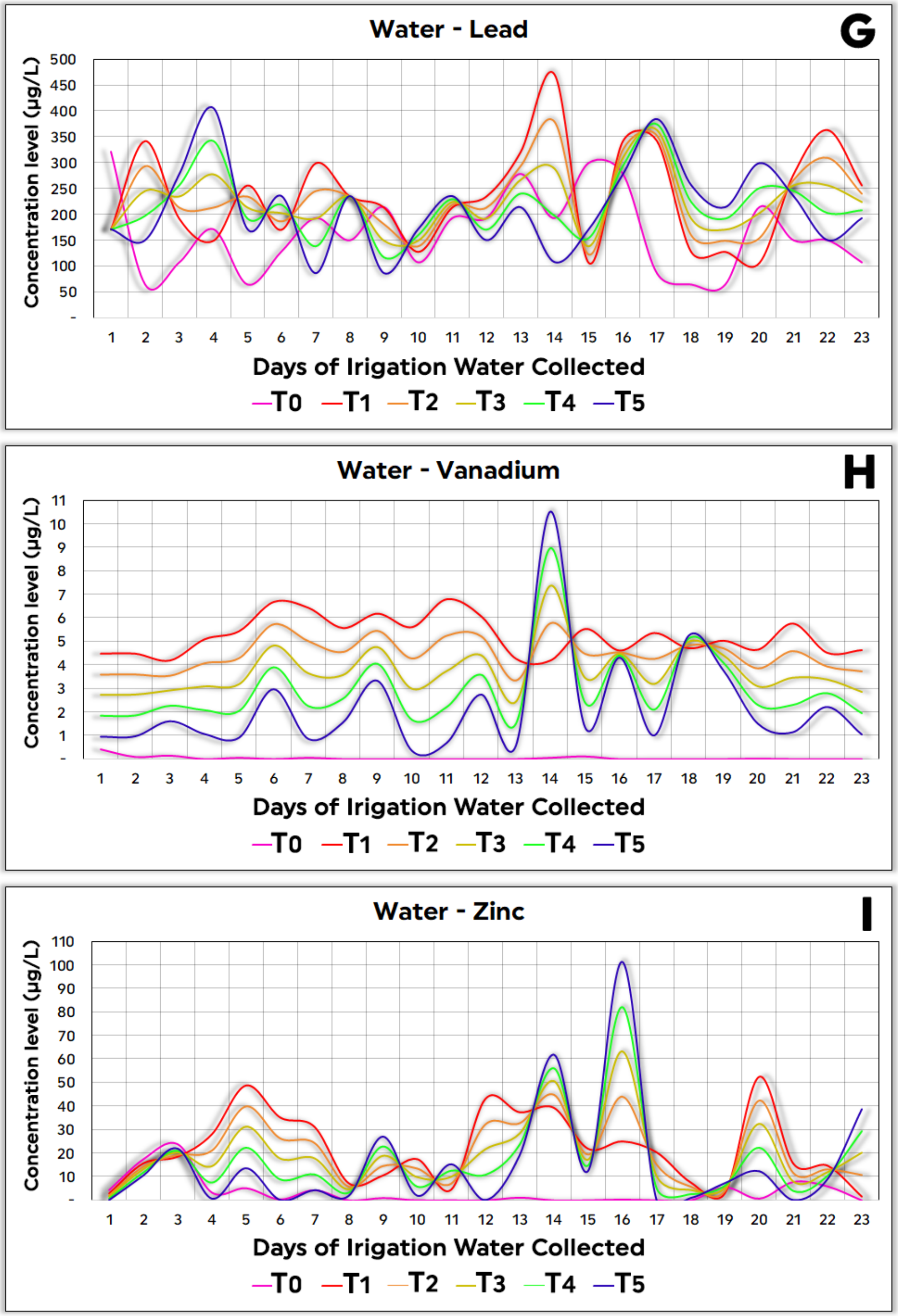

Figure 3.9 Concentration levels of heavy metals (µg/L) in water samples collected from Texas A&M University RELLIS Campus. G) Lead, H) Vanadium, I) Zinc

3.5.2. Accumulated Heavy Metal Concentration Level in Soil

Table 3.19 shows weighted average concentration of heavy metals in whole soil (i.e., at 0-10, 10-20 cm depth, and the soil collected in the saucer), Table 3.20 illustrates the statistical description of weighted average concentration of heavy metals in whole soil by treatments. One-way ANOVA results of weighted average concentration of heavy metals in whole soil by treatments are given in Table 3.21. Moreover, heavy metal concentration levels in initial and final soil by treatments are given graphically in Figures 3.10, 3.11, and 3.12.

For all water treatment, in the measurements taken from the parts of the soil, it can be seen from Table 3.19 that the accumulated Al, Be, Fe, Mn, Ni, and Se concentrations decreased after the irrigation applications, whereas As, Co, Cr, Cu, Pb, V, and Zn concentrations increased after the irrigation applications. Additionally, cadmium was not detected in the soil for all treatments

While the accumulated aluminum concentration was detected between 4.509 and 5,287 µg/kg (i.e., T_0, T_1, T_4, T_3, T_2, and T_5, respectively, from the highest to lowest), accumulated arsenic concentration was between 8.85 and 10.41 µg/kg (i.e., T_2, T_1, T_3, T_4, T_0, and T_5, respectively, from the highest to lowest). Moreover, accumulated beryllium concentration was ranged between 0.58 and 0.74 µg/kg (i.e., T_0, T_1, T_3, T_4, T_2, and T_5, respectively, from the highest to lowest), accumulated cobalt concentration was detected between 4.77 and 5.55 µg/kg (i.e., T_1, T_2, T_4, T_3, T_0, and T_5, respectively, from the highest to lowest), and accumulated chromium concentration was detected between 12.91 and 15.28 µg/kg (i.e., T_0, T_1, T_4, T_3, T_2, and T_5, respectively, from the highest to lowest).

Furthermore, accumulated copper concentration was between 9.04 and 12.61 µg/kg (i.e., T_4, T_3, T_1, T_0, T_2, and T_5, respectively, from the highest to lowest), whereas accumulated iron concentration was ranged between 12,795 and 14,285 µg/kg (i.e., T_1, T_4, T_0, T_2, T_3, and T_5, respectively, from the highest to lowest). Besides, accumulated manganese concentration was detected between 318.22 and 357.59 µg/kg (i.e., T_1, T_2, T_4, T_3, T_5, and T_0, respectively, from the highest to lowest), accumulated nickel concentration was between 11.50 and 13.54 µg/kg (i.e., T_1, T_2, T_3, T_4, T_0, and T_5, respectively, from the highest to lowest), and accumulated lead concentration was ranged between 73.22 and 77.56 µg/kg (i.e., T_2, T_4, T_3, T_1, T_0, and T_5, respectively, from the highest to lowest). Also, accumulated selenium concentration was detected between 0.08 and 0.11 µg/kg (i.e., T_0, T_3, T_2, T_4, T_1, and T_5, respectively, from the highest to lowest), accumulated vanadium concentration was between 16.17 and 19.05 µg/kg (i.e., T_0, T_1, T_4, T_2, T_3, and T_5, respectively, from the highest to lowest), and accumulated zinc concentration was ranged between 34.21 and 41.56 µg/kg (i.e., T_2, T_4, T_1, T_3, T_0, and T_5, respectively, from the highest to lowest).

It was observed that, most of the time, the highest heavy metals accumulated in the soil collected in the saucer. Lowest accumulations were observed in the 0-10 cm soil depth. Additionally, there were statistically significant difference in mean values of beryllium at the 0-10 cm soil depth and lead in the soil collected in the saucer between at least five groups (for beryllium $F_{5, 17}$ = [3.343], P = 0.040, Table B.1) (for lead $F_{5, 17}$ = [4.580], P = 0.014, Table B.3).

Compared to other studies, it can be said that heavy metals concentration levels found are relatively lower than the results of other studies. Adagunodo [114] found the As, Cd, Co, Cr, Cu, Ni, Pb, V, and Z concentration levels of the soil in his study. Arsenic and lead (i.e., for As, 1.60 - 3.70 mg/kg, for Pb 18.99 - 43.89 mg/kg) concentration was lower compared to this study, whereas other heavy metal concentration levels were higher (i.e., for Cd, 0.02 - 0.06 mg/kg, for Co, 6.30 - 19.10 mg/kg, for Cr, 23.00 - 341.00 mg/kg, for Cu, 3.91 - 20.69 mg/kg, for Ni, 7.90 - 31.80 mg/kg, for V, 22.00 - 124.00 mg/kg, and for Zn, 22.80 - 61.30 mg/kg). Osmani [115] found the Co, Cr, Ni, Pb, and Z concentration levels of the soil in his study. All heavy metals concentration was higher compared to this study (i.e., for Co, 75 - 103.3 mg/kg, for Cr, 310 - 370 mg/kg, for Ni, 410 - 610 mg/kg, for Pb, 0 - 165 mg/kg, and for Zn, 75 - 90 mg/kg). Ogundele [116] found the Cd, Cr, Cu, Ni, Pb, and Z concentration levels of the soil in his study. Only nickel (i.e., 14.87 ± 0.005 mg/kg) concentration was lower compared to this study, whereas other heavy metal concentration levels were higher (i.e., for Cd, 0.333 ± 0.001 mg/kg, for Cr, 50.67 ± 0.156 mg/kg, for Cu, 80.13 ± 0.007 mg/kg, for Pb, 97 ± 0.001 mg/kg, and for Zn, 219.23 ± 2.510 mg/kg). Chen [117] found the As, Cd, Cr, Cu, Ni, Pb, and Z concentration levels of the soil in his study. Arsenic and lead (i.e., for As, 4.54 mg/kg, for Pb 32.6 mg/kg) concentration was lower compared to this study, whereas other heavy metal concentration levels were higher (i.e., for Cd, 1.74 mg/kg, for Cr, 43.2 mg/kg, for Cu, 20.3 mg/kg, for Ni, 43.2 mg/kg, and for Zn, 180 mg/kg).

Table 3.19 Weighted average concentrations (μg/kg) of heavy metals in whole soil (i.e., at 0-10, 10-20 cm depth, and the soil collected in the saucer)

HM	$T_{initial}$	T_0	T_1	T_2	T_3	T_4	T_5
Al	5,742	5,287	5,183	4,751	4,909	5,045	4,509
As	4.79	9.08	9.89	10.41	9.87	9.11	8.85
Be	0.75	0.74	0.68	0.63	0.64	0.64	0.58
Cd		-	-	-	-	-	-
Co	3.96	5.07	5.55	5.34	5.10	5.19	4.77
Cr	11.64	15.28	14.84	13.63	14.11	14.38	12.91
Cu	4.64	9.11	9.81	9.11	10.57	12.61	9.04
Fe	14,396	13,765	14,285	13,555	13,549	13,928	12,795
Mn	534.85	318.22	357.59	351.13	333.27	346.31	323.06
Ni	19.49	12.53	13.54	13.36	12.62	12.59	11.50
Pb	63.74	73.95	75.15	77.56	75.36	75.60	73.22
Se	0.18	0.11	0.08	0.09	0.11	0.09	0.08
V	14.51	19.05	18.58	17.18	17.16	17.72	16.17
Zn	26.27	37.88	38.72	41.56	38.03	39.12	34.21

HM: Heavy Metal, T: Treatment, "-" Not Detected,
Al: Aluminum, As: Arsenic, Be: Beryllium, Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc

Table 3.20 Weighted average concentrations (μg/kg) of heavy metals in whole soil (i.e., at 0-10, 10-20 cm depth, and the soil collected in the saucer) by treatments expressed by descriptive statistics

HM	Treatment	Mean	SD	SE	Min	Max
Al	T_0	5,287	245	141	5,130	5,569
	T_1	5,184	206	119	4,953	5,351
	T_2	4,751	116	67	4,619	4,835
	T_3	4,909	569	328	4,330	5,467
	T_4	5,045	298	172	4,819	5,382
	T_5	4,509	208	120	4,366	4,748
As	T_0	9.08	1.57	0.91	7.31	10.31
	T_1	9.89	1.94	1.12	7.65	11.05
	T_2	10.41	2.86	1.65	7.34	12.99
	T_3	9.87	1.31	0.76	8.72	11.30
	T_4	9.11	2.06	1.19	6.73	10.34
	T_5	8.85	2.22	1.28	6.37	10.66
Be	T_0	0.74	0.03	0.02	0.70	0.77
	T_1	0.68	0.01	0.01	0.67	0.69
	T_2	0.63	0.02	0.01	0.61	0.66
	T_3	0.64	0.08	0.05	0.56	0.72
	T_4	0.64	0.04	0.03	0.59	0.66
	T_5	0.58	0.03	0.02	0.55	0.60
Co	T_0	5.07	0.12	0.07	4.96	5.19
	T_1	5.55	0.28	0.16	5.27	5.83
	T_2	5.34	0.36	0.21	4.93	5.58
	T_3	5.10	0.51	0.29	4.52	5.46
	T_4	5.19	0.42	0.24	4.71	5.45
	T_5	4.77	0.28	0.16	4.50	5.07

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt
Cadmium (Cd) was not detected.

Table 3.20 Continued

HM	Treatment	Mean	SD	SE	Min	Max
Cr	T_0	15.28	0.72	0.41	14.47	15.81
	T_1	14.84	0.43	0.25	14.38	15.22
	T_2	13.63	0.47	0.27	13.23	14.14
	T_3	14.11	1.80	1.04	12.38	15.97
	T_4	14.38	0.69	0.40	13.89	15.17
	T_5	12.91	1.11	0.64	12.11	14.18
Cu	T_0	9.11	3.82	2.20	6.85	13.51
	T_1	9.81	2.03	1.17	8.17	12.08
	T_2	9.11	2.54	1.46	7.51	12.04
	T_3	10.57	5.89	3.40	7.01	17.37
	T_4	12.61	8.57	4.95	7.43	22.50
	T_5	9.04	3.83	2.21	6.44	13.43
Fe	T_0	13,765	472	273	13,397	14,298
	T_1	14,285	911	526	13,240	14,911
	T_2	13,555	450	260	13,046	13,899
	T_3	13,549	1,332	769	12,011	14,322
	T_4	13,928	1,053	608	12,744	14,762
	T_5	12,795	407	235	12,396	13,209

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, Cr: Chromium, Cu: Copper, Fe: Iron
Cadmium (Cd) was not detected.

Table 3.20 Continued

HM	Treatment	Mean	SD	SE	Min	Max
Mn	T_0	318.22	3.59	2.07	314.34	321.43
	T_1	357.59	11.52	6.65	348.16	370.43
	T_2	351.13	18.42	10.64	330.32	365.33
	T_3	333.27	36.98	21.35	290.58	354.99
	T_4	346.31	17.98	10.38	325.58	357.62
	T_5	323.06	21.62	12.48	298.62	339.73
Ni	T_0	12.53	0.24	0.14	12.26	12.73
	T_1	13.54	0.76	0.44	12.75	14.27
	T_2	13.36	0.59	0.34	12.69	13.76
	T_3	12.62	1.46	0.84	10.94	13.48
	T_4	12.59	0.94	0.54	11.51	13.21
	T_5	11.50	0.75	0.43	10.87	12.33
Pb	T_0	73.95	5.08	2.93	69.71	79.58
	T_1	75.15	1.00	0.58	74.01	75.82
	T_2	77.56	7.26	4.19	72.32	85.84
	T_3	75.36	15.53	8.97	59.23	90.22
	T_4	75.60	3.86	2.23	72.65	79.96
	T_5	73.22	9.30	5.37	62.98	81.12

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, Mn: Manganese, Ni: Nickel, Pb: Lead
Cadmium (Cd) was not detected.

Table 3.20 Continued

HM	Treatment	Mean	SD	SE	Min	Max
Se	T_0	0.11	0.17	0.10	-	0.30
	T_1	0.08	0.09	0.05	-	0.18
	T_2	0.09	0.08	0.05	0.03	0.18
	T_3	0.11	0.14	0.08	-	0.27
	T_4	0.09	0.03	0.02	0.06	0.12
	T_5	0.08	0.07	0.04	0.00	0.12
V	T_0	19.05	0.95	0.55	18.18	20.06
	T_1	18.58	0.66	0.38	17.82	19.04
	T_2	17.18	0.47	0.27	16.65	17.54
	T_3	17.16	2.36	1.37	14.79	19.52
	T_4	17.72	0.91	0.52	17.19	18.77
	T_5	16.17	1.27	0.74	15.10	17.58
Zn	T_0	37.88	1.79	1.03	35.91	39.42
	T_1	38.72	0.61	0.35	38.13	39.35
	T_2	41.56	4.47	2.58	37.65	46.43
	T_3	38.03	2.50	1.44	35.66	40.65
	T_4	39.12	2.36	1.36	36.46	40.93
	T_5	34.21	4.18	2.41	29.53	37.54

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, Se: Selenium, V: Vanadium, Zn: Zinc

Cadmium (Cd) was not detected.

Table 3.21 One-way ANOVA results of weighted average concentrations (μg/kg) of heavy metals in whole soil (i.e., at 0-10, 10-20 cm depth, and the soil collected in the saucer)

HM		Sum of Squares	dF	Mean Squares	F	Sig
Al	Between G	1,239,041	5	247,808	2.602	0.081
	Within G	1,143,016	12	95,251		
	Total	2,382,058	17			
As	Between G	5.60	5	1.120	0.266	0.923
	Within G	50.58	12	4.215		
	Total	56.18	17			
Be	Between G	0.043	5	0.009	4.531	0.015*
	Within G	0.023	12	0.002		
	Total	0.066	17			
Co	Between G	1.038	5	0.208	1.691	0.211
	Within G	1.473	12	0.123		
	Total	2.512	17			
Cr	Between G	10.85	5	2.171	2.223	0.119
	Within G	11.72	12	0.976		
	Total	22.57	17			
Cu	Between G	28.94	5	5.788	0.235	0.940
	Within G	295.92	12	24.660		
	Total	324.86	17			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Cadmium (Cd) were not detected.

*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table 3.21 Continued

HM		Sum of Squares	dF	Mean Squares	F	Sig
	Between G	3,733,117	5	746,623	1.040	0.438
Fe	Within G	8,611,105	12	717,592		
	Total	12,344,222	17			
Mn	Between G	3,785	5	756.974	1.719	0.205
	Within G	5,286	12	440.480		
	Total	9,071	17			
	Between G	7.85	5	1.571	2.069	0.140
Ni	Within G	9.11	12	0.759		
	Total	16.97	17			
	Between G	33.65	5	6.729	0.096	0.991
Pb	Within G	843.83	12	70.319		
	Total	877.48	17			
	Between G	0.003	5	0.001	0.049	0.998
Se	Within G	0.135	12	0.011		
	Total	0.138	17			
	Between G	16.43	5	3.286	2.053	0.143
V	Within G	19.21	12	1.600		
	Total	35.63	17			
	Between G	85.30	5	17.060	1.939	0.161
Zn	Within G	105.59	12	8.799		
	Total	190.89	17			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc,
Cadmium (Cd) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

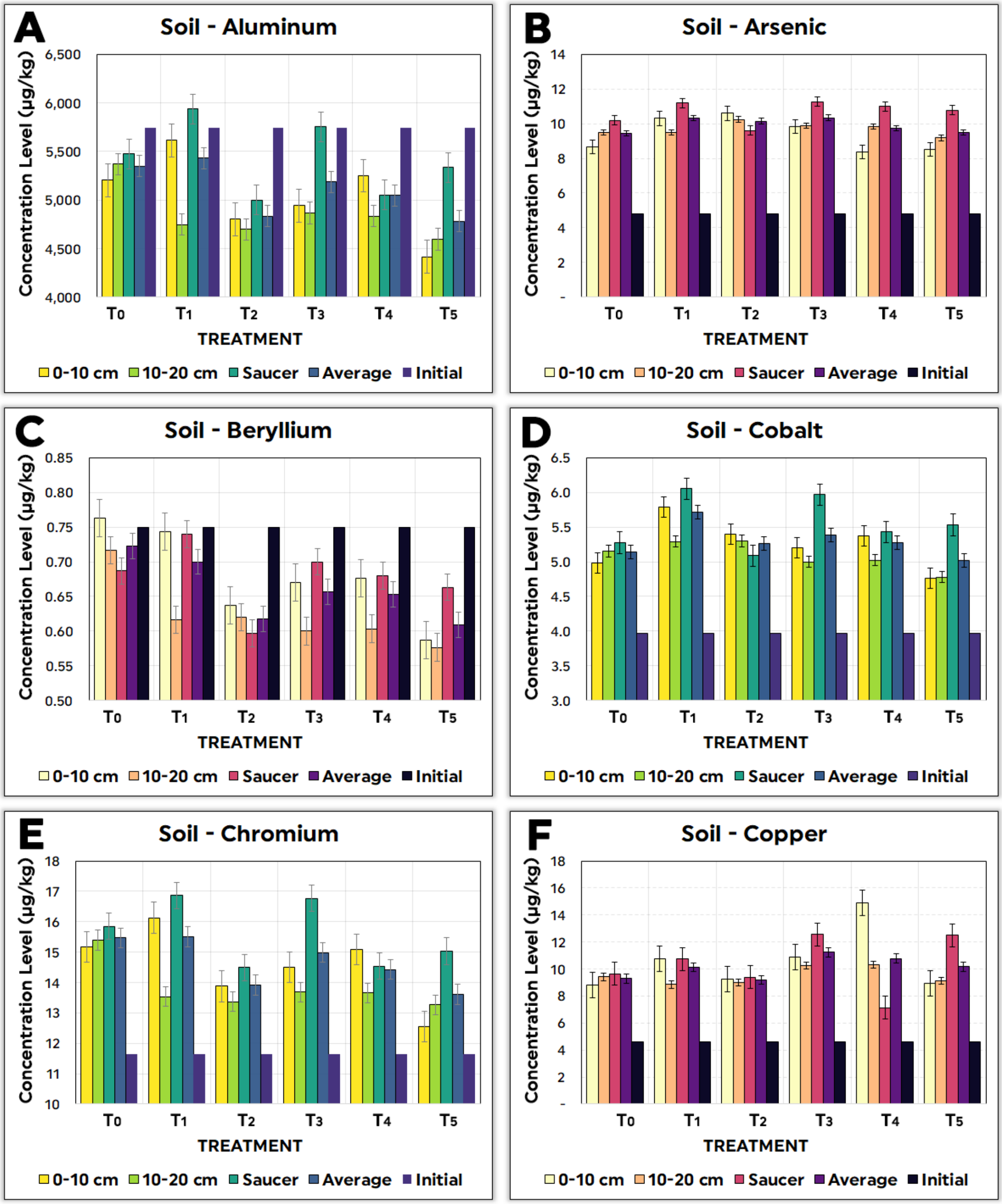

Figure 3.10 Accumulated heavy metal concentration level in initial and final soil by treatments A) Aluminum, B) Arsenic, C) Beryllium, D) Cobalt, D) Chromium, E) Copper

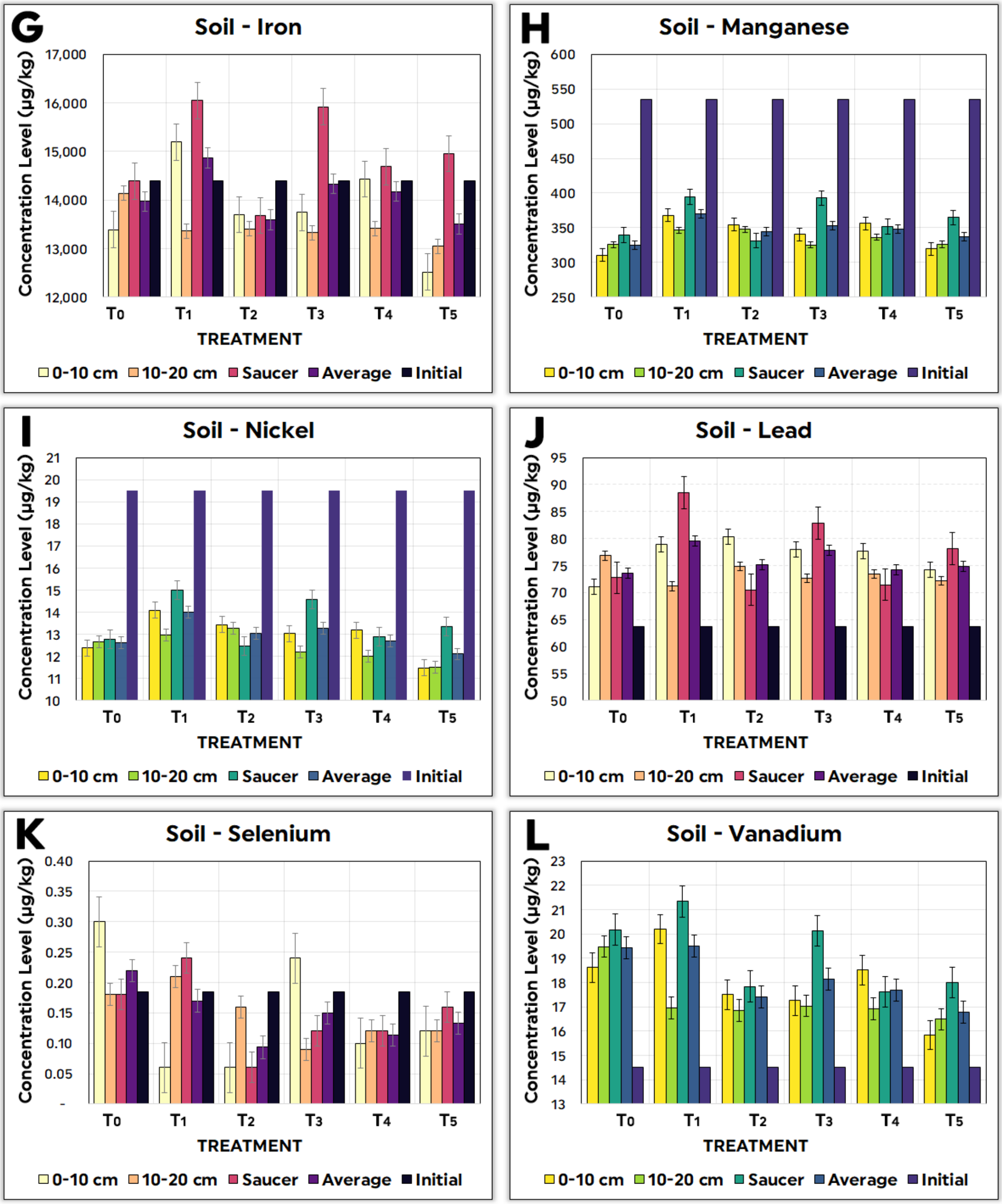

Figure 3.11 Accumulated heavy metal concentration level in initial and final soil by treatments A) Iron, B) Manganese, C) Nickel, D) Lead, D) Selenium, E) Vanadium

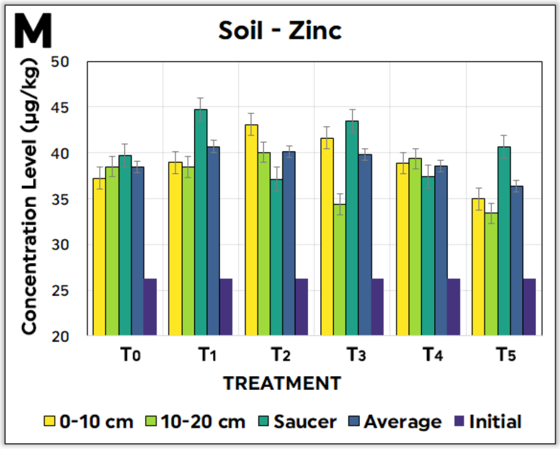

Figure 3.12 Accumulated Zinc concentration level in initial and final soil by treatments

3.5.3. Accumulated Heavy Metal Concentration Level in Plant Parts

Table 3.22 illustrates the weighted average concentrations level of heavy metals in the whole plant (i.e., root, crown, lower stem, upper stem, leaf, truss, and fruit). Tables 3.23, 3.25, 3.26, 3.27, 3.28, 3.29, and 3.30 show the statistical description of the weighted average concentrations level of heavy metals in treatments by plant parts, whereas Table 24 shows One-way ANOVA results of weighted average concentrations (µg/kg) of heavy metals in whole plant. Moreover, accumulated heavy metal concentration partitions in plant parts by treatments are given graphically in Figures 3.13, 3.14, 3.15, 3.16, 3.17, 3.18, 3.19, 3.20, 3.21, 3.22, 3.23. and 3.24.

For all water treatments, the measurements taken from root samples show a consistent order of heavy metal accumulation for the highest seven metals (i.e., Al, Fe, Pb, Mn, Zn, Cu, and, As, respectively, from the highest to the lowest amount of accumulation). For the eighth (i.e., Ni) with ninth (i.e., V) and the tenth (i.e., Co) with the eleventh (i.e., Cr) highest metal accumulation appeared interchangeably for different water treatments (i.e., for T_1-T_5, V accumulation was higher than Ni, whereas, for T_0, V accumulation was higher than Mn, and for T_0-T_3 Co accumulation was higher than Cr, while, for T_4 and T_5, Cr accumulation was higher than Co). Additionally, the measurements show that Be was the lowest accumulated heavy metal for root samples. Cadmium and selenium were not detected in root.

A similar trend was observed for the crown samples, where the amount of metal accumulated was lined up similar to the root (i.e., Al, Fe, Pb, Mn, Zn, Cu, and, As, respectively from the highest to the lowest amount of accumulation), with only the fourth (i.e., Zn) and fifth (i.e., Mn) highest metal accumulation appearing interchangeably for different water treatments (i.e., for T_1, T_2, T_4, and T_5 Mn accumulation was higher than Zn, whereas, for T_0 and T_3, Zn accumulation was higher than Mn). T_0 and T_1 treatments follow a similar trend in other metals that accumulate for the root samples, and there was no observed trend for other treatments (i.e., T_2-T_5). For T_0, T_1, and T_2 treatments, the highest metal accumulation was ordered as Ni, V, Co, Cr, and Be, respectively. For T_3 treatments, V, Ni, Co, Be, and Cr, respectively, were observed from the highest to the lowest amount of accumulation. For T_4 treatments, V, Ni, Cr, Co, and Be, respectively, were detected from the highest to the lowest amount of accumulation while for T_5 treatments, Cr, Ni, V, Co, and Be, respectively, were observed from the highest to the lowest amount of accumulation.

In the measurements taken from the lower stem samples, the first six heavy metals that accumulated the highest showed an irregular distribution compared to the following six heavy metals. Starting from the highest to the lowest amount of accumulation, for T_0, heavy metal accumulation was Zn, Pb, Al, Fe, Cu, and Mn, respectively, whereas, for T_3, heavy metal accumulation for the highest six heavy metals were Fe, Pb, Al, Zn, Mn, and Cu, respectively. Moreover, for T_4, the highest six accumulated heavy metals were Pb, Zn, Al, Fe, Mn, and Cu, respectively, while, for T_5, the highest six accumulated heavy metals were Pb, Al, Fe, Zn, Mn, and Cu, respectively. A similar trend was observed for T_1 and T_2 treatments compared to the other treatments (i.e., Fe, Al, Pb, Zn, Mn, and Cu, respectively, from the highest to the lowest amount of accumulation). In addition to these, a similar trend was observed for all treatments, where the amount of metal accumulated was lined up similarly (i.e., As, Co, Ni, V, and Be, respectively from the highest to the lowest amount of accumulation), with only the eighth (i.e., Co) and ninth (i.e., Ni) highest metal accumulation appearing interchangeably for different water treatments (i.e., for T_0-T_3 Co accumulation was higher than Ni, whereas, for T_4 and T_5, Ni accumulation was higher than Co). Apart from these, cadmium, chromium, and selenium were not detected in any treatments.

For the measurements taken from upper stem samples, three separate trends were observed (i.e., between treatments, T_0-T_2, T_1-T_3, and T_4-T_5). Starting from the highest to the lowest amount of accumulation, for T_0-T_2, heavy metals were ordered as Pb, Mn, Al, Zn, Fe, Cu, As, Co, Ni, V, and Be, respectively, for T_1-T_3, as Mn, Pb, Al, Fe, Zn, Cu, As, Co, Ni, V, and Be, respectively, for T_4-T_5, as Pb, Mn, Al, Zn, Cu, Fe, As, Co, Ni, V, and Be, respectively. Apart from these, cadmium, chromium, and selenium were not detected in any groups or treatments. On the other hand, although there were some differences between the groups, the trend was relatively similar for each group. Among the first two highest accumulated heavy metals, Pb was the highest accumulated heavy metal for T_0, T_2, T_3, T_4, and T_5 treatments, while Mn was the highest accumulated heavy metal for T_1 treatment. The third highest accumulated heavy metal for all groups was Al, the three highest heavy metals that follow different sequences for each group (i.e., for T_0-T_2 group, Zn, Fe, and Cu, respectively, for T_1-T_3 group, Fe, Zn, and Cu, respectively, for T_4-T_5 group, Zn, Cu, and Fe, respectively). The six heavy metals followed the same trend for all groups (i.e., As, Co, Ni, V, and Be, respectively).

In the measurements taken from the leaf samples, three treatments show the same trends (i.e., T_0, T_3, and T_4). The accumulated heavy metals order of these groups were Al, Mn, Fe, Pb, Zn, Cu, As, Ni, Co, V, and Be, respectively, from the highest to the lowest amount of accumulation. On the other hand, although there were some differences between the other treatments (i.e., T_1, T_2, and T_5), the trend was relatively similar for each treatment. Among the first three highest accumulated heavy metals, for T_1, it was ordered as Fe, Al, and Mn, respectively, for T_2, as Mn, Al, and Fe, respectively, for T_5, as Al, Fe, and Mn, respectively. For the ninth (i.e., Co) and tenth (i.e., V) highest metal accumulation appearing interchangeably for different water treatments (i.e., for T_1-T_2 Co accumulation was higher than V, whereas, for T_5, V accumulation was higher than Co). Beryllium was the lowest accumulated heavy metal for all of the treatments. Cadmium, chromium, and selenium were not detected in any of the treatments.

For the measurements taken from truss samples, the same trend was observed within T_0 and T_5 (i.e., Al, Mn, Pb, Fe, Zn, Cu, As, Ni, Co, and V, respectively, from the highest to the lowest amount of accumulation). Moreover, a similar trend was observed within T_2 and T_3 (i.e., Al, Pb, Mn, Fe, Zn, Cu, As, Ni, Co, and V, respectively, from the highest to the lowest amount of accumulation). However, the eighth (i.e., Ni) and the ninth (i.e., Co) highest metal accumulation appeared interchangeably for different water treatments between T_2 and T_3 (i.e., for T_2, Ni accumulation was higher than Co, whereas, for T_3, Co accumulation was higher than Ni). No trend was observed for T_1 and T_4 treatments (i.e., for T_1, Al, Fe, Mn, Pb, Zn, Cu, As, Co, Ni, and V, respectively, for T_4, Al, Mn, Pb, Zn, Fe, Cu, As, Co, and V, respectively, from the highest to the lowest amount of accumulation). Additionally, beryllium, cadmium, chromium, and selenium were not detected in any treatments.

In the measurements taken from the fruit samples, the same trend was observed within T_3 and T_4 (i.e., Zn, Fe, Al, Mn, Cu, Pb, As, Co, Ni, V, and Be, respectively, from the highest to the lowest amount of accumulation). Moreover, a similar trend was observed within T_1 and T_2 (i.e., Zn, Fe, Al, Mn, Cu, Pb, As, Co, V, Be, and Ni, respectively, from the highest to the lowest amount of accumulation). However, the first three highest accumulated heavy metals were differed for these treatments (i.e., for $T_{1,}$ Zn, and Al, and Fe, respectively, for $T_{2,}$ Fe, Al, and Zn, respectively, from the highest to the lowest amount of accumulation). Furthermore, a similar trend was observed within T_0 and T_5 (i.e., Al, Zn, Fe, Mn, Cu, Pb, Co, As, Ni, V, and Be, respectively, from the highest to the lowest amount of accumulation). While the first three highest accumulated heavy metals were differed according to these treatments (i.e., for $T_{0,}$ Al, Zn, and Fe, respectively, for $T_{5,}$ Zn, Al, and Fe, respectively, from the highest to the lowest amount of accumulation), it appears that there was an interchangeable difference between T_0 and T_5 for the seventh (i.e., Co) and eighth (i.e., As) highest metal accumulation (i.e., for T_0, Co accumulation was higher than As, whereas, for T_5, As accumulation was higher than Co). Additionally, cadmium, chromium, and selenium were not detected in any treatments.

For all water treatment, in the measurements taken from the parts of the plant, it was observed that the highest accumulated part for aluminum was the root and crown (for T_0, T_1, T_3, and T_4, accumulation in root was higher than crown, whereas, for T_2 and T_5, accumulation in crown was higher than root) while the lowest accumulated part was determined as fruit for all treatments. However, the accumulated concentration aluminum in the whole plant was determined highest in T_5 with 94.72 μg/kg and lowest in T_2 with 47.63 μg/kg (i.e., T_5, T_4, T_3, T_1, T_0, and T_2, respectively, from the highest to lowest).

It can be seen from Table 3.17 that the highest accumulated parts for arsenic were root, crown, and leaf (i.e., root for T_0, T_2, T_4, and T_5, crown for T_1, leaf for T_3), the lowest accumulated arsenic was in fruit. Furthermore, the accumulated concentration arsenic in the whole plant was determined highest in T_2 with 2.07 μg/kg and lowest in T_0 with 1.58 μg/kg (i.e., T_2, T_4, T_5, T_3, T_1, and T_0, respectively, from the highest to lowest).

For beryllium, it was only detected in root and crown (for T_0, T_2, and T_5, accumulation in crown was higher than root, whereas, for T_1, T_3, and T_4, accumulation in root was higher than crown). Moreover, the accumulated concentration beryllium in the plant parts was determined highest in T_3 with 0.14 μg/kg and lowest in T_2 with 0.01 μg/kg (i.e., T_3, T_4, T_5, T_1, T_0, and T_2, respectively, from the highest to lowest).

The plant parts with the highest amount of cobalt vary between the treatments. The highest detected part was root for T_1, T_2, and T_4, crown for T_0 and T_5, and upper stem for

T_3. Moreover, the lowest accumulated cobalt was in fruit. Additionally, the accumulated concentration cobalt in the plant parts was determined highest in T_1 with 0.49 μg/kg and lowest in T_4 with 0.29 μg/kg (i.e., T_1, T_3, T_0, T_2, T_5, and T_4, respectively, from the highest to lowest).

It can be seen from Table 3.17 that the highest accumulated part for chromium was in crown, root, and upper stem (i.e., crown for T_0, T_1, and T_5, root for T_2 and T_4, upper stem for T_3) the lowest accumulated chromium was in fruit, upper stem, and crown (i.e., fruit for T_2, T_4, and T_5, upper stem for T_0 and T_1, crown for T_3). However, it was not detected chromium in truss. Furthermore, the accumulated concentration chromium in the whole plant was determined highest in T_5 with 0.046 μg/kg and lowest in T_3 with 0.001 μg/kg (i.e., T_5, T_4, T_2, T_1, T_0, and T_3, respectively, from the highest to lowest).

The plant parts with the highest amount of copper vary for the treatments. While the highest detected part was in lower stem, leaf, root, and crown (i.e., lower stem for T_0 and T_2, leaf for T_3 and T_4, root for T_1, and crown for T_5), the lowest accumulated copper was in fruit, truss, and upper stem (i.e., fruit for T_1, T_3, and T_4, truss for T_0 and T_2, upper stem for T_5). Additionally, the accumulated concentration copper in the whole plant was determined highest in T_4 with 8.00 μg/kg and lowest in T_1 with 4.47 μg/kg (i.e., T_4, T_3, T_5, T_0, T_2, and T_1, respectively, from the highest to lowest).

Table 3.17 shows that the highest accumulated iron was detected in root and crown (for T_0, T_1, T_3, and T_4, accumulation in root was higher than crown, whereas, for T_2, T_5, accumulation in crown was higher than root). Moreover, the lowest accumulated iron was detected in fruit. Additionally, the accumulated concentration iron in the plant parts was determined highest in T_5 with 61.57 μg/kg and lowest in T_2 with 36.90 μg/kg (i.e., T_5, T_1, T_3, T_0, T_4, and T_2, respectively, from the highest to lowest).

It can be seen from Table 3.17 that the highest accumulated parts for manganese were detected as leaf, truss, and root (i.e., leaf for T_0, T_2, T_3, and T_5, truss for T_1, and root for T_4) the lowest accumulated manganese was in fruit, and truss root (i.e., fruit for T_0, T_1, T_3, and T_5, truss for T_2 and T_4). Furthermore, the accumulated concentration manganese in the whole plant was determined highest in T_0 with 54.97 μg/kg and lowest in T_2 with 44.95 μg/kg (i.e., T_0, T_1, T_3, T_4, T_5, and T_2, respectively, from the highest to lowest).

Table 3.17 shows that the highest accumulated parts for nickel were the root and crown (i.e., root for T_0, T_1, T_2, T_3, and T_4, crown for T_5) the lowest accumulated nickel was detected in fruit. Additionally, the accumulated concentration nickel in the whole plant was determined highest in T_0 with 0.49 μg/kg and lowest in T_4 with 0.29 μg/kg (i.e., T_0, T_3, T_1, T_5, T_2, and T_4, respectively, from the highest to lowest).

For all water treatments, while the highest accumulated lead was in leaf, the lowest accumulated Pb was in fruit. The accumulated concentration lead in the whole plant was determined highest in T_3 with 34.45 μg/kg and lowest in T_1 with 28.13 μg/kg (i.e., T_3, T_5, T_4, T_2, T_0, and T_1, respectively, from the highest to lowest).

It can be seen from Table 3.17 that the highest accumulated vanadium was in root and crown (i.e., root for T_0, T_1, T_2, T_3, and T_4, crown for T_5), the lowest accumulated vanadium was in fruit. Moreover, the accumulated concentration vanadium in the whole plant was determined highest in T_3 with 0.30 μg/kg and lowest in T_0 with 0.20 μg/kg (i.e., T_3, T_5, T_1, T_4, T_2, and T_0, respectively, from the highest to lowest).

Table 3.17 shows that the highest accumulated part for zinc was in leaf and crown (i.e., leaf for T_0, T_2, T_3, T_4, and T_5, crown for T_1), the lowest accumulated zinc was detected in fruit and upper stem (i.e., fruit for T_1, T_2, T_3, T_4, upper stem for T_0 and T_5). Furthermore, the accumulated concentration zinc in the whole plant was determined highest in T_0 with 20.02 μg/kg and lowest in T_2 with 14.42 μg/kg (i.e., T_0, T_5, T_4, T_3, T_1, and T_2, respectively, from the highest to lowest).

There was statistically significant difference in mean values of aluminum, chromium, and copper in whole plant (i.e., root, crown, lower stem, upper stem, leaf, truss, and fruit) between at least five groups (for aluminum $F_{5, 17}$ = [4.508], P = 0.015, for chromium $F_{5, 17}$ = [4.270], P = 0.018, for copper $F_{5, 17}$ = [3.292], P = 0.042, Table 3.24).

There was statistically significant difference in mean values of aluminum, arsenic, cobalt, chromium, copper, iron, lead, vanadium, and zinc in root between at least five groups (for aluminum $F_{5, 17}$ = [5.976], P = 0.001, for arsenic $F_{5, 17}$ = [6.580], P = 0.000, for cobalt $F_{5, 17}$ = [3.694], P = 0.010, for chromium $F_{5, 17}$ = [2.972], P = 0.027, for copper $F_{5, 17}$ = [2.669], P = 0.041, for iron $F_{5, 17}$ = [6.148], P = 0.000, for lead $F_{5, 17}$ = [3.182], P = 0.020, for vanadium $F_{5, 17}$ = [7.200], P = 0.000, for zinc $F_{5, 17}$ = [7.061], P = 0.000, Table B.4).

There was statistically significant difference in mean values of chromium and zinc in crown between at least five groups (for chromium $F_{5, 17}$ = [4.625], P = 0.014, for zinc $F_{5, 17}$ = [3.205], P = 0.046, Table B.5).

There was statistically significant difference in mean values of aluminum, iron, manganese, vanadium, and zinc in lower stem between at least five groups (for aluminum

$F_{5, 17}$ = [11.887], P = 0.000, for iron $F_{5, 17}$ = [6.295], P = 0.004, for manganese $F_{5, 17}$ = [3.632], P = 0.031, for vanadium $F_{5, 17}$ = [6.086], P = 0.005, for zinc $F_{5, 17}$ = [3.177], P = 0.047, Table B.6).

There was statistically significant difference in mean values of aluminum, arsenic, iron, and vanadium in upper stem between at least five groups (for aluminum $F_{5, 17}$ = [4.565], P = 0.003, for arsenic $F_{5, 17}$ = [2.788], P = 0.035, for iron $F_{5, 17}$ = [2.612], P = 0.045, for vanadium $F_{5, 17}$ = [2.643], P = 0.043, Table B.7).

There was statistically significant difference in mean values of aluminum, arsenic, beryllium, iron, manganese, lead, vanadium, and zinc in leaf between at least five groups (for aluminum $F_{5, 17}$ = [14.205], P = 0.000, for arsenic $F_{5, 17}$ = [2.410], P = 0.050, for beryllium $F_{5, 17}$ = [11.909], P = 0.000, for iron $F_{5, 17}$ = [5.832], P = 0.000, for manganese $F_{5, 17}$ = [5.633], P = 0.000, for lead $F_{5, 17}$ = [9.771], P = 0.000, for vanadium $F_{5, 17}$ = [4.276], P = 0.003, for zinc $F_{5, 17}$ = [6.053], P = 0.000, Table B.8).

There was statistically significant difference in mean values of beryllium in fruit between at least five groups (for beryllium $F_{5, 17}$ = [3.035], P = 0.020, Table B.9).

Based on the heavy metal concentration level, it was determined that the contents of all heavy metal in the parts (i.e., soil, fruit, plant) were within permissible concentration levels [118], [119], [120].

Ogundele [116] found Cd, Cr, Cu, Ni, Pb, and Zn concentration levels of the plant in his study. Cadmium and zinc (i.e., for Cd, < 0.028 mg/kg, for Zn, 117.8 ± 0.035 mg/kg) concentration was higher compared to this study, whereas other heavy metal concentration levels were lower (i.e., for Cr, 0.078 mg/kg, for Cu, 37.6 ± 0.005 mg/kg, for Pb, 142.5 ±

0.004 mg/kg, and for Ni, 3.90 ± 0.003 mg/kg). Chen [117] found Cd, Co, Cr, Ni, Pb, and Zn concentration levels of the plant in his study. Only cadmium (0.09 mg/kg) concentration was higher compared to this study, whereas other heavy metal concentration levels were lower (i.e., for Co, 5.98 mg/kg, for Cr, 0.75 mg/kg, for Ni, 2.36 mg/kg, for Pb, 9.01 mg/kg, and for Zn, 9.90 mg/kg). Furthermore, For the fruit part, only lead (2.11 mg/kg) concentration was lower compared to this study, whereas other heavy metal concentration levels were higher (i.e., for As, 0.6 mg/kg, for Cd, 0.11 mg/kg, for Cr, 0.26 mg/kg, for Cu, 3.52 mg/kg, for Ni, 0.95 mg/kg, and for Zn, 27.7 mg/kg).

Table 3.22 Weighted average concentrations (μg/kg) of heavy metals in whole plant (i.e., root, crown, lower stem, upper stem, leaf, truss, and fruit)

HM	T_0	T_1	T_2	T_3	T_4	T_5
Al	58.830	59.832	47.626	69.183	78.197	94.720
As	1.580	1.630	2.068	1.742	1.907	1.922
Be	0.007	0.008	0.005	0.136	0.050	0.021
Cd	-	-	-	-	-	-
Co	0.447	0.488	0.357	0.485	0.295	0.313
Cr	0.009	0.011	0.011	0.001	0.020	0.046
Cu	5.749	4.475	4.793	6.026	7.999	5.804
Fe	39.270	56.816	38.226	43.135	36.897	61.568
Mn	54.966	51.376	44.948	51.979	44.968	45.730
Ni	0.490	0.397	0.322	0.456	0.293	0.415
Pb	30.669	28.132	30.716	34.454	31.888	33.520
Se	-	-	-	-	-	-
V	0.205	0.243	0.201	0.304	0.201	0.258
Zn	20.025	14.680	14.423	15.755	16.361	20.019

HM: Heavy Metal, T: Treatment, “-“ Not Detected,
Al: Aluminum, As: Arsenic, Be: Beryllium, Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc

Table 3.23 Weighted average concentrations (μg/kg) of heavy metals in whole plant (i.e., root, crown, lower stem, upper stem, leaf, truss, and fruit) by treatments expressed by descriptive statistics

HM	Treatment	Mean	SD	SE	Min	Max
Al	T_0	59.22	14.96	8.64	49.83	76.47
	T_1	59.04	22.64	13.07	44.86	85.14
	T_2	47.62	4.10	2.37	43.60	51.79
	T_3	69.08	5.14	2.97	63.55	73.71
	T_4	77.69	14.29	8.25	64.77	93.04
	T_5	92.91	6.68	3.86	86.68	99.97
As	T_0	1.59	0.04	0.02	1.54	1.62
	T_1	1.63	0.32	0.18	1.27	1.81
	T_2	2.06	0.08	0.05	1.96	2.13
	T_3	1.73	0.59	0.34	1.34	2.41
	T_4	1.91	0.33	0.19	1.59	2.26
	T_5	1.90	0.27	0.16	1.66	2.20
Be	T_0	0.007	0.002	0.001	0.005	0.009
	T_1	0.008	0.003	0.001	0.005	0.010
	T_2	0.005	0.002	0.001	0.004	0.007
	T_3	0.135	0.158	0.091	0.029	0.317
	T_4	0.050	0.026	0.015	0.032	0.080
	T_5	0.021	0.004	0.002	0.017	0.025
Co	T_0	0.45	0.03	0.02	0.42	0.48
	T_1	0.49	0.18	0.10	0.29	0.63
	T_2	0.36	0.12	0.07	0.23	0.47
	T_3	0.48	0.22	0.13	0.32	0.74
	T_4	0.29	0.03	0.02	0.27	0.33
	T_5	0.31	0.06	0.04	0.26	0.38

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt
Cadmium (Cd) and Selenium (Se) were not detected.

Table 3.23 Continued

HM	Treatment	Mean	SD	SE	Min	Max
Cr	T_0	0.008	0.007	0.004	0.004	0.017
	T_1	0.012	0.006	0.003	0.006	0.018
	T_2	0.011	0.011	0.006	0.002	0.023
	T_3	0.001	0.001	0.001	0.000	0.003
	T_4	0.020	0.017	0.010	0.001	0.032
	T_5	0.048	0.026	0.015	0.019	0.067
Cu	T_0	5.73	1.12	0.64	4.45	6.41
	T_1	4.45	0.73	0.42	3.71	5.17
	T_2	4.78	0.75	0.44	4.33	5.65
	T_3	5.99	1.19	0.69	5.16	7.36
	T_4	7.95	2.04	1.18	5.67	9.62
	T_5	5.76	0.52	0.30	5.40	6.36
Fe	T_0	39.35	10.38	5.99	30.86	50.92
	T_1	55.84	33.60	19.40	35.35	94.61
	T_2	38.32	2.67	1.54	36.02	41.26
	T_3	43.00	5.32	3.07	38.96	49.03
	T_4	36.79	4.80	2.77	31.43	40.65
	T_5	60.36	3.67	2.12	57.43	64.47
Mn	T_0	54.88	3.49	2.01	50.98	57.70
	T_1	51.03	10.54	6.09	42.24	62.72
	T_2	45.45	11.07	6.39	32.70	52.57
	T_3	51.89	6.07	3.50	46.49	58.46
	T_4	44.83	2.26	1.31	42.58	47.10
	T_5	45.21	3.19	1.84	42.88	48.85

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese
Cadmium (Cd) and Selenium (Se) were not detected.

Table 3.23 Continued

HM	Treatment	Mean	SD	SE	Min	Max
Ni	T_0	0.49	0.17	0.10	0.29	0.59
	T_1	0.40	0.14	0.08	0.25	0.53
	T_2	0.32	0.13	0.08	0.21	0.47
	T_3	0.45	0.34	0.20	0.20	0.84
	T_4	0.29	0.06	0.03	0.23	0.35
	T_5	0.42	0.05	0.03	0.36	0.45
Pb	T_0	30.63	1.98	1.14	28.35	31.81
	T_1	27.82	1.53	0.88	26.74	29.57
	T_2	30.53	2.48	1.43	27.75	32.50
	T_3	34.45	3.08	1.78	31.57	37.70
	T_4	31.84	2.30	1.33	29.67	34.25
	T_5	33.72	7.89	4.56	25.01	40.37
V	T_0	0.21	0.03	0.01	0.18	0.23
	T_1	0.24	0.09	0.05	0.18	0.35
	T_2	0.20	0.01	0.00	0.19	0.21
	T_3	0.30	0.16	0.09	0.20	0.48
	T_4	0.20	0.01	0.01	0.19	0.21
	T_5	0.26	0.02	0.01	0.24	0.28
Zn	T_0	20.01	2.26	1.30	17.40	21.45
	T_1	14.68	1.99	1.15	12.49	16.38
	T_2	14.53	2.98	1.72	11.52	17.47
	T_3	15.70	3.58	2.07	12.65	19.65
	T_4	16.32	0.30	0.18	15.99	16.60
	T_5	19.54	2.72	1.57	17.29	22.56

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc
Cadmium (Cd) and Selenium (Se) were not detected.

Table 3.24 One-way ANOVA results of weighted average concentrations (μg/kg) of heavy metals in whole plant (i.e., root, crown, lower stem, upper stem, leaf, truss, and fruit)

HM		Sum of Squares	dF	Mean Squares	F	Sig
Al	Between G	3,862	5	772	4.508	0.015*
	Within G	2,056	12	171		
	Total	5,918	17			
As	Between G	0.50	5	0.101	0.950	0.484
	Within G	1.27	12	0.106		
	Total	1.78	17			
Be	Between G	0.039	5	0.008	1.807	0.186
	Within G	0.051	12	0.004		
	Total	0.090	17			
Co	Between G	0.115	5	0.023	1.365	0.304
	Within G	0.202	12	0.017		
	Total	0.317	17			
Cr	Between G	0.00	5	0.001	4.270	0.018*
	Within G	0.00	12	0.000		
	Total	0.01	17			
Cu	Between G	22.51	5	4.503	3.292	0.042*
	Within G	16.41	12	1.368		
	Total	38.92	17			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Cadmium (Cd) and Selenium (Se) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table 3.24 Continued

HM		Sum of Squares	dF	Mean Squares	F	Sig
Fe	Between G	1,497	5	299	1.373	0.301
	Within G	2,617	12	218		
	Total	4,114	17			
Mn	Between G	274	5	54.740	1.102	0.409
	Within G	596	12	49.666		
	Total	870	17			
Ni	Between G	0.08	5	0.017	0.544	0.740
	Within G	0.37	12	0.031		
	Total	0.46	17			
Pb	Between G	87.07	5	17.413	1.168	0.380
	Within G	178.95	12	14.912		
	Total	266.01	17			
V	Between G	0.02	5	0.005	0.864	0.532
	Within G	0.07	12	0.006		
	Total	0.09	17			
Zn	Between G	86.64	5	17.327	2.716	0.072
	Within G	76.55	12	6.379		
	Total	163.18	17			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc
Cadmium (Cd) and Selenium (Se) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table 3.25 Concentration level (μg/kg) of heavy metals in T_0 treatment by plant parts expressed by descriptive statistics

Plant Part	HM	Mean	SD	SE	Min	Max	HM	Mean	SD	SE	Min	Max
Root	Al	147.84	95.33	38.92	46.52	323.92	Co	0.47	0.18	0.07	0.28	0.77
Crown		115.79	13.36	7.71	100.99	126.96		0.50	0.26	0.15	0.22	0.72
Lower S.		19.57	1.56	0.90	17.78	20.68		0.39	0.05	0.03	0.34	0.43
Upper S.		21.51	3.28	1.34	18.13	26.86		0.46	0.06	0.02	0.39	0.56
Leaf		125.12	30.76	10.25	101.16	177.55		0.50	0.05	0.02	0.44	0.58
Truss		41.97	-	-	-	-		0.30	-	-	-	-
Fruit		21.79	11.48	4.34	11.11	46.10		0.20	0.09	0.03	0.12	0.37
Root	As	2.91	1.31	0.53	1.84	4.92	Cr	0.27	0.25	0.10	0.00	0.65
Crown		2.54	1.00	0.57	1.55	3.54		0.46	0.49	0.29	0.07	1.01
Lower S.		0.94	0.07	0.04	0.89	1.01		-	-	-	-	-
Upper S.		0.96	0.20	0.08	0.77	1.24		-	-	-	-	-
Leaf		2.92	0.09	0.03	2.77	3.05		-	-	-	-	-
Truss		0.56	-	-	-	-		-	-	-	-	-
Fruit		0.19	0.04	0.02	0.13	0.26		-	-	-	-	-
Root	Be	0.02	0.01	0.00	0.00	0.03	Cu	6.53	2.32	0.95	3.96	9.79
Crown		0.03	0.01	0.01	0.02	0.03		7.34	4.30	2.49	2.37	9.89
Lower S.		0.01	0.01	0.00	0.00	0.02		14.44	12.40	7.16	6.42	28.72
Upper S.		0.00	0.00	0.00	0.00	0.01		3.90	0.56	0.23	3.17	4.46
Leaf		0.01	0.00	0.00	0.01	0.01		8.39	1.80	0.60	6.04	11.01
Truss		-	-	-	-	-		2.13	-	-	-	-
Fruit		0.02	0.01	0.00	0.01	0.03		4.98	1.48	0.56	2.82	7.74

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, S: Stem
Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper
Cadmium (Cd) and Selenium (Se) were not detected.

Table 3.25 Continued

Plant Part	HM	Mean	SD	SE	Min	Max	HM	Mean	SD	SE	Min	Max
Root	Fe	111.66	71.45	29.17	37.91	244.39	Pb	37.21	15.80	6.45	22.97	61.07
Crown		88.30	9.42	5.44	77.44	94.13		41.07	12.52	7.23	27.24	51.64
Lower S.		12.75	11.31	6.53	-	21.60		32.56	6.22	3.59	28.37	39.71
Upper S.		4.77	5.48	2.24	-	13.80		30.46	1.96	0.80	28.19	32.62
Leaf		97.72	14.82	4.94	75.05	113.16		38.62	2.72	0.91	35.33	42.16
Truss		11.92	-	-	-	-		27.95	-	-	-	-
Fruit		14.83	5.00	1.89	8.16	22.67		2.56	1.20	0.46	0.76	3.94
Root	Mn	30.97	10.37	4.23	22.15	50.72	V	1.39	0.46	0.19	0.87	2.11
Crown		23.26	3.85	2.22	19.05	26.58		0.65	0.28	0.16	0.48	0.97
Lower S.		13.23	2.84	1.64	11.49	16.51		0.12	0.02	0.01	0.10	0.14
Upper S.		29.20	3.08	1.26	24.70	33.38		0.10	0.02	0.01	0.07	0.13
Leaf		112.62	9.27	3.09	96.38	123.59		0.36	0.05	0.02	0.29	0.46
Truss		33.73	-	-	-	-		0.07	-	-	-	-
Fruit		11.37	1.56	0.59	9.51	13.42		0.03	0.01	0.00	0.02	0.05
Root	Ni	1.72	0.57	0.23	1.23	2.78	Zn	22.02	4.77	1.95	15.43	29.64
Crown		1.25	0.57	0.33	0.78	1.88		33.75	14.39	8.31	17.32	44.12
Lower S.		0.16	0.12	0.07	0.07	0.30		36.68	6.86	3.96	29.49	43.15
Upper S.		0.26	0.19	0.08	0.06	0.51		16.98	2.41	0.98	13.36	20.33
Leaf		0.92	0.22	0.07	0.56	1.17		23.64	2.68	0.89	19.54	27.29
Truss		0.41	-	-	-	-		10.54	-	-	-	-
Fruit		0.07	0.09	0.03	-	0.24		19.47	2.55	0.96	16.92	23.75

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, S: Stem

Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc

Cadmium (Cd) and Selenium (Se) were not detected.

Table 3.26 Concentration level (μg/kg) of heavy metals in T_1 treatment by plant parts expressed by descriptive statistics

Plant Part	HM	Mean	SD	SE	Min	Max	HM	Mean	SD	SE	Min	Max
Root	Al	237.92	93.03	37.98	114.64	397.86	Co	0.63	0.18	0.07	0.32	0.86
Crown		196.37	9.45	5.45	187.91	206.57		0.57	0.15	0.09	0.43	0.73
Lower S.		68.81	10.68	6.16	61.15	81.01		0.44	0.06	0.04	0.37	0.49
Upper S.		27.80	9.10	3.72	19.13	40.87		0.45	0.17	0.07	0.20	0.67
Leaf		121.89	56.17	18.72	71.34	207.43		0.71	0.69	0.23	0.39	2.52
Truss		143.72	-	-	-	-		0.38	-	-	-	-
Fruit		15.15	6.34	2.24	8.21	24.89		0.18	0.12	0.04	0.08	0.45
Root	As	5.02	1.76	0.72	2.25	7.20	Cr	0.29	0.21	0.08	0.05	0.59
Crown		4.53	1.56	0.90	3.04	6.15		0.44	0.48	0.28	0.06	0.98
Lower S.		1.38	0.28	0.16	1.09	1.66		-	-	-	-	-
Upper S.		1.17	0.39	0.16	0.49	1.61		-	-	-	-	-
Leaf		2.89	0.42	0.14	2.38	3.48		-	-	-	-	-
Truss		0.91	-	-	-	-		-	-	-	-	-
Fruit		0.21	0.08	0.03	0.11	0.35		-	-	-	-	-
Root	Be	0.02	0.01	0.00	0.01	0.03	Cu	9.14	2.27	0.93	5.17	11.54
Crown		0.02	0.01	0.00	0.01	0.02		8.69	2.22	1.28	6.39	10.82
Lower S.		0.01	0.00	0.00	0.01	0.01		7.14	1.64	0.95	5.48	8.76
Upper S.		0.00	0.00	0.00	-	0.01		3.02	1.26	0.52	0.68	4.12
Leaf		0.01	0.01	0.00	0.00	0.02		6.73	1.43	0.48	4.74	8.47
Truss		-	-	-	-	-		3.78	-	-	-	-
Fruit		0.02	0.01	0.00	0.01	0.03		3.86	1.47	0.52	2.38	7.09

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, S: Stem

Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper

Cadmium (Cd) and Selenium (Se) were not detected.

Table 3.26 Continued

Plant Part	HM	Mean	SD	SE	Min	Max	HM	Mean	SD	SE	Min	Max
Root	Fe	179.91	70.94	28.96	86.27	302.43	Pb	53.71	12.63	5.16	37.03	73.54
Crown		168.70	27.13	15.66	144.71	198.14		52.47	5.71	3.30	47.01	58.40
Lower S.		93.30	31.43	18.14	66.39	127.84		38.12	1.42	0.82	36.70	39.54
Upper S.		16.87	19.26	7.86	-	41.70		28.84	5.92	2.42	18.79	34.04
Leaf		134.34	70.80	23.60	75.78	230.14		37.54	7.73	2.58	24.72	45.79
Truss		79.98	-	-	-	-		41.49	-	-	-	-
Fruit		15.11	3.78	1.34	11.11	21.29		2.37	1.15	0.41	0.91	4.09
Root	Mn	38.67	9.16	3.74	26.82	53.44	V	1.77	0.66	0.27	0.76	2.62
Crown		25.95	3.86	2.23	22.69	30.21		0.81	0.17	0.10	0.70	1.01
Lower S.		17.34	1.49	0.86	15.66	18.52		0.30	0.05	0.03	0.26	0.36
Upper S.		34.99	11.69	4.77	16.17	48.60		0.13	0.06	0.02	0.06	0.21
Leaf		105.18	20.44	6.81	79.03	131.66		0.44	0.22	0.07	0.26	0.76
Truss		43.77	-	-	-	-		0.24	-	-	-	-
Fruit		11.77	1.89	0.67	8.00	14.57		0.02	0.01	0.00	0.01	0.03
Root	Ni	1.36	0.95	0.39	0.44	2.99	Zn	15.34	3.99	1.63	11.47	22.76
Crown		1.13	0.56	0.33	0.68	1.77		22.57	2.60	1.50	19.57	24.15
Lower S.		0.38	0.14	0.08	0.22	0.50		22.03	4.76	2.75	16.88	26.29
Upper S.		0.16	0.15	0.06	-	0.39		10.27	3.23	1.32	4.13	13.35
Leaf		0.93	1.14	0.38	0.18	3.90		19.96	1.64	0.55	17.63	23.12
Truss		0.35	-	-	-	-		10.01	-	-	-	-
Fruit		0.00	0.01	0.00	-	0.03		17.64	2.98	1.05	14.81	24.65

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, S: Stem

Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc

Cadmium (Cd) and Selenium (Se) were not detected.

Table 3.27 Concentration level (μg/kg) of heavy metals in T_2 treatment by plant parts expressed by descriptive statistics

Plant Part	HM	Mean	SD	SE	Min	Max	HM	Mean	SD	SE	Min	Max
Root	Al	277.22	47.79	19.51	196.37	317.85	Co	0.58	0.14	0.06	0.42	0.77
Crown		308.03	365.02	210.75	85.13	729.29		0.49	0.19	0.11	0.31	0.68
Lower S.		51.92	14.03	8.10	35.83	61.58		0.40	0.08	0.05	0.31	0.48
Upper S.		25.33	4.44	1.81	19.28	30.97		0.39	0.11	0.05	0.23	0.49
Leaf		79.77	11.87	3.96	60.76	98.71		0.38	0.11	0.04	0.25	0.52
Truss		38.58	-	-	-	-		0.18	-	-	-	-
Fruit		18.71	9.71	3.43	9.61	35.88		0.15	0.06	0.02	0.06	0.23
Root	As	5.56	0.71	0.29	4.39	6.50	Cr	0.46	0.26	0.11	0.12	0.82
Crown		5.15	2.37	1.37	2.93	7.64		0.47	0.59	0.34	-	1.14
Lower S.		1.51	0.60	0.35	1.09	2.20		-	-	-	-	-
Upper S.		1.66	0.22	0.09	1.33	1.88		-	-	-	-	-
Leaf		3.39	0.37	0.12	2.85	3.81		-	-	-	-	-
Truss		1.05	-	-	-	-		-	-	-	-	-
Fruit		0.23	0.07	0.02	0.14	0.33		-	-	-	-	-
Root	Be	0.01	0.01	0.01	-	0.03	Cu	7.32	0.77	0.31	6.09	8.14
Crown		0.02	0.02	0.01	0.00	0.05		7.64	2.50	1.44	4.88	9.77
Lower S.		0.01	0.00	0.00	0.00	0.01		12.47	6.61	3.82	6.58	19.62
Upper S.		0.00	0.00	0.00	-	0.00		3.88	0.63	0.26	3.24	4.91
Leaf		0.01	0.00	0.00	0.00	0.01		6.21	1.19	0.40	4.05	8.03
Truss		-	-	-	-	-		1.62	-	-	-	-
Fruit		0.01	0.00	0.00	0.00	0.02		3.80	1.51	0.53	2.12	6.14

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, S: Stem

Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper

Cadmium (Cd) and Selenium (Se) were not detected.

Table 3.27 Continued

Plant Part	HM	Mean	SD	SE	Min	Max	HM	Mean	SD	SE	Min	Max
Root	Fe	207.51	37.62	15.36	142.64	245.29	Pb	46.62	6.62	2.70	40.42	57.33
Crown		258.47	312.40	180.36	75.02	619.18		43.50	17.97	10.37	22.79	54.84
Lower S.		60.77	34.74	20.06	38.58	100.81		40.13	5.56	3.21	35.10	46.10
Upper S.		10.31	5.87	2.39	4.59	19.71		34.07	4.21	1.72	27.48	39.54
Leaf		76.49	4.78	1.59	66.64	82.76		35.87	6.00	2.00	26.84	45.04
Truss		7.85	-	-	-	-		30.45	-	-	-	-
Fruit		24.35	15.63	5.53	13.29	58.82		2.54	0.99	0.35	1.06	4.09
Root	Mn	33.72	2.38	0.97	30.85	37.05	V	2.51	0.52	0.21	1.62	2.97
Crown		26.56	9.50	5.48	20.29	37.49		1.18	1.05	0.61	0.41	2.37
Lower S.		15.30	3.95	2.28	12.18	19.74		0.24	0.05	0.03	0.20	0.30
Upper S.		30.82	6.73	2.75	22.08	36.91		0.12	0.01	0.01	0.11	0.14
Leaf		88.01	14.60	4.87	66.32	103.87		0.28	0.02	0.01	0.22	0.30
Truss		19.34	-	-	-	-		0.06	-	-	-	-
Fruit		11.38	2.39	0.84	8.36	14.61		0.05	0.03	0.01	0.02	0.12
Root	Ni	1.53	0.25	0.10	1.07	1.71	Zn	11.78	2.97	1.21	7.98	15.10
Crown		1.39	0.62	0.36	1.02	2.10		15.18	3.72	2.15	12.30	19.38
Lower S.		0.32	0.13	0.08	0.21	0.47		21.16	4.93	2.85	15.80	25.51
Upper S.		0.23	0.22	0.09	-	0.62		12.25	7.11	2.90	7.71	26.53
Leaf		0.53	0.13	0.04	0.35	0.76		16.25	2.18	0.73	11.64	18.04
Truss		0.21	-	-	-	-		5.26	-	-	-	-
Fruit		0.00	0.00	0.00	-	0.01		18.27	3.30	1.17	13.34	24.31

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, S: Stem

Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc

Cadmium (Cd) and Selenium (Se) were not detected.

Table 3.28 Concentration level (μg/kg) of heavy metals in T_3 treatment by plant parts expressed by descriptive statistics

Plant Part	HM	Mean	SD	SE	Min	Max	HM	Mean	SD	SE	Min	Max
Root		186.49	81.24	33.17	63.23	308.64		0.31	0.11	0.05	0.12	0.46
Crown		95.84	63.08	36.42	46.67	166.96		0.25	0.08	0.05	0.20	0.34
Lower S.		29.34	14.77	8.53	20.16	46.38		0.49	0.11	0.06	0.37	0.57
Upper S.	Al	19.22	4.52	1.85	13.65	26.59	Co	0.58	0.40	0.16	0.27	1.31
Leaf		181.96	38.81	12.94	144.84	278.15		0.48	0.09	0.03	0.35	0.59
Truss		52.28	-	-	-	-		0.24	-	-	-	-
Fruit		18.70	6.10	2.03	10.21	25.83		0.16	0.08	0.03	0.07	0.29
Root		2.79	0.77	0.32	1.43	3.48		0.13	0.19	0.08	-	0.48
Crown		2.35	0.65	0.37	1.64	2.90		0.00	0.01	0.00	-	0.01
Lower S.		1.14	0.16	0.09	0.96	1.26		-	-	-	-	-
Upper S.	As	1.32	0.65	0.26	0.49	2.05	Cr	-	-	-	-	-
Leaf		3.22	0.85	0.28	2.25	4.59		-	-	-	-	-
Truss		0.47	-	-	-	-		-	-	-	-	-
Fruit		0.19	0.08	0.03	0.09	0.38		-	-	-	-	-
Root		0.01	0.00	0.00	0.00	0.01		5.25	2.31	0.94	0.76	6.74
Crown		0.01	0.01	0.01	0.00	0.02		4.35	1.74	1.00	2.44	5.83
Lower S.		0.06	0.08	0.05	0.01	0.16		7.76	0.40	0.23	7.41	8.19
Upper S.	Be	0.20	0.29	0.12	0.01	0.76	Cu	4.11	0.85	0.35	3.34	5.57
Leaf		0.10	0.08	0.03	0.01	0.27		9.88	2.05	0.68	7.56	13.30
Truss		-	-	-	-	-		3.04	-	-	-	-
Fruit		0.01	0.01	0.00	0.00	0.02		5.39	2.38	0.79	3.47	9.32

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, S: Stem

Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper

Cadmium (Cd) and Selenium (Se) were not detected.

Table 3.28 Continued

Plant Part	HM	Mean	SD	SE	Min	Max	HM	Mean	SD	SE	Min	Max
Root		133.41	62.60	25.56	37.04	225.39		31.78	14.35	5.86	14.60	50.75
Crown		71.44	43.57	25.16	39.89	121.16		28.43	6.40	3.69	24.22	35.79
Lower S.		41.41	16.76	9.68	31.14	60.75		31.26	7.68	4.43	22.87	37.94
Upper S.	Fe	15.41	10.38	4.24	8.66	35.54	Pb	34.22	0.25	0.10	33.86	34.57
Leaf		100.44	4.60	1.53	93.39	110.61		50.27	9.51	3.17	38.64	65.52
Truss		16.77	-	-	-	-		35.97	-	-	-	-
Fruit		21.34	15.24	5.08	9.71	54.15		2.44	1.37	0.46	0.45	4.40
Root		21.58	7.87	3.21	7.61	28.10		1.71	0.75	0.30	0.62	2.84
Crown		14.19	3.48	2.01	11.83	18.19		0.46	0.15	0.09	0.36	0.63
Lower S.		12.05	2.84	1.64	8.99	14.60		0.23	0.05	0.03	0.18	0.28
Upper S.	Mn	30.10	6.08	2.48	25.09	37.96	V	0.33	0.32	0.13	0.10	0.96
Leaf		115.36	9.45	3.15	100.19	130.31		0.33	0.06	0.02	0.26	0.41
Truss		29.65	-	-	-	-		0.06	-	-	-	-
Fruit		13.10	5.19	1.73	7.76	26.16		0.04	0.02	0.01	0.03	0.09
Root		1.03	0.52	0.21	0.15	1.73		10.54	4.72	1.93	1.36	14.05
Crown		0.34	0.16	0.09	0.16	0.44		14.22	6.33	3.65	7.52	20.09
Lower S.		0.49	0.35	0.20	0.15	0.85		23.32	5.04	2.91	20.24	29.13
Upper S.	Ni	0.41	0.55	0.22	0.00	1.37	Zn	10.92	3.67	1.50	7.56	16.56
Leaf		0.73	0.19	0.06	0.49	1.08		21.70	3.22	1.07	17.60	26.38
Truss		0.12	-	-	-	-		11.22	-	-	-	-
Fruit		0.05	0.08	0.03	-	0.23		21.79	7.86	2.62	16.54	41.13

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, S: Stem

Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc

Cadmium (Cd) and Selenium (Se) were not detected.

Table 3.29 Concentration level (μg/kg) of heavy metals in T_4 treatment by plant parts expressed by descriptive statistics

Plant Part	HM	Mean	SD	SE	Min	Max	HM	Mean	SD	SE	Min	Max
Root	Al	496.57	199.29	81.36	278.51	779.08	Co	0.59	0.13	0.05	0.40	0.72
Crown		233.84	99.19	57.27	127.07	323.13		0.36	0.12	0.07	0.22	0.44
Lower S.		18.23	2.43	1.40	16.71	21.03		0.34	0.03	0.02	0.31	0.37
Upper S.		19.53	2.99	1.22	16.06	23.60		0.29	0.04	0.02	0.25	0.35
Leaf		197.11	45.98	15.33	129.76	250.37		0.38	0.06	0.02	0.30	0.48
Truss		31.49	-	-	-	-		0.19	-	-	-	-
Fruit		13.77	7.16	2.39	7.52	29.79		0.15	0.06	0.02	0.07	0.26
Root	As	4.30	0.59	0.24	3.75	5.21	Cr	0.85	0.70	0.29	0.02	1.90
Crown		2.50	0.07	0.04	2.46	2.58		0.54	0.48	0.28	-	0.92
Lower S.		1.90	0.57	0.33	1.55	2.56		-	-	-	-	-
Upper S.		1.49	0.19	0.08	1.15	1.69		-	-	-	-	-
Leaf		3.52	0.47	0.16	2.81	4.33		-	-	-	-	-
Truss		0.70	-	-	-	-		-	-	-	-	-
Fruit		0.20	0.06	0.02	0.15	0.29		-	-	-	-	-
Root	Be	0.03	0.01	0.01	0.01	0.05	Cu	7.99	1.92	0.79	5.15	10.02
Crown		0.00	0.01	0.00	-	0.01		6.42	2.01	1.16	4.20	8.12
Lower S.		0.11	0.10	0.06	0.04	0.23		8.36	0.50	0.29	7.94	8.91
Upper S.		0.08	0.04	0.02	0.05	0.15		6.34	4.16	1.70	3.30	14.57
Leaf		0.03	0.01	0.00	0.01	0.04		12.87	13.24	4.41	6.83	47.87
Truss		-	-	-	-	-		3.50	-	-	-	-
Fruit		0.01	0.00	0.00	0.01	0.01		4.96	3.58	1.19	2.66	14.34

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, S: Stem

Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper

Cadmium (Cd) and Selenium (Se) were not detected.

Table 3.29 Continued

Plant Part	HM	Mean	SD	SE	Min	Max	HM	Mean	SD	SE	Min	Max
Root	Fe	372.35	153.08	62.49	185.63	571.60	Pb	53.51	11.10	4.53	37.57	68.20
Crown		184.66	83.77	48.37	91.05	252.56		48.67	14.03	8.10	38.28	64.63
Lower S.		16.73	7.23	4.17	12.24	25.06		33.61	3.33	1.92	31.69	37.45
Upper S.		3.15	1.42	0.58	1.92	5.76		32.43	3.77	1.54	25.78	36.70
Leaf		87.90	6.30	2.10	80.76	97.71		45.88	3.88	1.29	39.88	50.57
Truss		11.66	-	-	-	-		25.82	-	-	-	-
Fruit		15.71	6.76	2.25	8.83	31.37		2.36	0.98	0.33	0.76	4.40
Root	Mn	42.10	24.65	10.06	19.31	78.02	V	3.46	0.94	0.38	2.72	4.97
Crown		25.46	8.86	5.12	15.67	32.94		0.91	0.22	0.12	0.66	1.07
Lower S.		10.62	1.23	0.71	9.31	11.76		0.17	0.04	0.02	0.13	0.22
Upper S.		27.96	4.10	1.67	22.96	32.87		0.10	0.03	0.01	0.07	0.13
Leaf		97.11	6.82	2.27	86.89	105.73		0.30	0.05	0.02	0.25	0.40
Truss		26.76	-	-	-	-		0.11	-	-	-	-
Fruit		13.02	5.13	1.71	8.16	22.96		0.04	0.01	0.00	0.02	0.06
Root	Ni	1.36	0.34	0.14	1.10	1.94	Zn	15.03	2.67	1.09	11.70	19.66
Crown		0.87	0.37	0.21	0.52	1.25		16.62	5.29	3.05	11.31	21.88
Lower S.		0.45	0.26	0.15	0.24	0.74		22.24	4.52	2.61	18.40	27.22
Upper S.		0.22	0.22	0.09	0.06	0.65		12.87	1.65	0.67	10.70	14.82
Leaf		0.47	0.22	0.07	0.10	0.77		20.46	1.80	0.60	18.03	22.78
Truss		0.04	-	-	-	-		12.07	-	-	-	-
Fruit		0.07	0.12	0.04	-	0.29		19.93	6.27	2.09	14.91	35.14

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, S: Stem

Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc

Cadmium (Cd) and Selenium (Se) were not detected.

Table 3.30 Concentration level (μg/kg) of heavy metals in T_5 treatment by plant parts expressed by descriptive statistics

Plant Part	HM	Mean	SD	SE	Min	Max	HM	Mean	SD	SE	Min	Max
Root	Al	328.86	163.58	66.78	120.96	536.95	Co	0.47	0.14	0.06	0.30	0.68
Crown		500.92	271.76	156.90	302.02	810.56		0.68	0.25	0.14	0.43	0.93
Lower S.		28.81	8.49	4.90	19.73	36.56		0.32	0.08	0.05	0.25	0.41
Upper S.		15.59	3.52	1.44	10.40	19.86		0.27	0.06	0.02	0.21	0.34
Leaf		226.94	61.54	20.51	133.75	328.08		0.43	0.09	0.03	0.26	0.57
Truss		30.36	-	-	-	-		0.19	-	-	-	-
Fruit		15.57	7.82	2.96	8.55	31.56		0.14	0.06	0.02	0.07	0.20
Root	As	5.04	1.13	0.46	3.57	6.53	Cr	0.50	0.26	0.10	0.24	0.91
Crown		4.27	1.63	0.94	2.52	5.74		2.34	1.26	0.73	1.02	3.52
Lower S.		1.41	0.31	0.18	1.06	1.62		-	-	-	-	-
Upper S.		1.27	0.27	0.11	0.90	1.58		-	-	-	-	-
Leaf		3.47	0.65	0.22	2.52	4.33		-	-	-	-	-
Truss		0.97	-	-	-	-		-	-	-	-	-
Fruit		0.20	0.05	0.02	0.12	0.26		-	-	-	-	-
Root	Be	0.02	0.02	0.01	-	0.04	Cu	7.60	1.85	0.75	4.91	10.46
Crown		0.03	0.01	0.01	0.02	0.04		9.44	0.16	0.09	9.25	9.55
Lower S.		0.04	0.01	0.01	0.02	0.05		7.52	1.01	0.59	6.93	8.69
Upper S.		0.02	0.01	0.00	0.01	0.04		4.00	1.04	0.42	2.89	5.09
Leaf		0.02	0.01	0.00	0.01	0.03		8.78	1.19	0.40	7.12	10.37
Truss		-	-	-	-	-		3.24	-	-	-	-
Fruit		0.01	0.01	0.00	0.00	0.02		4.75	0.76	0.29	3.99	6.12

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, S: Stem

Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper

Cadmium (Cd) and Selenium (Se) were not detected.

Table 3.30 Continued

Plant Part	HM	Mean	SD	SE	Min	Max	HM	Mean	SD	SE	Min	Max
Root		247.32	113.31	46.26	102.85	390.91		48.97	11.24	4.59	38.46	68.55
Crown		479.42	259.76	149.97	217.44	736.91		52.94	13.38	7.72	44.69	68.37
Lower S.		23.34	10.17	5.87	15.29	34.77		30.43	1.82	1.05	28.66	32.30
Upper S.	Fe	2.49	1.89	0.77	0.17	4.51	Pb	29.29	7.69	3.14	20.17	42.00
Leaf		149.01	44.40	14.80	89.64	207.91		51.12	6.46	2.15	40.77	62.85
Truss		18.85	-	-	-	-		26.35	-	-	-	-
Fruit		12.38	3.35	1.27	9.43	18.32		3.53	0.43	0.16	2.88	3.94
Root		24.45	6.02	2.46	17.79	34.16		2.11	0.65	0.27	1.39	3.08
Crown		23.44	9.74	5.62	16.83	34.63		1.33	0.69	0.40	0.89	2.12
Lower S.		10.67	0.35	0.20	10.34	11.03		0.19	0.01	0.00	0.18	0.20
Upper S.	Mn	24.42	4.23	1.73	17.26	28.56	V	0.11	0.02	0.01	0.08	0.13
Leaf		98.07	13.03	4.34	81.32	118.04		0.47	0.14	0.05	0.34	0.71
Truss		29.66	-	-	-	-		0.08	-	-	-	-
Fruit		10.81	2.01	0.76	8.99	14.06		0.03	0.01	0.00	0.02	0.05
Root		1.06	0.48	0.20	0.58	1.81		14.12	2.24	0.91	10.81	17.52
Crown		1.72	0.61	0.35	1.06	2.26		21.57	0.76	0.44	20.82	22.33
Lower S.		0.41	0.20	0.12	0.23	0.63		20.95	8.32	4.80	13.93	30.14
Upper S.	Ni	0.20	0.07	0.03	0.07	0.26	Zn	12.70	6.53	2.67	7.84	25.10
Leaf		0.80	0.11	0.04	0.65	1.00		31.90	14.87	4.96	17.23	54.86
Truss		0.40	-	-	-	-		10.95	-	-	-	-
Fruit		0.07	0.05	0.02	-	0.14		19.97	3.43	1.30	17.45	27.25

HM: Heavy Metal, SD: Standard Deviation, SE: Standard Error, Min: Minimum, Max: Maximum, S: Stem

Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc

Cadmium (Cd) and Selenium (Se) were not detected.

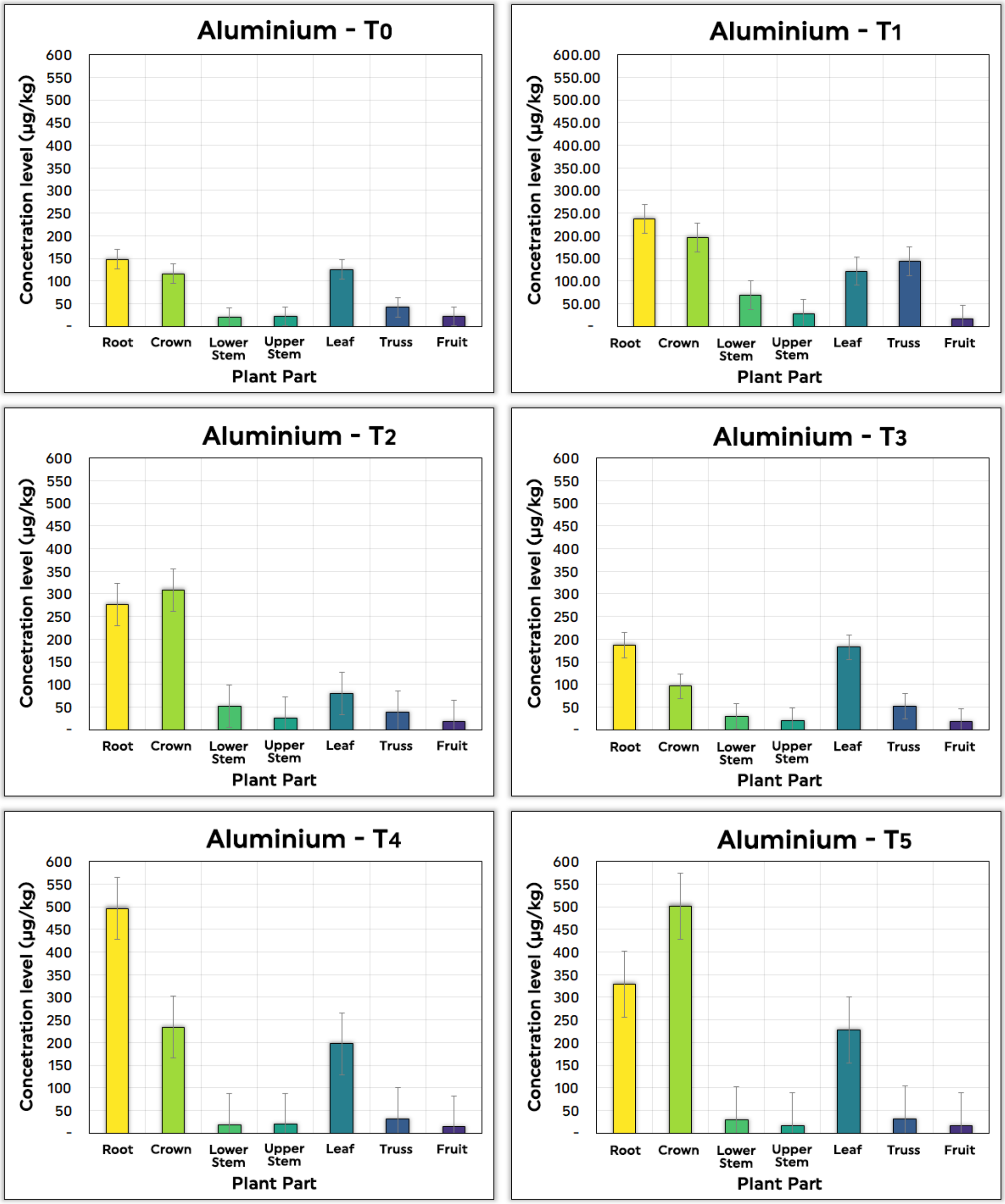

Figure 3.13 Accumulated aluminum (Al) concentration partitions in plant parts by treatments

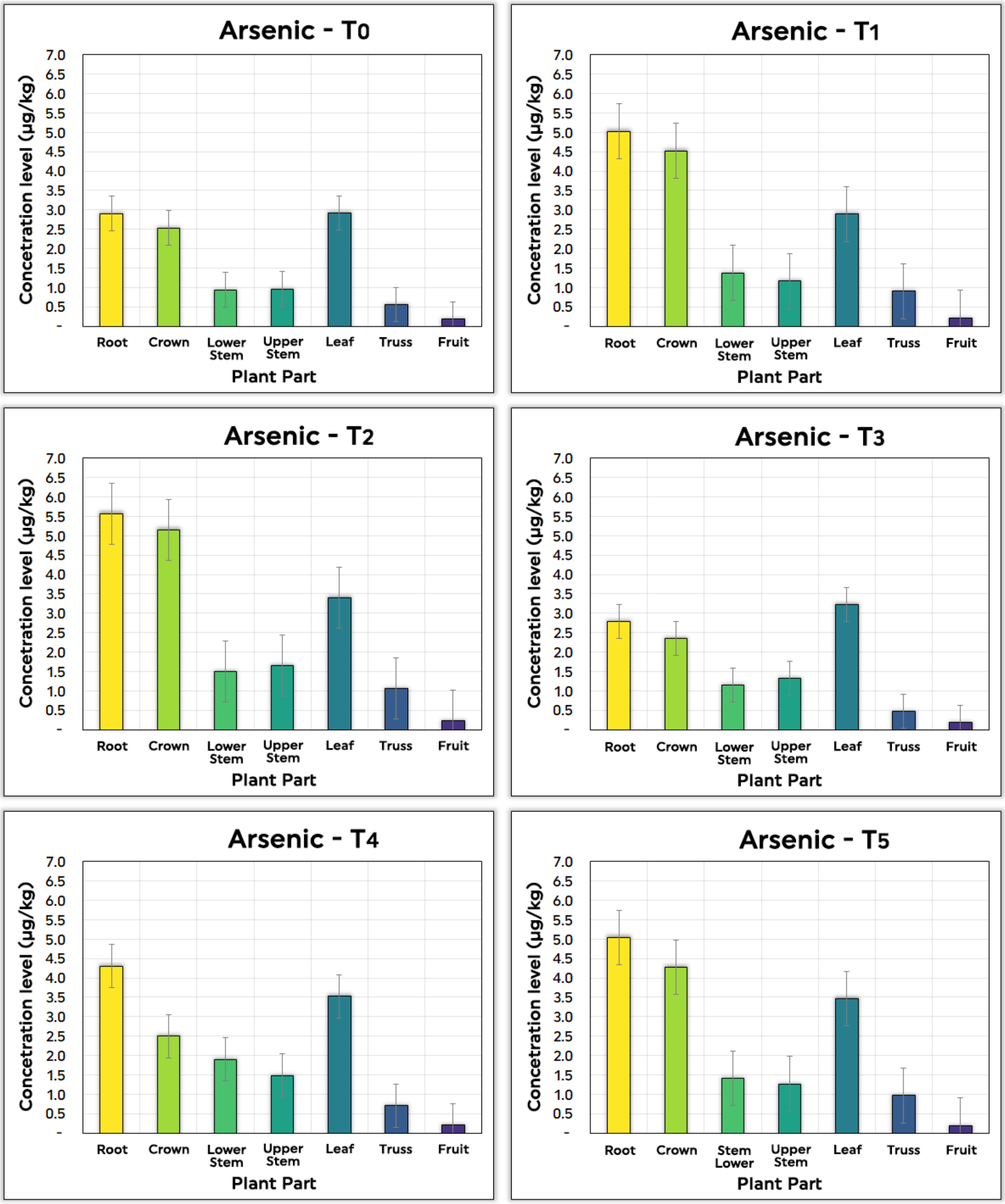

Figure 3.14 Accumulated arsenic (As) concentration partitions in plant parts by treatments

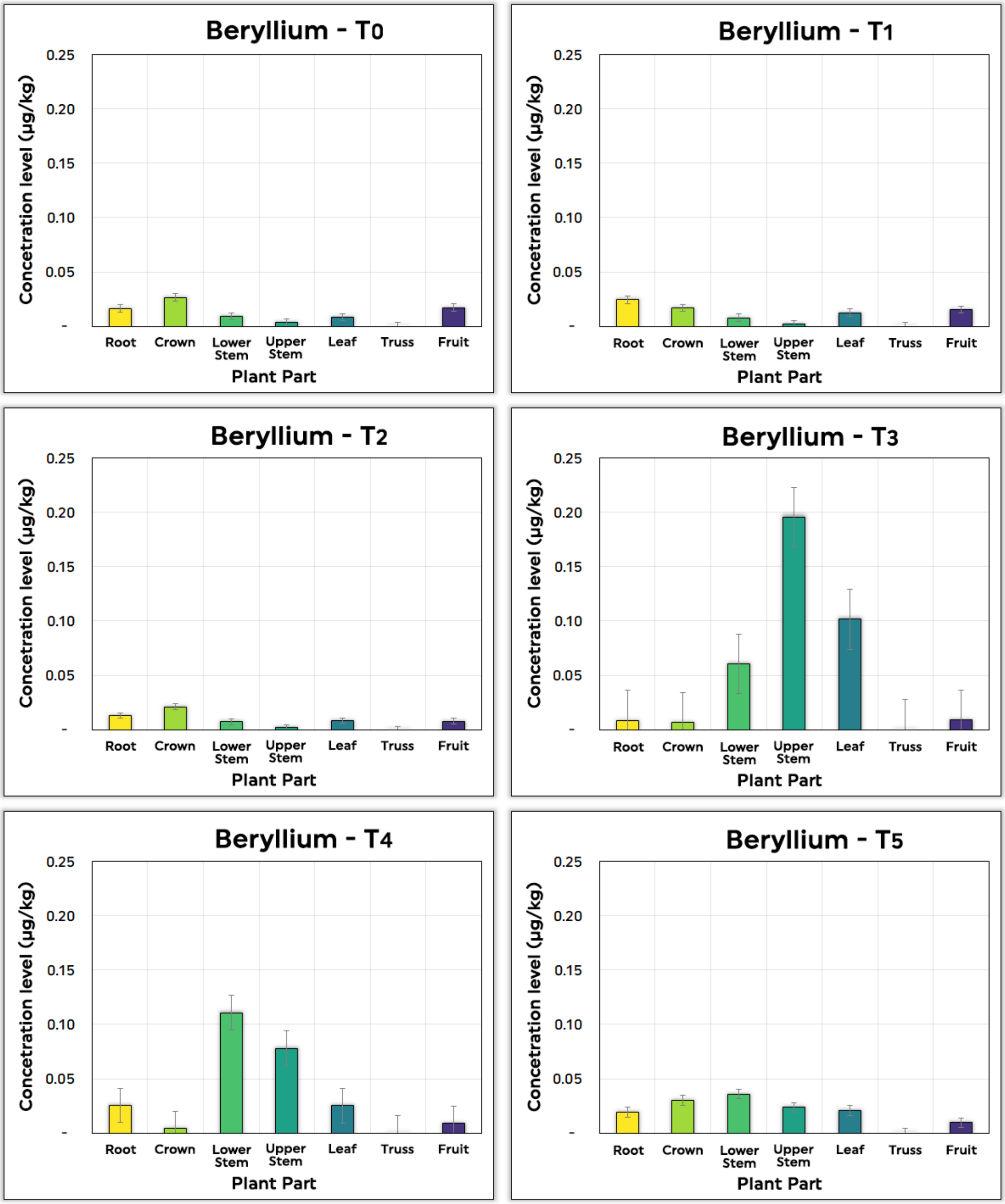

Figure 3.15 Accumulated beryllium (Be) concentration partitions in plant parts by treatments

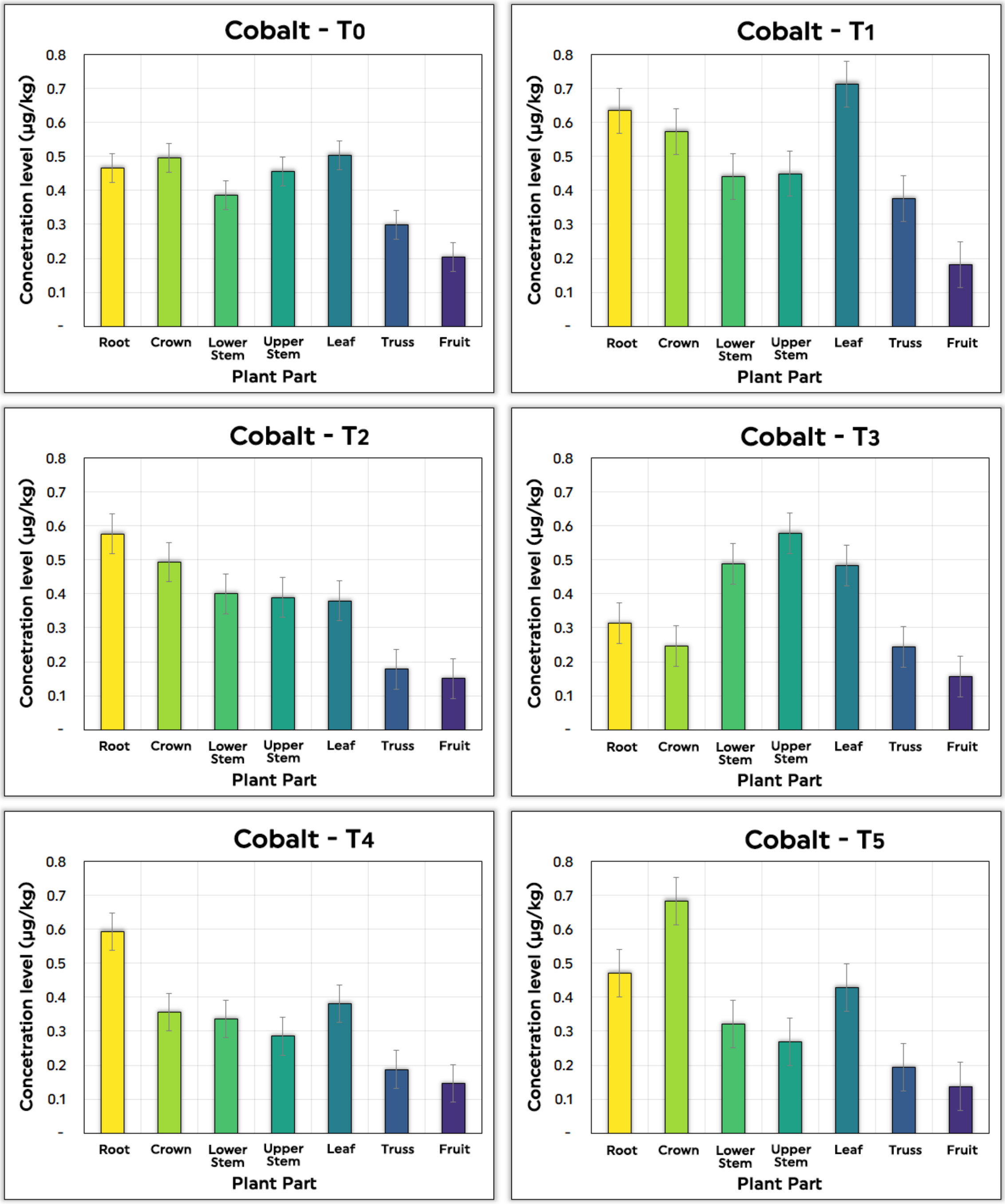

Figure 3.16 Accumulated cobalt (Co) concentration partitions in plant parts by treatments

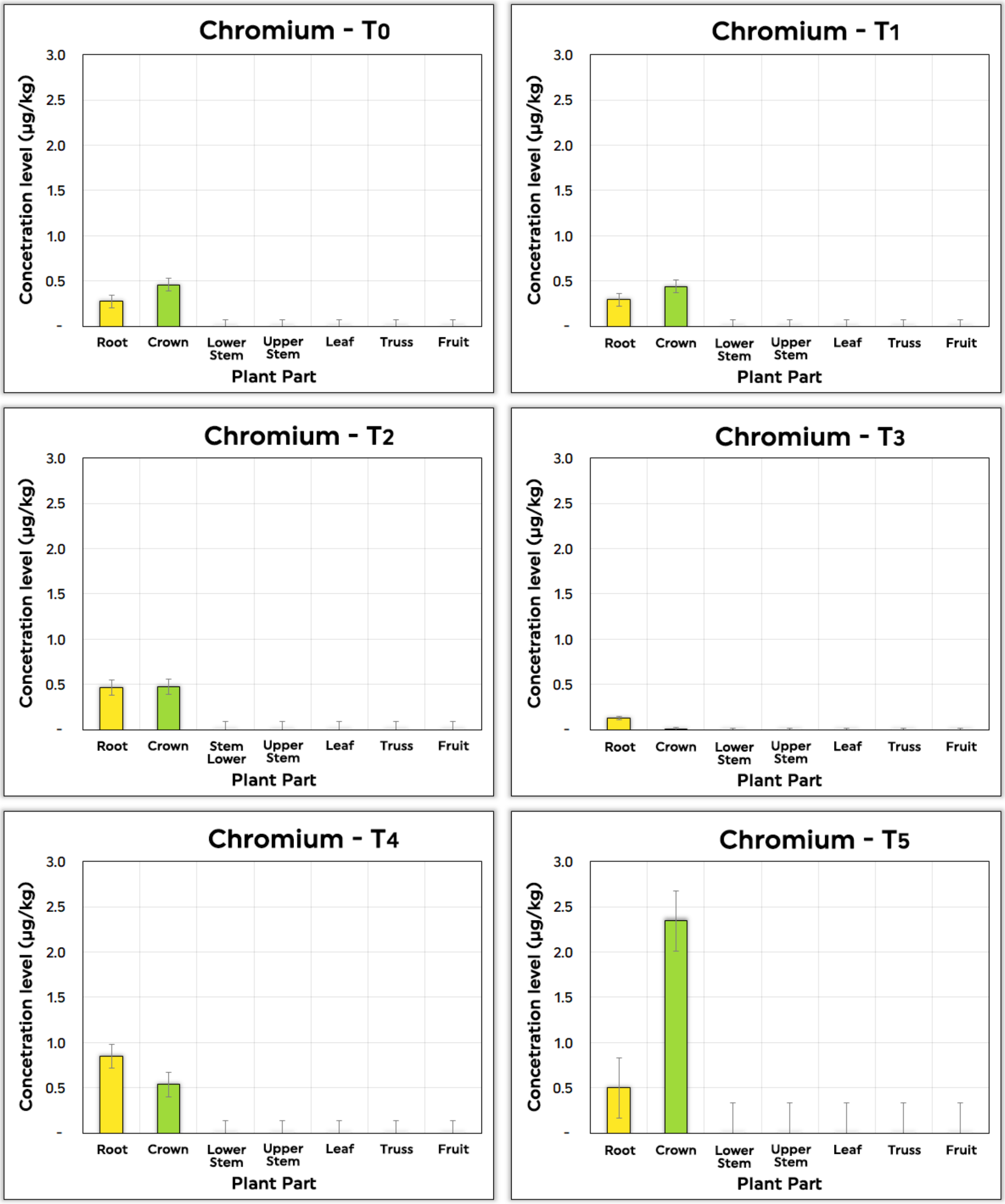

Figure 3.17 Accumulated chromium (Cr) concentration partitions in plant parts by treatments

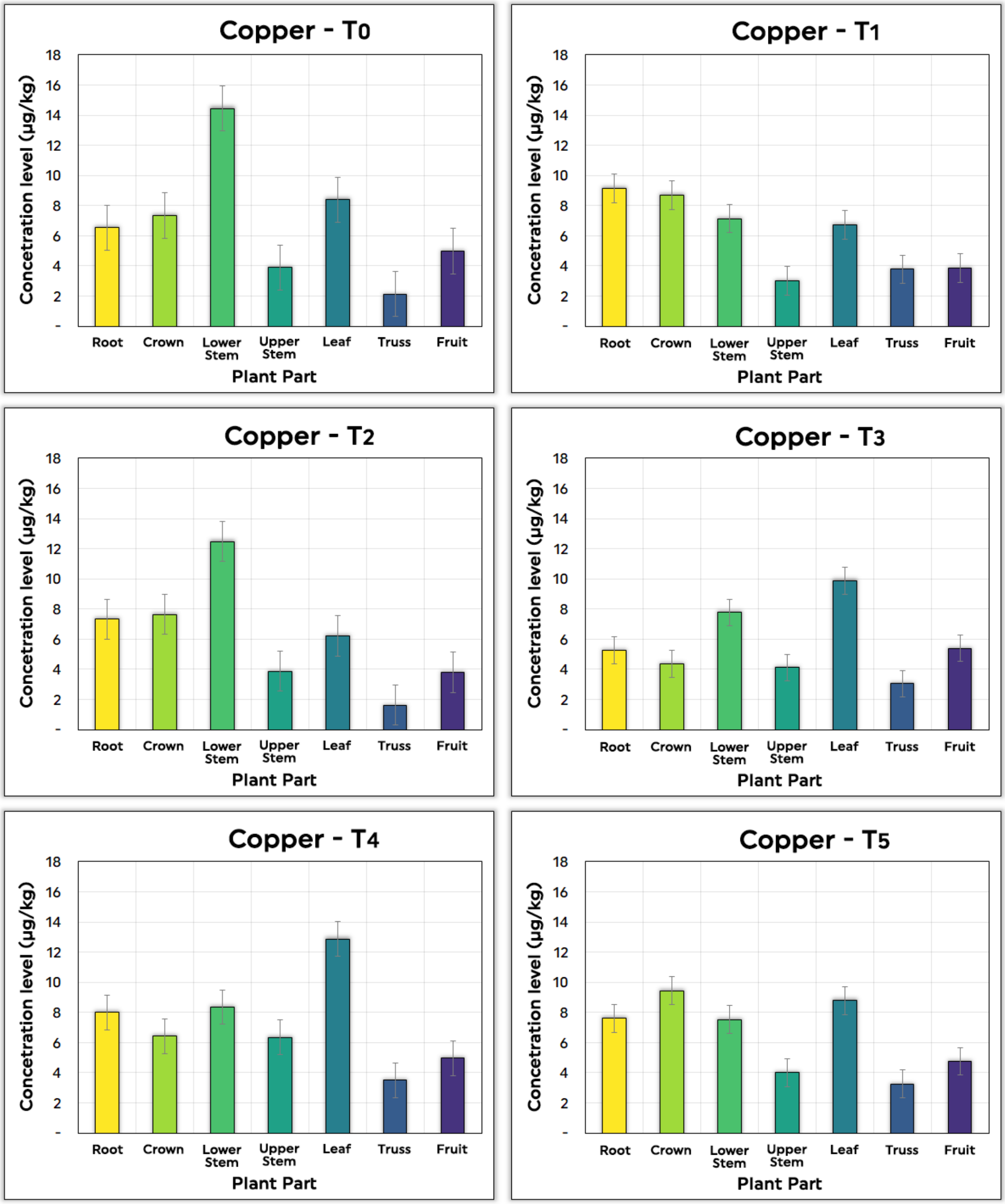

Figure 3.18 Accumulated copper (Cu) concentration partitions in plant parts by treatments

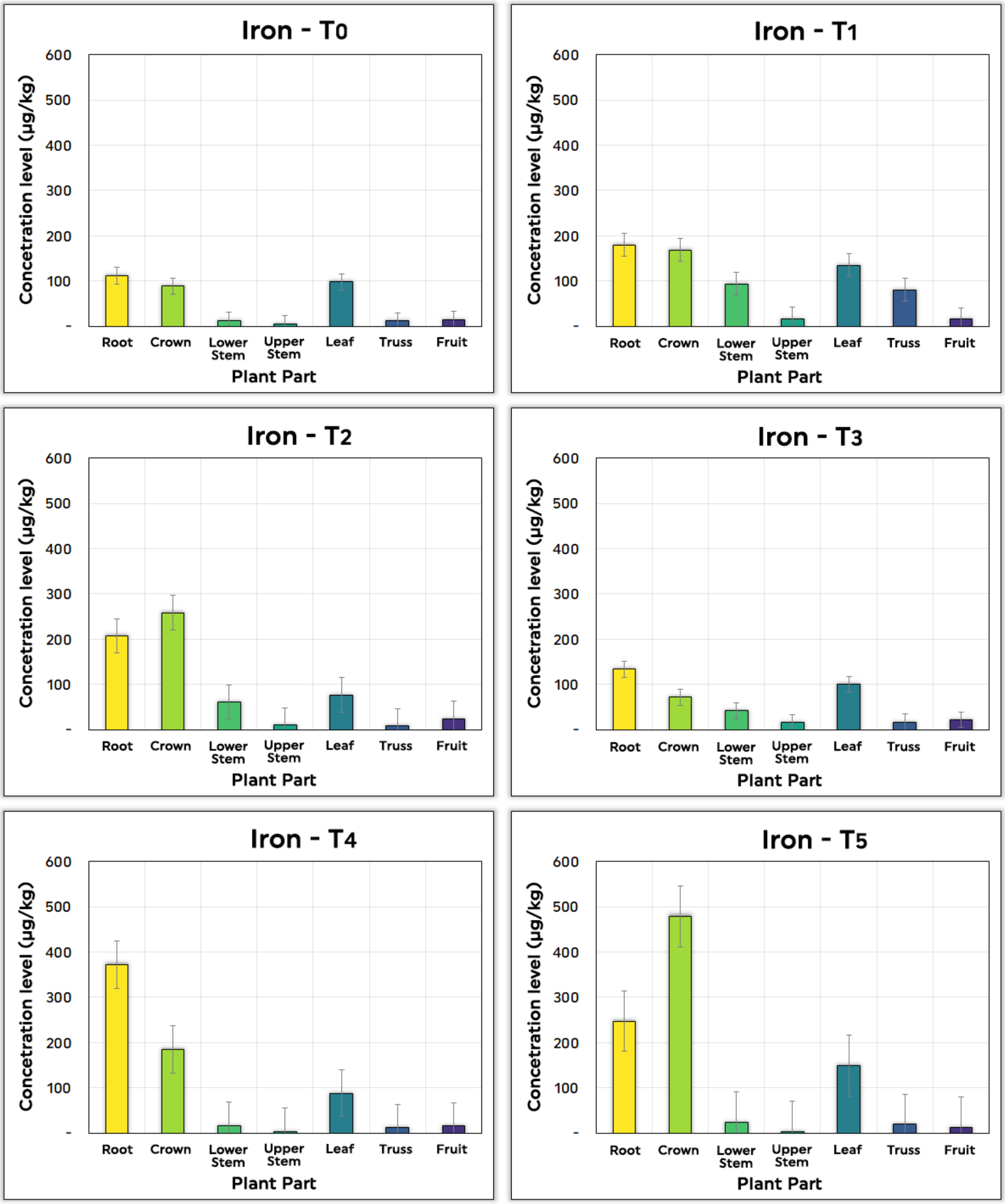

Figure 3.19 Accumulated iron (Fe) concentration partitions in plant parts by treatments

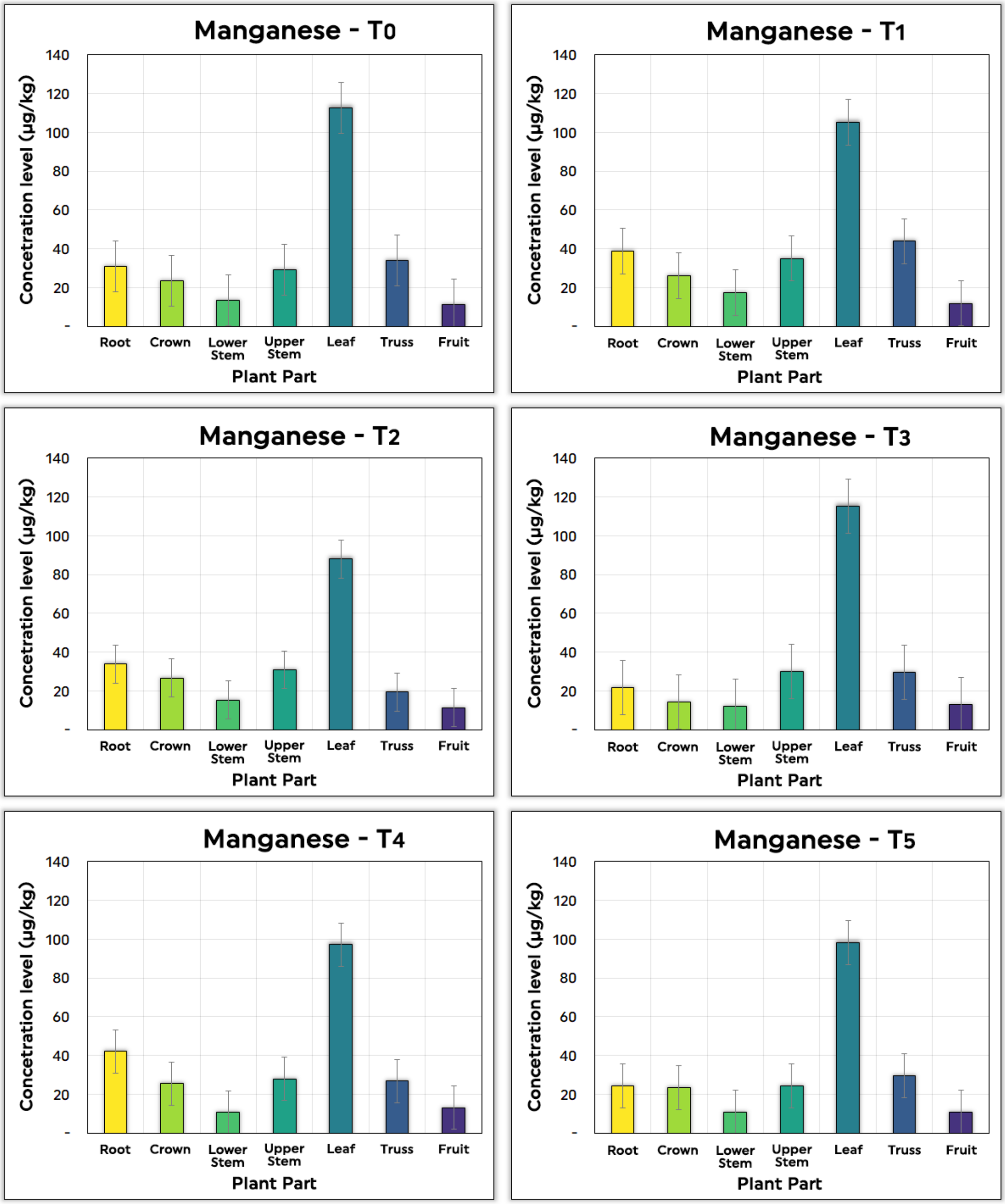

Figure 3.20 Accumulated manganese (Mn) concentration partitions in plant parts by treatments

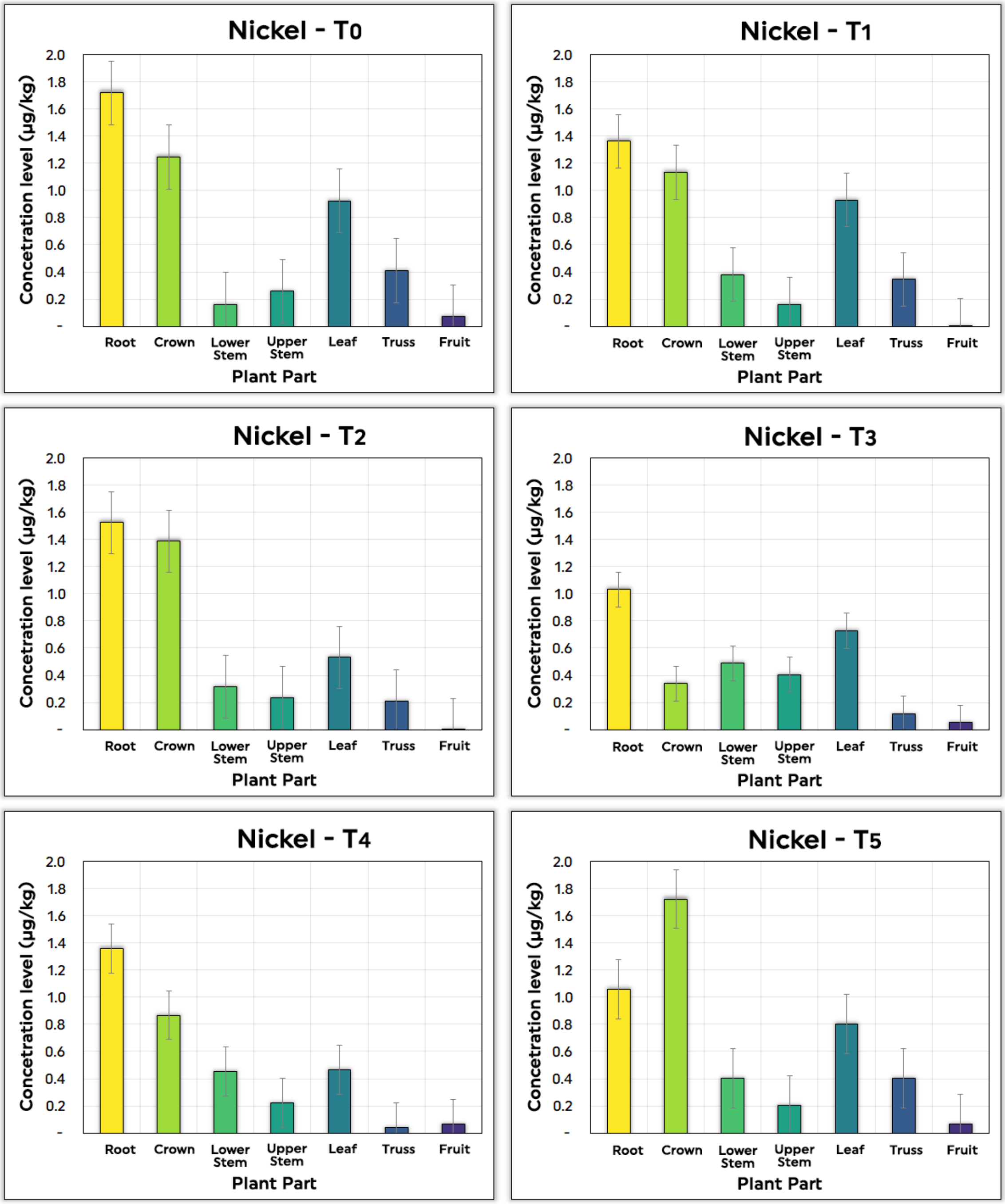

Figure 3.21 Accumulated nickel (Ni) concentration partitions in plant parts by treatments

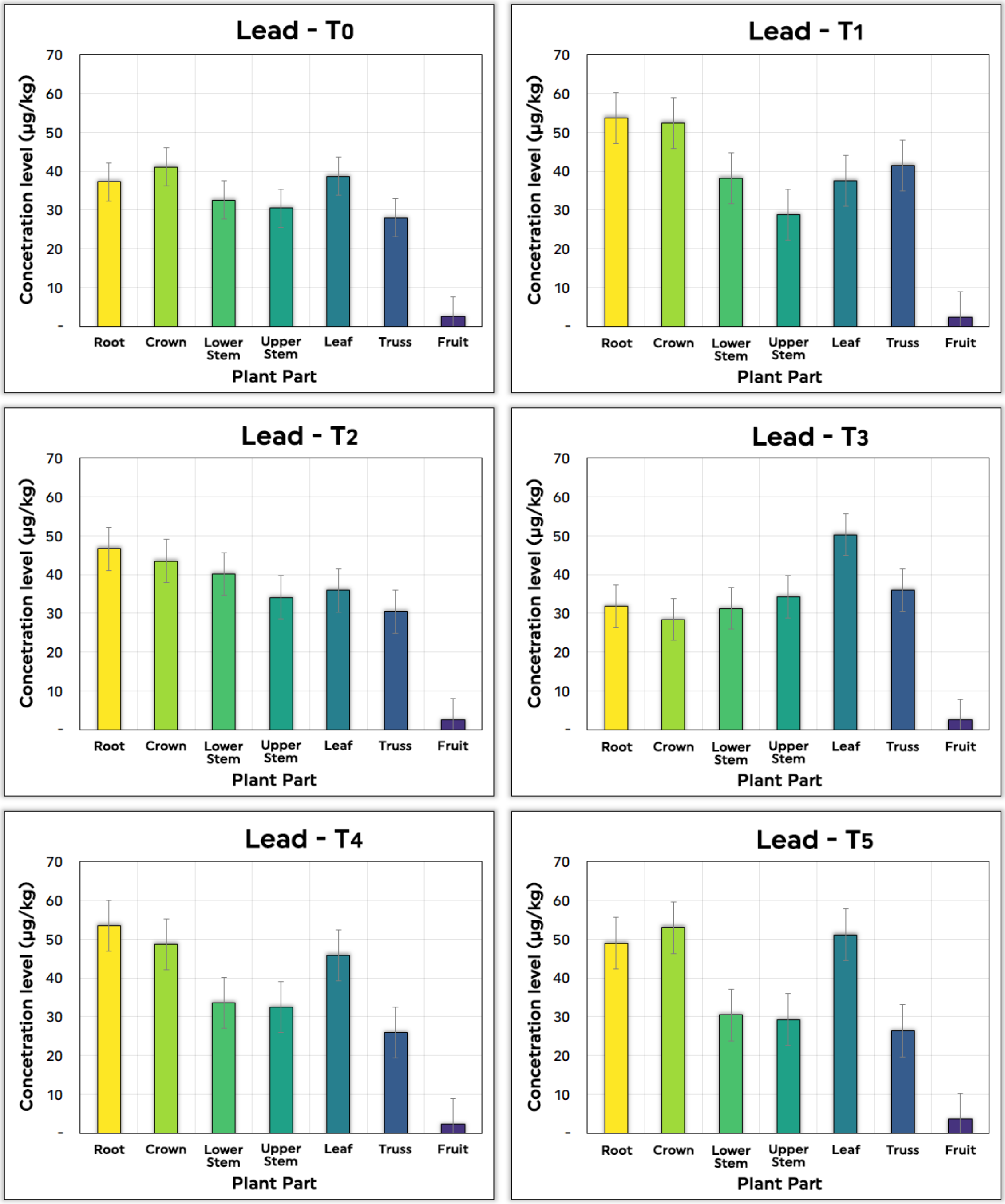

Figure 3.22 Accumulated lead (Pb) concentration partitions in plant parts by treatments

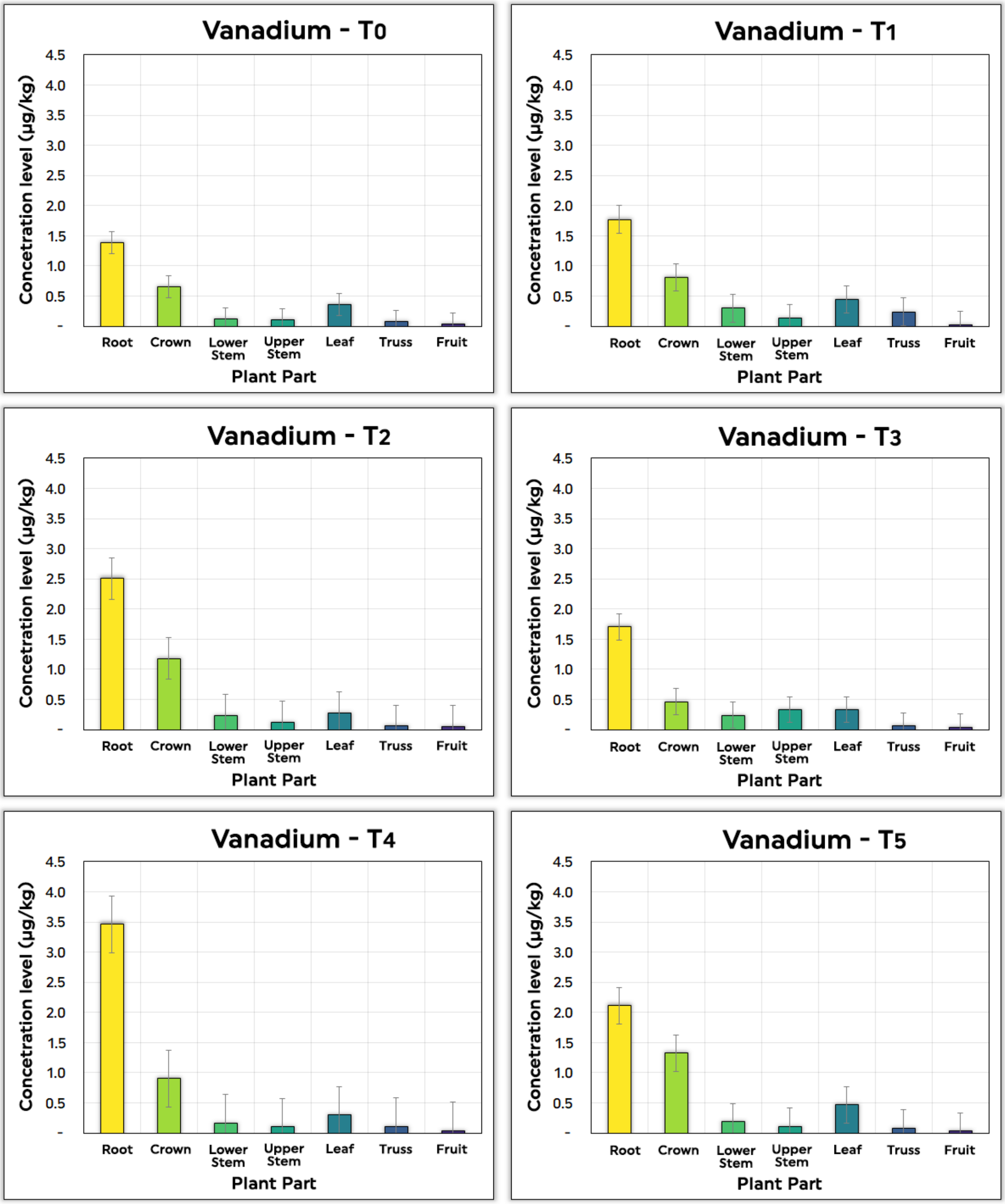

Figure 3.23 Accumulated vanadium (V) concentration partitions in plant parts by treatments

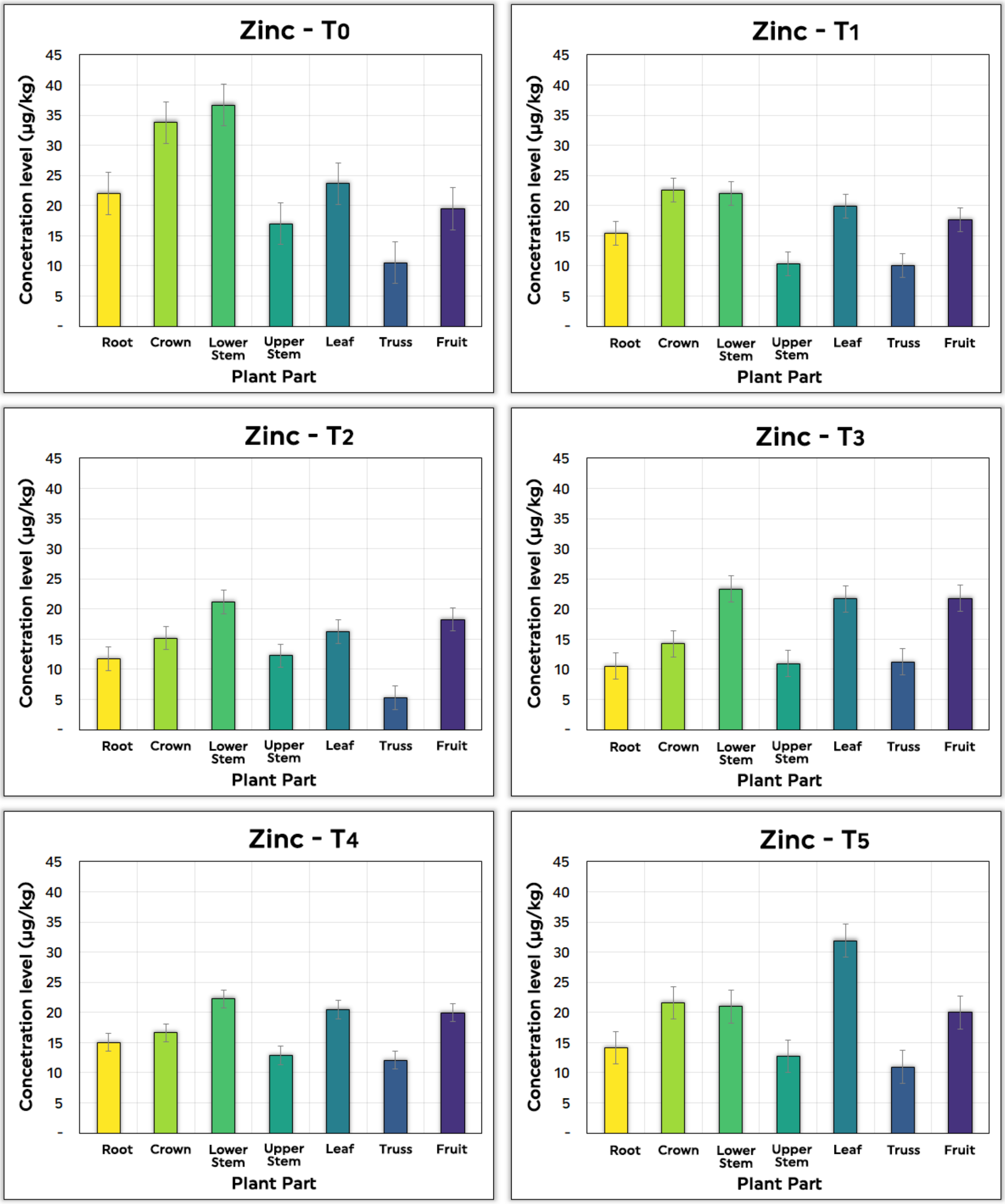

Figure 3.24 Accumulated zinc (Zn) concentration partitions in plant parts by treatments

4. CONCLUSIONS

This study aimed to investigate the effects of wastewater on soil quality, tomato plant growth, and heavy metal accumulation in soil and plant partitions in order to determine wastewater applicability toward agricultural use.

Based on the study findings, irrigating with wastewater treatments had a positive effect on soil nutrient levels. Nitrogen and phosphorus content in the wastewater was higher compared to control water and soil nitrogen and phosphorus concentrations increased over time. No potassium was found in applied wastewater treatments. Comparing initial and final soil concentrations showed that potassium reserves in the soil were removed by the plants. Plant height, weight, and fruit yields were higher in all wastewater treatments than control.

Soil salinity increased with the application of wastewater treatments. In this study, soil salinity levels did not reach toxic levels. However, if additional crops were grown using the same soil, and wastewater treatments continued, salinity toxicity could become an issue.

Membrane bioreactor treated wastewater (T_1) was found to be highest in organic matter concentration compared to raw wastewater and mixtures. This was unexpected as raw wastewater was typically higher than treated wastewater.

Some heavy metals are required plant micronutrients and are as essential as nitrogen, phosphorus, and potassium for healthy plant growth. On the other hand, in high concentrations, these same elements may become toxic. The average heavy metal concentrations in the applied wastewater treatments were all below EPA and FAO allowable maximum limits for use as irrigation water.

Measured heavy metal concentrations in the soil and plants grown with wastewater irrigation were within permissible concentration levels in all measured partitions (i.e., soil layers, roots, stems, leaves, fruit, etc.). Comparing heavy metal accumulation in soil and plant, Al, Be, Cr, Fe, Ni, Se, and V metals accumulation were highest in soil, whereas, As, Co, Cu, Mn, Pb, and Zn metal accumulation were the highest in plants. Cadmium was not detected in the soil or irrigation water. Selenium was not detected in any plant partitions. Chromium was only detected in the plant roots and crowns.

This study had some limitations. All wastewaters are unique with different heavy metal compositions. Applying the same irrigation amounts to similar crops may not yield the same results. In addition, laboratory analytical time and costs limited the number of samples that could be processed.

The findings of this study suggest that applying raw or treated wastewater instead of depleting freshwater resources for agricultural purposes may be a viable option, specifically in regions where water resources are scarce. However, further studies are needed to understand the effects of pathogens and emerging contaminants such as PFAS on plants and fruits. As a result of this study, the use of wastewater in agriculture may be encouraged since the fruit had heavy metal amounts far below allowable maximum limits.

REFERENCES

[1] P. H. Gleick *et al.*, “Freshwater Withdrawal by Country and Sector,” *The World’s Water*, pp. 227–235, 2014.

[2] P. H. Gleick, E. Pacific Institute for Studies in Development, and Stockholm Environment Institute., “Water in crisis : a guide to the world’s fresh water resources,” p. 473, 1993.

[3] B. Jimenez and T. Asano, “Water Reuse: An International Survey of current practice, issues and needs,” *Water Intell. Online*, vol. 7, no. 0, 2015, doi: 10.2166/9781780401881.

[4] WHO, “Guidelines for the safe use of wastewater, excreta and greywater,” *WHO*, vol. IV, 2006.

[5] P. Drechsel, U. J. Blumenthal, and B. Keraita, “Balancing health and livelihoods,” *Adjust. wastewater Irrig. Guidel. Resour. Ctries. Urban Agric. Mag.*, pp. 7–9, 2002.

[6] UN, “Water and Energy Sustainability Information Brief,” *Unesco*, vol. 1, pp. 1–8, 2014.

[7] E. N. Ndunda, “Wastewater reuse in urban and peri-urban irrigation: an economic assessment of improved wastewater treatment, low-risk adaptations and risk awareness in Nairobi, Kenya,” *Univ. Pretoria*, 2013.

[8] I. Angin, A. V. Yaganoglu, and M. Turan, “Effects of long-term wastewater irrigation on soil properties,” *J. Sustain. Agric.*, vol. 26, no. 3, pp. 31–42, 2005, doi: 10.1300/J064v26n03_05.

[9] T. Sato, M. Qadir, S. Yamamoto, T. Endo, and A. Zahoor, “Global, regional, and country level need for data on wastewater generation, treatment, and use,” *Agric. Water Manag.*, vol. 130, pp. 1–13, 2013, doi: 10.1016/j.agwat.2013.08.007.

[10] M. Qadir and C. A. Scott, “Non-pathogenic trade-offs of wastewater irrigation,” *Wastewater Irrig. Heal.*, pp. 127–152, 2009, doi: 10.4324/9781849774666-16.

[11] N. Kretschmer, L. Ribbe, and H. Gaese, “Wastewater Reuse for Agriculture,” *Technol. Resour. Manag. Dev. Contrib. Sustain. Dev.*, vol. 2, pp. 37–64, 2002.

[12] UN, “World Population Prospects The 2012 Revision Highlights and Advance Tables,” *UN*, 2013.

[13] V. Lazarova *et al.*, “Role of water reuse for enhancing integrated water management in Europe and Mediterranean countries,” *Water Sci. Technol.*, vol. 43, no. 10, pp. 25–33, 2001, doi: 10.2166/wst.2001.0571.

[14] S. Toze, “Reuse of effluent water - benefits and risks,” *Agric. Water Manag.*, vol. 80, no. 1–3, pp. 147–159, 2006, doi: 10.1016/j.agwat.2005.07.010.

[15] C. Lubello, R. Gori, F. P. Nicese, and F. Ferrini, “Municipal-treated wastewater reuse for plant nurseries irrigation,” *Water Res.*, vol. 38, no. 12, pp. 2939–2947, 2004, doi: 10.1016/j.watres.2004.03.037.

[16] R. M. P. Leal, U. Herpin, A. F. da Fonseca, L. P. Firme, C. R. Montes, and A. J. Melfi, “Sodicity and salinity in a Brazilian Oxisol cultivated with sugarcane irrigated with wastewater,” *Agric. Water Manag.*, vol. 96, no. 2, pp. 307–316, 2009, doi: 10.1016/j.agwat.2008.08.009.

[17] B. F. F. Pereira, Z. He, P. J. Stoffella, C. R. Montes, A. J. Melfi, and V. C. Baligar, “Nutrients and Nonessential Elements in Soil after 11 Years of Wastewater Irrigation,” *J. Environ. Qual.*, vol. 41, no. 3, pp. 920–927, 2012, doi: 10.2134/jeq2011.0047.

[18] S. S. Patil, H. D. Gandhe, and I. B. Ghorade, “Assessment of Physicochemical Properties of soil samples of Ahmednagar Industrial Area, Ahmednagar (Maharashtra),” *Eur. Acad. Res.*, vol. 2, no. 2, pp. 2581–2600, 2014.

[19] WWAP, *WWAP (United Nations World Water Assessment Programme)*. 2017.

[20] D. Wichelns, P. Drechsel, and M. Qadir, “Wastewater: Economic asset in an urbanizing world,” in *Wastewater: Economic Asset in an Urbanizing World*, Springer Netherlands, 2015, pp. 3–14.

[21] G. A. Cornish and N. C. Kielen, *Wastewater Use in Irrigated Agriculture Confronting the Livelihood and Environmental Realities*. 2004.

[22] A. J. Hamilton, F. Stagnitti, X. Xiong, S. L. Kreidl, K. K. Benke, and P. Maher, “Wastewater Irrigation: The State of Play,” *Vadose Zo. J.*, vol. 6, no. 4, pp. 823–

840, Nov. 2007, doi: 10.2136/vzj2007.0026.

[23] M. Guardiola-Claramonte, T. Sato, R. Choukr-Allah, and M. Qadir, “Wastewater production, treatment and reuse around the mediterranean region: Current status and main drivers,” in *Integrated Water Resources Management in the Mediterranean Region: Dialogue Towards New Strategy*, Springer Netherlands, 2012, pp. 139–174.

[24] J. Winpenny *et al.*, “The wealth of waste: the economics of wastewater use in agriculture,” *Food Agric. Organ. United Nations*, vol. 35, 2010.

[25] P. Drechsel, C. A. Scott, L. Raschid-Sally, M. Redwood, and A. Bahri, “Assessing and mitigating risk in low-income countries,” *Wastewater iIrigation Heal.*, 2010.

[26] R. Misheloff, “Integrated Water Resource Management II: Feasibility of Wastewater Reuse,” *United States Agency Int. Dev.*, 2010.

[27] EPA, “Guidelines for water reuse,” *US Environ. Prot. Agency*, 2004.

[28] S. Barbagallo, G. L. Cirelli, and S. Indelicato, “Wastewater reuse in Italy,” *Water Sci. Technol.*, vol. 43, no. 10, pp. 43–50, 2001, doi: 10.2166/wst.2001.0576.

[29] P. Botti *et al.*, “Reclamation and agricultural reuse of wastewater: the experience of the Cagliari sewage treatment plant (Sardinia, Italy),” *Water Sci. Technol.*, vol. 59, no. 1, pp. 65–72, 2009, doi: 10.2166/wst.2009.776.

[30] H. Gunston, “Wastewater Use in Irrigated Agriculture Confronting the Livelihood and Environmental Realities,” *Exp. Agric.*, vol. 45, no. 1, 2008.

[31] A. Dare, “Irrigation with Treated Wastewater: Potential and Limitations,” *Purdue Univ. Agric. Biol. Eng.*, 2014.

[32] M. Qadir *et al.*, “Agricultural use of marginal-quality water - opportunities and challenges,” *Water Food Water Life A Compr. Assess. Water Manag. Agric.*, pp. 425–458, 2013, doi: 10.4324/9781849773799.

[33] K. Schacht, Y. Chen, J. Tarchitzky, and B. Marschner, “The use of treated wastewater for irrigation as a component of integrated water resources management: Reducing environmental implications on soil and groundwater by

evaluating site-specific soil sensitivities," in *Integrated Water Resources Management: Concept, Research and Implementation,* Springer International Publishing, 2016, pp. 459–470.

[34] N. Icekson-Tal, O. Avraham, J. Sack, and H. Cikurel, "Water reuse in Israel-the Dan Region Project: evaluation of water quality and reliability of plant's operation," *Water Sci. Technol. Water Supply*, vol. 3, no. 4, pp. 231–237, 2003, doi: 10.2166/ws.2003.0067.

[35] N. Haruvy, "Wastewater reuse - regional and economic considerations," *Resour. Conserv. Recycl.*, vol. 23, no. 1–2, pp. 57–66, 1998, doi: 10.1016/s0921-3449(98)00010-x.

[36] A. Arar, "The future role of the use of sewage effluent for irrigation in the Near East," *Aswan Semin. Cairo*, 1989.

[37] R. M. Carr, U. J. Blumenthal, and D. D. Mara, "Health guidelines for the use of wastewater in agriculture: developing realistic guidelines," *Wastewater Use Irrig. Agric. Confronting Livelihood Environ. Realities*, pp. 41–58, 2004, doi: 10.1079/9780851998237.0041.

[38] J. Winpenny *et al.*, "The wealth of waste: the economics of wastewater use in agriculture.," *FAO*, 2010.

[39] M. Qadir and C. A. Scott, "Non-pathogenic trade-offs of wastewater irrigation," *Wastewater Irrig. Heal.*, vol. 1, pp. 127–152, 2009.

[40] Y. Suzuki, M. Ogoshi, H. Yamagata, M. Ozaki, and T. Asano, "Large-area and on-site water reuse in Japan," *Int. Semin. Sustain. Dev. Water Resour. Plur. Technol. held Korean Natl. Inst. Environ. Res.*, 2002.

[41] O. Al-Lahham, N. M. El Assi, and M. Fayyad, "Impact of treated wastewater irrigation on quality attributes and contamination of tomato fruit," *Agric. Water Manag.*, vol. 61, no. 1, pp. 51–62, 2003, doi: 10.1016/S0378-3774(02)00173-7.

[42] EPA, "Guidlines for water reuse," *Guidel. water reuse*, no. September, 2012.

[43] R. Ayers and D. Westcot, "Water quality for agriculture," *Rome Food Agric. Organ. United Nations.*, vol. 29, p. 174, 1985.

[44] P. Najafi, S. F. Mousavi, and M. Feizi, “Effects of using sub surface drip in irrigation of tomato and eggplant with treated municipal wastewater,” *Iran. J. Soil Waters Sci.*, vol. 20, no. 1, pp. 155–163, 2006.

[45] O. Al-Lahham, N. M. El Assi, and M. Fayyad, “Translocation of heavy metals to tomato (Solanum lycopersicom L.) fruit irrigated with treated wastewater,” *Sci. Hortic. (Amsterdam).*, vol. 113, no. 3, pp. 250–254, 2007, doi: 10.1016/j.scienta.2007.03.017.

[46] R. Aiello, G. L. Cirelli, and S. Consoli, “Effects of reclaimed wastewater irrigation on soil and tomato fruits: A case study in Sicily (Italy),” *Agric. Water Manag.*, vol. 93, no. 1–2, pp. 65–72, 2007, doi: 10.1016/j.agwat.2007.06.008.

[47] P. K. Rai and B. D. Tripathi, “Heavy metals in industrial wastewater, soil and vegetables in Lohta village, India,” *Toxicol. Environ. Chem.*, vol. 90, no. 2, pp. 247–257, 2008, doi: 10.1080/02772240701458584.

[48] V. Samaras, C. D. Tsadilas, and J. T. Tsialtas, “Use of Treated Wastewater as Fertilization and Irrigation Amendment in Pot-grown Processing Tomatoes,” *J. Plant Nutr.*, vol. 32, no. 5, pp. 741–754, 2009, doi: 10.1080/01904160902787859.

[49] H. A. Abdelrahman, S. A. Alkhamisi, M. Ahmed, and H. Ali, “Effects of Treated Wastewater Irrigation on Element Concentrations in Soil and Maize Plants,” *Commun. Soil Sci. Plant Anal.*, vol. 42, no. 17, pp. 2046–2063, 2011, doi: 10.1080/00103624.2011.596236.

[50] B. Kahlaoui, M. Hachicha, S. Rejeb, M. N. Rejeb, B. Hanchi, and E. Misle, “Effects of saline water on tomato under subsurface drip irrigation: Nutritional and foliar aspects,” *J. Soil Sci. Plant Nutr.*, vol. 11, no. 1, pp. 69–86, 2011, doi: 10.4067/s0718-95162011000100007.

[51] G. L. Cirelli, S. Consoli, F. Licciardello, R. Aiello, F. Giuffrida, and C. Leonardi, “Treated municipal wastewater reuse in vegetable production,” *Agric. Water Manag.*, vol. 104, pp. 163–170, 2012, doi: 10.1016/j.agwat.2011.12.011.

[52] A. Alrajhi, S. Beecham, N. S. Bolan, and A. Hassanli, “Evaluation of soil chemical properties irrigated with recycled wastewater under partial root-zone

drying irrigation for sustainable tomato production," *Agric. Water Manag.*, vol. 161, pp. 127–135, 2015, doi: 10.1016/j.agwat.2015.07.013.

[53] W. Chunfang, S. Xiaohou, X. Huilian, C. Tingting, and W. Weina, "Effects of compound microbial inoculant treated wastewater irrigation on soil nutrients and enzyme activities," *Int. J. Agric. Biol. Eng.*, vol. 9, no. 6, pp. 100–108, 2016, doi: 10.3965/j.ijabe.20160906.2127.

[54] USDA-NRCS, "United States Department of Agriculture Natural Resources Conservation Service In cooperation with Texas Agricultural Experiment Station and Texas State Soil and Water Conservation Board."

[55] Irrometer, "At what Centibar value should I be irrigating?" [Online]. Available: https://www.irrometer.com/faq.html.

[56] S. Jabeen, M. Shah, … S. K.-J. of M., and undefined 2010, "Determination of major and trace elements in ten important folk therapeutic plants of Haripur basin, Pakistan," *academicjournals.org*, vol. 4, no. 7, pp. 559–566, 2010.

[57] S. Chaoua, S. Boussaa, … A. E. G.-J. of the S., and undefined 2019, "Impact of irrigation with wastewater on accumulation of heavy metals in soil and crops in the region of Marrakech in Morocco," *Elsevier*.

[58] J. Havlin, P. S.-C. in S. S. and, and undefined 1980, "A nitric acid plant tissue digest method for use with inductively coupled plasma spectrometry," *Taylor Fr.*, vol. 11, no. 10, pp. 969–980, Jan. 1980, doi: 10.1080/00103628009367096.

[59] A. Baille, "Principle and methods for predicting crop water requirement in greenhouse environments," *Cah. Options Méditerranéennes*, vol. 31, pp. 177–187, 1999.

[60] R. G. Allen, L. S. Pereira, D. Raes, and M. Smith, "Crop evapotraspiration guidelines for computing crop water requirements.," *FAO*, vol. 300, no. 9, p. 50, 1998.

[61] R. Schofield, A. T.-S. S. S. of America, and undefined 1955, "The measurement of soil pH," *Wiley Online Libr.*, vol. 19, no. 2, pp. 164–167, Apr. 1955, doi: 10.2136/sssaj1955.03615995001900020013x.

[62] J. Rhoades, “Methods of soil analysis: part 2; chemical and microbiological properties,” *Am. Soc. Agron. Winsconsin, US*, vol. 2, pp. 167–179, 1986.

[63] W. Lindsay, W. N.-S. science society of America, and undefined 1978, “Development of a DTPA soil test for zinc, iron, manganese, and copper,” *Wiley Online Libr.*, vol. 42, no. 3, pp. 421–428, May 1978, doi: 10.2136/sssaj1978.03615995004200030009x.

[64] P. N. Soltanpour and J. L. Havlin, “A nitric acid plant tissue digest method for use with inductively coupled plasma spectrometry,” *Commun. Soil Sci. Plant Anal.*, vol. 11, no. 10, pp. 969–980, Jan. 1980, doi: 10.1080/00103628009367096.

[65] U.S.EPA, “Method 200.8: Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma-Mass Spectrometry,” *EPA*, vol. Revision 5, no. EMMC Version, 1994.

[66] P. K. Shrivastava, M. M. Parikh, N. G. Sawani, and S. Raman, “Effect of drip irrigation and mulching on tomato yield,” *Agric. Water Manag.*, vol. 25, no. 2, pp. 179–184, Apr. 1994, doi: 10.1016/0378-3774(94)90044-2.

[67] R. B. Singandhupe, G. G. S. N. Rao, N. G. Patil, and P. S. Brahmanand, “Fertigation studies and irrigation scheduling in drip irrigation system in tomato crop (Lycopersicon esculentum L.),” *Eur. J. Agron.*, vol. 19, no. 2, pp. 327–340, May 2003, doi: 10.1016/S1161-0301(02)00077-1.

[68] C. Kirda *et al.*, “Yield response of greenhouse grown tomato to partial root drying and conventional deficit irrigation,” *Agric. Water Manag.*, vol. 69, no. 3, pp. 191–201, Oct. 2004, doi: 10.1016/J.AGWAT.2004.04.008.

[69] E. Tarantino and P. Rubino, “Comparison of irrigation methods and regimes on processing tomatoes in the Metaponto area,” *Irrigazione*, vol. 29, no. 2, pp. 17–26, 1982.

[70] M. J. B. Alam, M. R. Islam, Z. Muyen, M. Mamun, and S. Islam, “Water quality parameters along rivers,” *Int. J. Environ. Sci. Technol.*, vol. 4, no. 1, pp. 159–167, 2007, doi: 10.1007/BF03325974.

[71] H. Jeong, H. Kim, and T. Jang, “Irrigation water quality standards for indirect

wastewater reuse in agriculture: a contribution toward sustainable wastewater reuse in South Korea," *Water*, vol. 8, no. 4, p. 169, 2016, doi: 10.3390/w8040169.

[72] R. Ayers and D. Westcot, "Water quality for agriculture," *Rome Food Agric. Organ. United Nations*, vol. 29, p. 174, 1985.

[73] M. Pescod, "Wastewater treatment and use in agriculture," 1992.

[74] T. Bauder, R. Waskom, P. Sutherland, and J. Davis, "Irrigation water quality criteria," *Ext. Fact Sheet No. 0.506*, pp. 1–4, 2011.

[75] A. F. Rusydi, "Correlation between conductivity and total dissolved solid in various type of water: A review," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 118, no. 1, p. 012019, Feb. 2018, doi: 10.1088/1755-1315/118/1/012019.

[76] Hanna Instruments, "The Basics of Electrical Conductivity (EC)." [Online]. Available: https://blog.hannainst.com/the-basics-of-electrical-conductivity-ec.

[77] L. A. Richards *et al.*, *Diagnosis and improvement of saline and alkali soils. Vol. 78. No. 2. LWW, 1954.*, 2nd ed., vol. 78. 1954.

[78] A. J. Kadhem, "Assessment of Water Quality in Tigris River-Iraq by Using GIS Mapping," *Nat. Resour.*, vol. 2013, no. 06, pp. 441–448, Oct. 2013, doi: 10.4236/NR.2013.46054.

[79] USDA and NCRS, "Soil Quality Indicators: pH," *USDA Nat. Resour. Conserv. Serv.*, 1998.

[80] M. Sağlam and K. Belliturk, " Su kirliliği ve toprak üzerindeki etkisi," *Alatarım*, vol. 2, no. 1, pp. 46–49, 2003.

[81] O. Vazquez-Montiel, N. Horan, D. M.-W. S. and Technology, and undefined 1996, "Management of domestic wastewater for reuse in irrigation," *Elsevier*, 1996, doi: 10.1016/0273-1223(96)00438-6.

[82] A. Hayes, C. Mancino, I. P.-A. Journal, and undefined 1990, "Irrigation of turfgrass with secondary sewage effluent: I. Soil and leachate water quality," *Wiley Online Libr.*, vol. 82, no. 5, pp. 939–943, Sep. 1990, doi: 10.2134/agronj1990.00021962008200050020x.

[83] T. Scherer, B. Seelig, and D. Franzen, "Soil, water and plant characteristics

important to irrigation," 1996.

[84] T. P. Abegunrin, G. O. Awe, D. O. Idowu, O. O. Onigbogi, and O. E. Onofua, "Effect of kitchen wastewater irrigation on soil properties and growth of cucumber (Cucumis sativus)," *J. Soil Sci. Environ. Manag.*, vol. 4, no. 7, pp. 139–145, Nov. 2013, doi: 10.5897/JSSEM2013.0412.

[85] A. Shahalam, B. M. Abu Zahra, and A. Jaradat, "Wastewater irrigation effect on soil, crop and environment: A pilot scale study at Irbid, Jordan," *Water. Air. Soil Pollut.*, vol. 106, no. 3–4, pp. 425–445, 1998, doi: 10.1023/A:1005046912234.

[86] N. Khai, P. Tuan, N. Vinh, and I. Oborn, "Effects of using wastewater as nutrient sources on soil chemical properties in peri-urban agricultural systems," *VNU journal Sci.*, pp. 87–95, 2008.

[87] M. Rusan, S. Hinnawi, and L. Rousan, "Long term effect of wastewater irrigation of forage crops on soil and plant quality parameters," *Desalination*, vol. 215, pp. 143–152, 2007.

[88] F. M. Kiziloglu, Turan M., Sahin U., Kuslu Y., and Dursun A., "Effects of untreated and treated wastewater irrigation on some chemical properties of cauliflower (Brassica olerecea L. var. botrytis) and red cabbage (Brassica olerecea L. var. rubra) grown on calcareous soil in Turkey," *Agric. Water Manag.*, vol. 95, pp. 716–724, 2008.

[89] D. Alvarez-Bernal, S. M. Contreras-Ramos, N. Trujillo-Tapia, V. Olalde-Portugal, J. T. Frías-Hernández, and L. Dendooven, "Effects of tanneries wastewater on chemical and biological soil characteristics," *Appl. Soil Ecol.*, vol. 33, no. 3, pp. 269–277, Oct. 2006, doi: 10.1016/J.APSOIL.2005.10.007.

[90] A. da Fonseca, A. Melfi, C. M.-C. in Soil, and undefined 2005, "Maize growth and changes in soil fertility after irrigation with treated sewage effluent. I. Plant dry matter yield and soil nitrogen and phosphorus availability," *Taylor Fr.*, vol. 36, no. 13–14, pp. 1965–1981, 2005, doi: 10.1081/CSS-200062539.

[91] M. N. Wuddivira and G. Camps-Roach, "Effects of organic matter and calcium on soil structural stability," *Eur. J. Soil Sci.*, vol. 58, no. 3, pp. 722–727, Jun. 2007,

doi: 10.1111/J.1365-2389.2006.00861.X.
[92] K. L. Cheng and R. H. Bray, "Determination of calcium and magnesium in soil and plant material," *Soil Sci.*, vol. 72, no. 6, pp. 449–458, 1951.
[93] Y. Chen, A. Banin, and A. Borochovitch, "Effect of Potassium on Soil Structure in Relation to Hydraulic Conductivity," *Dev. Soil Sci.*, vol. 12, no. C, pp. 135–147, Jan. 1983, doi: 10.1016/S0166-2481(08)70289-7.
[94] C. L. Acharya and I. P. Abrol, "Exchangeable sodium and soil water behavior under field conditions," *Soil Sci.*, vol. 125, no. 5, pp. 310–319, 1978.
[95] M. Sillanpaa, "Micronutrient assessment at the country level: An International Study, FAO Soils Bulletin 63," *FAO Soils Bull. 63./ FAO, Rome (Italy). L. Water Dev. Div.*, p. 214, 1990.
[96] Ş. Çay, "Konya Kentesel Atık Sularının Tarımsal Sulamada Kullanılması ve Mısır Bitkisi Yetiştiriciliğine Etkileri," Çukurova Üniversitesi, Adana, 2013.
[97] S. Arcak, A. Karaca, and K. Haktanir, "Investigations on sewage sludges: chemical composition and effects on some chemical properties of soil," in *Proceedings of International symposium on desertification (ISD)*, 2000, pp. 339–344.
[98] K. Saltali, A. R. Brohi, and A. V. Bilgili, "The effect of tobacco waste on the soil characteristics and plant nutrient contents of alkaline soils," in *Proceedings of International Symposium on Desertification (ISD)*, 2000, pp. 531–534.
[99] E. I. Demirtaş, F. Öktüren, and A. N. Arı, "Örtüaltı Domates Yetiştiriciliğinde Kentsel Katı Atık Kompostu Kullanımının Bakiye Etkilerinin Belirlenmesi," *Ziraat Fakültesi Derg.*, vol. 8, no. 2, pp. 23–35, 2013.
[100] A. Cicek, M. R. Karaman, and M. Turan, "Yield and nutrient status of wheat plant (T. aestivum) influenced by municipal wastewater irrigation," *J. Food, Agric. Environ.*, vol. 11, no. 1, pp. 733–737, 2005.
[101] C. Dewi and Y. K. Arbawa, "Performance Evaluation of Distance Function in KNN and WKNN for Classification of Soil Organic Matter," *Proc. 2019 4th Int. Conf. Sustain. Inf. Eng. Technol. SIET 2019*, pp. 196–199, Sep. 2019, doi:

10.1109/SIET48054.2019.8986030.

[102] M. A. El-Naim, M. El-Housseini, and M. H. Naeem, “Safety use of sewage sludge as soil conditioner,” *J. Environ. Sci. Heal.*, vol. 39, no. 2, pp. 435–444, 2004, doi: 10.1081/ESE-120027534.

[103] J. Zavadil, “The effect of municipal wastewater irrigation on the yield and quality of vegetables and crops,” *Soil water Res.*, vol. 4, no. 3, pp. 91–103, 2009.

[104] C. F. Ozkan, “Antalya ve çevresi örtüaltı domates yetiştiriciliğinde toprak verimliliği, bitki besleme, bazı kalite ve stres parametreleri arasındaki ilişkiler,” Ege Üniversitesi , Izmır, 2008.

[105] K. Ates and N. Ozbay, “Bingöl ili ekolojik şartlarına uygun sofralık domates çeşitlerinin belirlenmesi,” *Türk Tarım ve Doğa Bilim. Derg.*, vol. 2, no. 2, pp. 226–236, 2015.

[106] M. A. Maurer, F. S. Davies, and D. A. Graetz, “Reclaimed Wastewater Irrigation and Fertilization of Mature `Redblush’ Grapefruit Trees on Spodosols in Florida,” *J. Am. Soc. Hortic. Sci.*, vol. 120, no. 3, pp. 394–402, May 1995, doi: 10.21273/JASHS.120.3.394.

[107] G. H. Neilsen, D. S. Stevenson, J. J. Fitzpatrick, and C. H. Brownlee, “Nutrition and yield of young apple trees irrigated with municipal waste water,” *J. Am. Soc. Hortic. Sci.*, 1989.

[108] B. Kacar and V. A. Katkat, “Bitki Besleme Nobel Yayın No: 849,” *Fen Bilim.*, vol. 30, no. 5, 2010.

[109] et al. Ekici, B., “Sera domates yetiştiriciliğinde kısmi kök kuruluğu (partial rootzone drying) sulama tekniğinin bitki büyümesi, verim ve meyve kalitesi üzerine etkileri,” Çukurova Üniversitesi, 2002.

[110] A. N. M. de Koning, “Growth of a tomato crop,” *Acta Hortic.*, no. 328, pp. 141–146, Mar. 1993, doi: 10.17660/ACTAHORTIC.1993.328.11.

[111] E. Heuvelink, “Growth, development and yield of a tomato crop: periodic destructive measurements in a greenhouse,” *Sci. Hortic. (Amsterdam).*, vol. 61, no. 1–2, pp. 77–99, 1995.

[112] H. Harssema, "Root temperature and growth of Young tomato plants," Wageningen Agricultural University, 1977.

[113] D. R. Rowe and I. M. Abdel-Magid, "Health aspects of using reclaimed water in engineering," *Handb. Wastewater Reclam. Reuse*, vol. 1, no. 107, 1995.

[114] T. A. Adagunodo, L. A. Sunmonu, and M. E. Emetere, "Heavy metals' data in soils for agricultural activities," *Data Br.*, vol. 18, pp. 1847–1855, Jun. 2018, doi: 10.1016/J.DIB.2018.04.115.

[115] M. Osmani, A. Bani, and B. Hoxha, "Heavy Metals and Ni Phytoextractionin in the Metallurgical Area Soils in Elbasan," *Albanian J. Agric. Sci.*, vol. 14, no. 4, pp. 414–419, 2015.

[116] O. Dt, A. Aa, and O. Oe, "Heavy Metal Concentrations in Plants and Soil along Heavy Traffic Roads in North Central Nigeria," *J Env. Anal Toxicol*, vol. 5, no. 6, p. 334, 2015, doi: 10.4172/2161-0525.1000334.

[117] Z. Chen, "Relationship between heavy metal concentrations in soils of Taiwan and uptake by crops," 2000.

[118] G. Tóth, T. Hermann, M. R. Da Silva, and L. Montanarella, "Heavy metals in agricultural soils of the European Union with implications for food safety," *Environ. Int.*, vol. 88, pp. 299–309, Mar. 2016, doi: 10.1016/J.ENVINT.2015.12.017.

[119] E. van der Voet *et al.*, "Environmental challenges of anthropogenic metals flows and cycles," *United Nations Environ. Program.*, 2013.

[120] "Permissible limits of heavy metals in soil and plants.," in *World Health Organization (WHO)*, 1996.

APPENDIX A

RAW DATA

Table A.1 The amount of plant water consumption (W_C), irrigation water (W_{IR}), and evapotranspiration (ET) by daily

Day	W_C (mm)	W_{IR} (mm)	ET (mm)	Day	W_C (mm)	W_{IR} (mm)	ET (mm)
1	3.88	7.08	3.20	29	4.08	7.08	3.00
2	3.38	7.08	3.70	30	3.98	7.08	3.10
3	3.88	7.08	3.20	31	3.58	7.08	3.50
4	4.38	7.08	2.70	32	3.68	7.08	3.40
5	4.28	7.08	2.80	33	4.08	7.08	3.00
6	3.78	7.08	3.30	34	3.98	7.08	3.10
7	4.58	7.08	2.50	35	3.28	7.08	3.80
8	4.08	7.08	3.00	36	2.78	7.08	4.30
9	4.38	7.08	2.70	37	3.28	7.08	3.80
10	4.48	7.08	2.60	38	3.78	7.08	3.30
11	4.28	7.08	2.80	39	3.68	7.08	3.40
12	4.38	7.08	2.70	40	3.18	7.08	3.90
13	4.28	7.08	2.80	41	3.98	7.08	3.10
14	3.88	7.08	3.20	42	3.48	7.08	3.60
15	3.98	7.08	3.10	43	7.32	10.62	3.30
16	4.38	7.08	2.70	44	7.42	10.62	3.20
17	4.28	7.08	2.80	45	7.22	10.62	3.40
18	3.58	7.08	3.50	46	7.32	10.62	3.30
19	3.08	7.08	4.00	47	7.22	10.62	3.40
20	3.58	7.08	3.50	48	6.82	10.62	3.80
21	4.08	7.08	3.00	49	6.92	10.62	3.70
22	3.98	7.08	3.10	50	7.32	10.62	3.30
23	3.48	7.08	3.60	51	7.22	10.62	3.40
24	4.28	7.08	2.80	52	6.52	10.62	4.10
25	3.78	7.08	3.30	53	6.02	10.62	4.60
26	4.08	7.08	3.00	54	6.52	10.62	4.10
27	4.18	7.08	2.90	55	7.02	10.62	3.60
28	3.98	7.08	3.10	56	6.92	10.62	3.70

Table A.1 continued

Day	W_C (mm)	W_{IR} (mm)	ET (mm)	Day	W_C (mm)	W_{IR} (mm)	ET (mm)
57	6.42	10.62	4.20	87	9.15	14.15	5.00
58	7.22	10.62	3.40	88	9.65	14.15	4.50
59	6.72	10.62	3.90	89	10.15	14.15	4.00
60	7.02	10.62	3.60	90	10.05	14.15	4.10
61	7.12	10.62	3.50	91	9.55	14.15	4.60
62	6.92	10.62	3.70	92	10.35	14.15	3.80
63	7.02	10.62	3.60	93	9.85	14.15	4.30
64	6.92	10.62	3.70	94	10.15	14.15	4.00
65	6.52	10.62	4.10	95	10.25	14.15	3.90
66	6.62	10.62	4.00	96	10.05	14.15	4.10
67	7.02	10.62	3.60	97	10.15	14.15	4.00
68	6.92	10.62	3.70	98	10.05	14.15	4.10
69	6.32	10.62	4.30	99	9.65	14.15	4.50
70	9.35	14.15	4.80	100	9.75	14.15	4.40
71	9.85	14.15	4.30	101	10.15	14.15	4.00
72	10.35	14.15	3.80	102	10.05	14.15	4.10
73	10.25	14.15	3.90	103	9.55	14.15	4.60
74	9.75	14.15	4.40	104	9.05	14.15	5.10
75	10.55	14.15	3.60	105	9.55	14.15	4.60
76	10.05	14.15	4.10	106	10.05	14.15	4.10
77	10.35	14.15	3.80	107	9.95	14.15	4.20
78	10.45	14.15	3.70	108	9.45	14.15	4.70
79	10.25	14.15	3.90	109	10.25	14.15	3.90
80	10.35	14.15	3.80	110	9.75	14.15	4.40
81	10.25	14.15	3.90	111	10.05	14.15	4.10
82	9.85	14.15	4.30	112	10.15	14.15	4.00
83	9.95	14.15	4.20	113	9.95	14.15	4.20
84	10.35	14.15	3.80	114	10.05	14.15	4.10
85	10.25	14.15	3.90	115	9.55	14.15	4.60
86	9.65	14.15	4.50				

Table A.2 Measured pH values of the applied irrigation water supplied from Texas A&M University RELLIS Campus and applied in tomato plant cultivation during this study

#	T_0	T_1	T_2	T_3	T_4	T_5
1	8.74	8.36	8.37	8.30	8.22	8.21
2	8.32	8.08	8.34	8.55	8.71	8.85
3	8.10	8.22	8.67	8.88	9.10	9.16
4	8.39	7.96	8.62	8.87	9.10	9.14
5	8.68	8.18	9.03	9.36	9.56	9.70
6	8.58	8.25	8.31	8.33	8.35	8.37
7	8.52	8.07	8.33	8.51	8.64	8.70
8	8.61	8.40	8.61	8.71	9.03	9.05
9	8.63	8.18	9.74	10.13	10.39	10.59
10	8.38	8.06	8.04	8.00	7.92	7.83
11	8.63	8.48	8.58	8.62	8.67	8.71
12	8.37	8.23	8.11	8.00	7.72	7.39
13	8.40	7.99	8.45	8.68	8.81	8.96
14	8.47	8.06	10.90	11.71	12.09	12.32
15	8.47	8.26	8.80	9.11	9.33	9.51
16	8.54	8.36	9.87	10.37	10.83	11.36
17	8.45	8.56	8.83	9.04	9.19	9.32
18	8.53	8.34	8.43	8.49	8.55	8.63
19	8.43	8.19	8.29	8.35	8.38	8.42
20	8.27	8.24	9.30	9.63	9.84	9.98
21	8.40	8.10	8.49	8.74	8.90	8.98
22	8.90	8.63	8.70	8.76	8.79	8.83
23	8.97	8.65	9.08	9.13	9.25	9.35

#: Days of the water collected

Table A.3 Measured electrical conductivity (μS/cm) values of the applied irrigation water supplied from Texas A&M University RELLIS Campus and applied in tomato plant cultivation during this study

#	T_0	T_1	T_2	T_3	T_4	T_5
1	937	1,483	1,383	1,281	1,169	1,043
2	1,019	1,656	1,572	1,513	1,424	1,349
3	1,029	1,702	1,825	1,913	2,212	2,130
4	923	1,802	1,849	2,004	2,125	2,240
5	925	1,956	2,114	2,283	2,489	2,651
6	830	2,191	1,882	1,573	1,250	948
7	847	1,918	1,797	1,654	1,505	1,303
8	856	1,741	1,633	1,491	1,677	1,413
9	827	1,920	2,402	2,879	3,381	3,888
10	848	2,250	2,064	1,905	1,757	1,598
11	851	2,111	1,960	1,823	1,664	1,526
12	890	1,968	1,663	1,361	1,072	765
13	863	1,424	1,463	1,490	1,508	1,553
14	884	1,325	1,250	1,175	1,100	1,025
15	898	1,950	1,901	1,827	1,755	1,704
16	904	2,112	1,972	1,831	1,691	1,550
17	933	2,170	2,111	2,078	2,046	1,990
18	930	2,281	1,923	1,546	1,164	797
19	961	1,851	1,681	1,485	1,280	1,086
20	1,010	1,661	1,936	2,205	2,465	2,708
21	1,023	1,560	1,661	1,739	1,809	1,793
22	1,016	1,471	1,388	1,324	1,225	1,137
23	869	1,405	1,449	1,490	1,512	1,580

#: Days of the water collected

Table A.4 Measured total dissolved solids (mg/L) values of the applied irrigation water supplied from Texas A&M University RELLIS Campus and applied in tomato plant cultivation during this study

#	T_0	T_1	T_2	T_3	T_4	T_5
1	469	741	691	640	584	519
2	509	827	786	756	711	675
3	514	851	912	962	1,107	1,064
4	462	901	925	1,002	1,062	1,120
5	463	978	1,058	1,142	1,245	1,326
6	415	1,097	941	787	625	474
7	424	959	899	827	752	651
8	428	871	818	749	839	707
9	414	959	1,201	1,440	1,689	1,942
10	424	1,127	1,033	953	878	799
11	426	1,057	980	912	833	763
12	445	984	832	681	536	384
13	432	712	732	745	754	776
14	442	663	625	588	550	513
15	449	976	951	914	878	851
16	452	1,056	986	916	845	775
17	466	1,086	1,056	1,039	1,023	993
18	465	1,141	962	773	583	399
19	481	925	841	743	641	543
20	505	831	967	1,103	1,233	1,357
21	511	780	831	870	905	899
22	508	736	694	662	613	569
23	435	703	725	745	757	790

#: Days of the water collected

Table A.5 Analysis results of initial and final pH, electrical conductivity (EC), nitrate-nitrogen (NO_3-N), phosphorus (P), and organic matter (OM) of soil used in this study

Treatment	Replicate	pH	EC (µS/cm)	NO_3-N (mg/kg)	P (mg/kg)	OM (%)
$T_{initial}$		7.50	324	49	14	1.56
T_0	R_1	7.90	480	29	432	2.87
	R_2	7.90	378	58	411	1.95
	R_3	8.10	345	46	456	2.29
T_1	R_1	8.30	488	71	410	1.87
	R_2	8.00	433	41	419	2.17
	R_3	8.20	350	68	406	1.97
T_2	R_1	7.90	1,120	132	501	2.11
	R_2	8.00	853	151	373	2.00
	R_3	8.20	701	90	322	1.74
T_3	R_1	8.20	1,620	172	472	1.88
	R_2	8.10	1,160	146	420	1.75
	R_3	8.40	664	88	307	1.78
T_4	R_1	8.40	988	108	245	1.86
	R_2	7.80	1,570	254	471	1.81
	R_3	8.30	1,320	77	405	1.81
T_5	R_1	8.40	705	87	348	1.77
	R_2	8.50	1,030	121	316	1.71
	R_3	8.40	1,310	122	461	1.81

EC: Electrical Conductivity, NO_3-N: Nitrate-Nitrogen, P: Phosphorus,
OM: Organic Matter

Table A.6 Analysis results of initial and final calcium (Ca), magnesium (Mg), potassium (K), sodium (Na), and exchangeable sodium percentage (ESP) of soil used in this study

Treatment	Replicate	Ca (mg/kg)	Mg (mg/kg)	K (mg/kg)	Na (mg/kg)	ESP (%)
$T_{initial}$		7,355	247	297	16	20.21
T_0	R_1	5,167	224	160	12	21.57
	R_2	4,791	174	112	4	7.87
	R_3	5,201	199	137	8	14.43
T_1	R_1	5,225	176	121	8	14.47
	R_2	4,983	174	129	15	28.30
	R_3	4,975	170	120	7	13.28
T_2	R_1	5,042	175	115	7	13.11
	R_2	4,913	179	136	10	19.09
	R_3	4,715	158	107	6	12.03
T_3	R_1	4,970	184	141	12	22.61
	R_2	5,112	178	140	15	27.55
	R_3	4,980	165	148	8	15.09
T_4	R_1	4,768	157	139	11	21.67
	R_2	5,083	187	147	10	18.43
	R_3	4,857	171	145	8	15.44
T_5	R_1	4,835	162	132	7	13.63
	R_2	4,781	153	133	12	23.63
	R_3	4,865	167	130	8	15.47

Ca: Calcium, Mg: Magnesium, K: Potassium, Na: Sodium,
ESP: Exchangeable Sodium Percentage

Table A.7 Average fruit wet-dry weight (g), average fruit length-width (mm), harvested fruit per plant (g), and yield per plant (g)

Treat	Rep	Average Wet Weight (g)	Average Dry Weight (g)	Average Length (mm)	Average Width (mm)	Fruit Per Plant	Yield Per Plant (g)
T_0	R_1	71.5	4.66	52.4	49.1	2	142.9
	R_2	73.1	5.34	48.8	52.3	4	292.3
	R_3	66.8	5.18	47.9	49.9	2	133.6
T_1	R_1	55.0	4.01	45.5	46.9	8	439.8
	R_2	51.0	4.46	39.5	48.4	2	102.1
	R_3	69.2	5.10	48.1	54.6	5	346.0
T_2	R_1	65.3	4.34	46.6	50.2	4	261.1
	R_2	55.7	4.23	47.5	46.5	8	446.0
	R_3	73.4	6.10	50.2	52.3	2	146.9
T_3	R_1	79.3	5.21	51.4	53.6	5	396.5
	R_2	66.2	5.07	48.3	51.4	5	330.8
	R_3	47.0	3.74	43.7	47.0	5	235.1
T_4	R_1	88.3	6.29	53.9	55.4	5	441.5
	R_2	76.8	4.86	45.2	55.1	5	383.9
	R_3	79.3	6.23	49.2	56.2	4	317.2
T_5	R_1	81.8	5.67	49.6	55.5	6	490.9
	R_2	109.8	7.78	53.8	61.5	1	109.8
	R_3	59.4	4.43	45.0	49.5	5	297.1

Treat: Treatment, Rep: Replicate

Table A.8 Plant parts' (i.e., root, crown, lower stem) dry-wet weight (g)

Treat	Rep	Root		Crown		Lower Stem	
		Wet Weight (g)	Dry Weight (g)	Wet Weight (g)	Dry Weight (g)	Wet Weight (g)	Dry Weight (g)
T_0	R_1	2.42	1.80	2.03	1.46	7.14	2.05
	R_2	2.57	2.08	2.47	1.63	7.83	2.03
	R_3	2.02	1.56	3.48	1.65	9.66	2.84
T_1	R_1	2.99	1.96	4.80	2.50	8.27	2.36
	R_2	4.82	2.23	3.98	2.23	9.02	2.87
	R_3	7.35	3.20	3.74	1.79	6.77	2.00
T_2	R_1	2.23	1.56	3.08	1.82	8.45	2.48
	R_2	3.18	1.89	4.27	2.12	8.21	2.77
	R_3	1.79	1.42	5.36	2.43	7.98	2.96
T_3	R_1	1.55	1.27	2.94	1.90	7.03	2.81
	R_2	1.30	1.16	6.15	2.91	6.74	2.29
	R_3	2.75	2.03	5.23	2.71	10.10	3.15
T_4	R_1	1.46	1.13	5.16	3.46	6.10	2.22
	R_2	3.34	2.11	5.87	2.30	4.70	1.55
	R_3	3.88	2.55	6.61	3.29	5.02	2.26
T_5	R_1	2.02	1.48	3.84	2.24	6.48	2.46
	R_2	4.43	2.55	6.18	2.90	7.88	2.29
	R_3	4.59	1.79	6.46	3.34	9.39	3.38

Treat: Treatment, Rep: Replicate

Table A.9 Plant parts' (i.e., upper stem, leaf, truss) dry-wet weight (g)

Treat	Rep	Upper Stem		Leaf		Truss	
		Wet Weight (g)	Dry Weight (g)	Wet Weight (g)	Dry Weight (g)	Wet Weight (g)	Dry Weight (g)
T_0	R_1	465.1	84.0	328.0	47.2	2.23	0.49
	R_2	254.5	51.0	139.7	42.3		
	R_3	407.5	83.1	275.4	49.1		
T_1	R_1	366.7	76.4	240.3	42.4	5.19	1.12
	R_2	391.9	88.1	241.5	48.0		
	R_3	470.7	66.2	280.7	42.2		
T_2	R_1	402.1	78.0	226.6	47.7	5.54	1.43
	R_2	456.2	80.5	251.1	45.0		
	R_3	484.7	87.6	224.4	48.0		
T_3	R_1	469.7	92.1	258.3	48.6	4.33	1.18
	R_2	526.5	91.7	326.0	52.5		
	R_3	536.9	94.2	312.8	50.1		
T_4	R_1	456.5	82.4	224.7	38.5	6.94	1.52
	R_2	435.2	81.9	242.6	51.7		
	R_3	452.2	90.0	222.3	50.4		
T_5	R_1	353.5	78.3	206.3	40.2	2.21	0.52
	R_2	364.5	80.1	256.9	56.1		
	R_3	429.5	92.4	323.7	60.1		

Treat: Treatment, Rep: Replicate

Table A.10 The final plant height measured after this study completed

Treat	Rep	Plant Height (cm)
T_0	R_1	147.3
	R_2	146.7
	R_3	162.6
T_1	R_1	198.1
	R_2	152.4
	R_3	134.6
T_2	R_1	162.6
	R_2	182.9
	R_3	152.4
T_3	R_1	175.3
	R_2	157.5
	R_3	207.0
T_4	R_1	158.8
	R_2	156.2
	R_3	170.2
T_5	R_1	210.8
	R_2	157.5
	R_3	146.1

Treat: Treatment, Rep: Replicate

Table A.11 Wet-dry weight (g) length-diameter (mm) measurement of harvested tomato fruits for T_0 treatment

Treat	Rep	#	Wet Weight (g)	Dry Weight (g)	Length (mm)	Width (mm)
T_0	R_1	1	52.44	3.21	47.6	44.0
		2	90.48	6.11	57.1	54.2
	R_2	1	130.46	8.02	56.5	64.4
		2	77.57	5.36	52.2	54.0
		3	37.27	3.61	42.0	42.8
		4	47.01	4.35	44.5	48.0
	R_3	1	85.29	6.45	50.1	56.0
		2	48.31	3.90	45.6	43.8

Treat: Treatment, Rep: Replicate, #: number of harvested tomatoes

Table A.12 Wet-dry weight (g) length-diameter (mm) measurement of harvested tomato fruits for T_1 treatment

Treat	Rep	#	Wet Weight (g)	Dry Weight (g)	Length (mm)	Width (mm)
T_1	R_1	1	32.74	2.32	37.3	40.9
		2	20.75	1.51	31.1	35.8
		3	57.39	4.19	43.1	48.0
		4	77.87	5.70	51.7	51.7
		5	61.09	4.32	46.3	49.4
		6	49.44	3.72	52.3	45.8
		7	58.15	4.53	47.4	48.3
		8	82.40	5.78	54.5	55.0
	R_2	1	68.23	5.81	41.0	53.5
		2	33.84	3.12	37.9	43.2
	R_3	1	76.08	3.75	50.9	51.2
		2	149.53	11.59	59.1	71.0
		3	121.79	9.34	54.2	65.6
		4	27.14	2.15	37.0	37.3
		5	40.60	3.80	39.5	47.7

Treat: Treatment, Rep: Replicate, #: number of harvested tomatoes

Table A.13 Wet-dry weight (g) length-diameter (mm) measurement of harvested tomato fruits for T_2 treatment

Treat	Rep	#	Wet Weight (g)	Dry Weight (g)	Length (mm)	Width (mm)
T_2	R_1	1	49.72	3.35	43.0	46.9
		2	60.28	3.45	47.7	47.6
		3	59.21	3.47	45.8	49.6
		4	91.86	7.09	49.8	56.5
	R_2	1	45.94	3.40	42.8	43.1
		2	51.17	3.95	47.7	45.4
		3	54.48	4.21	46.1	47.4
		4	53.97	4.20	47.3	46.1
		5	67.40	5.13	50.6	49.1
		6	59.80	4.43	50.7	46.2
		7	73.48	5.22	52.8	50.7
		8	39.71	3.26	42.3	43.6
	R_3	1	72.08	6.36	49.2	52.2
		2	74.77	5.85	51.2	52.3

Treat: Treatment, Rep: Replicate, #: number of harvested tomatoes

Table A.14 Wet-dry weight (g) length-diameter (mm) measurement of harvested tomato fruits for T_3 treatment

Treat	Rep	#	Wet Weight (g)	Dry Weight (g)	Length (mm)	Width (mm)
T_3	R_1	1	69.95	4.57	48.0	51.4
		2	55.52	4.12	46.2	47.1
		3	99.46	7.21	56.2	57.3
		4	75.76	5.32	52.5	52.3
		5	95.84	4.82	54.3	60.0
	R_2	1	107.10	7.51	57.3	58.2
		2	61.95	4.34	46.8	48.0
		3	48.74	4.28	44.8	48.6
		4	56.88	4.84	43.4	54.2
		5	56.13	4.41	49.2	47.9
	R_3	1	46.04	2.45	42.8	50.5
		2	60.32	4.85	42.0	50.3
		3	39.11	3.37	41.8	44.6
		4	41.35	3.84	43.9	45.1
		5	48.23	4.19	47.8	44.6

Treat: Treatment, Rep: Replicate, #: number of harvested tomatoes

Table A.15 Wet-dry weight (g) length-diameter (mm) measurement of harvested tomato fruits for T_4 treatment

Treat	Rep	#	Wet Weight (g)	Dry Weight (g)	Length (mm)	Width (mm)
T_4	R_1	1	141.03	9.25	57.6	70.7
		2	62.39	4.81	53.8	47.5
		3	71.32	5.58	52.6	50.8
		4	96.62	7.04	53.7	58.5
		5	70.18	4.75	52.0	49.6
	R_2	1	185.65	7.00	62.6	80.0
		2	56.46	4.59	39.1	52.4
		3	34.04	3.06	36.0	44.5
		4	42.56	4.26	40.6	46.6
		5	65.15	5.38	47.8	52.2
	R_3	1	110.93	7.59	52.4	62.3
		2	102.69	5.34	54.4	61.6
		3	63.56	7.75	50.2	51.6
		4	40.00	4.23	39.6	49.2

Treat: Treatment, Rep: Replicate, #: number of harvested tomatoes

Table A.16 Wet-dry weight (g) length-diameter (mm) measurement of harvested tomato fruits for T_5 treatment

Treat	Rep	#	Wet Weight (g)	Dry Weight (g)	Length (mm)	Width (mm)
T_5	R_1	1	50.01	3.01	40.8	50.7
		2	120.25	7.79	55.1	61.9
		3	102.90	8.03	52.1	62.9
		4	73.64	5.07	50.4	52.0
		5	83.59	5.83	52.4	54.8
		6	60.52	4.27	46.8	50.6
	R_2	1	109.76	7.78	53.8	61.5
	R_3	1	66.19	4.60	46.9	50.6
		2	73.34	5.10	46.5	55.0
		3	50.68	4.02	45.2	45.3
		4	72.57	5.56	47.7	54.0
		5	34.36	2.88	38.6	42.7

Treat: Treatment, Rep: Replicate, #: number of harvested tomatoes

Table A.17 Measured concentration levels of heavy metals (μg/L) in T_0 water samples collected from Texas A&M University RELLIS Campus

#	Al	As	Co	Cu	Fe	Mn	Pb	V	Zn
1	17.14	1.40	-	149.12	-	0.59	320.32	0.42	4.37
2	17.83	0.64	-	289.02	-	-	64.06	0.09	17.43
3	17.81	0.64	-	301.82	-	-	106.77	0.15	23.89
4	19.45	-	-	64.15	-	-	170.84	-	3.36
5	18.72	-	-	176.78	-	0.04	64.06	0.06	5.18
6	19.46	-	-	43.86	-	1.69	128.13	-	0.40
7	18.35	-	-	148.15	-	2.76	192.19	0.06	4.31
8	18.97	-	-	24.64	-	0.96	149.48	-	-
9	19.21	-	-	109.86	-	1.47	213.55	-	1.01
10	19.78	-	-	64.13	-	2.06	106.77	-	-
11	19.16	-	-	18.96	22.57	1.69	192.19	-	-
12	18.95	-	-	82.20	14.69	1.69	192.19	-	-
13	20.15	-	-	141.32	8.17	2.17	277.61	-	1.14
14	18.93	-	-	9.20	7.52	1.84	192.19	0.06	-
15	18.79	-	-	54.13	-	2.17	298.97	0.11	-
16	18.11	1.40	-	88.72	-	1.03	277.61	-	0.34
17	18.26	-	-	117.65	-	2.61	85.42	-	-
18	17.60	-	-	111.39	-	1.51	64.06	-	-
19	17.13	0.51	-	214.00	-	0.00	64.06	-	5.59
20	17.49	-	-	63.02	-	-	213.55	0.02	0.74
21	17.00	-	-	167.17	-	-	149.48	-	7.81
22	16.98	0.38	-	129.00	-	-	149.48	-	5.92
23	17.54	-	-	90.77	-	0.44	106.77	-	0.00

"-": Not Detected, "#" Days of the irrigation water collected, Beryllium (Be), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Selenium (Se) were not detected. Al: Aluminum, As: Arsenic, Co: Cobalt Cu: Copper, Fe: Iron, Mn: Manganese, Pb: Lead, V: Vanadium, Zn: Zinc

Table A.18 Measured concentration levels of heavy metals (μg/L) in T_1 water samples collected from Texas A&M University RELLIS Campus

#	Al	As	Co	Cu	Fe	Mn	Pb	V	Zn
1	16.00	3.19	0.50	-	-	-	170.84	4.48	2.76
2	16.98	2.93	0.67	-	-	0.48	341.67	4.48	15.54
3	17.27	1.91	0.41	-	-	-	192.19	4.20	18.37
4	16.02	2.17	0.55	-	-	-	149.48	5.09	27.86
5	19.15	4.47	0.92	3.17	155.88	10.80	256.26	5.43	48.65
6	110.46	6.38	0.74	7.01	225.86	10.99	170.84	6.66	35.06
7	22.00	6.76	0.61	2.09	230.32	7.39	298.99	6.41	31.09
8	18.37	4.98	0.25	-	-	-	234.90	5.56	7.13
9	19.73	6.12	0.32	0.46	-	-	213.55	6.17	10.36
10	23.02	4.08	0.54	7.04	144.68	4.74	128.13	5.60	17.36
11	25.99	7.27	0.48	5.28	40.37	-	213.55	6.77	4.37
12	37.84	4.85	0.58	12.34	540.67	32.01	234.90	6.05	43.00
13	31.78	3.70	0.51	9.46	426.15	24.29	320.32	4.28	37.28
14	32.75	4.59	0.53	6.82	430.92	22.38	469.80	4.20	39.16
15	29.26	4.85	0.61	5.78	215.73	8.78	106.77	5.52	21.73
16	279.44	5.36	0.62	5.66	212.77	10.95	341.67	4.62	24.90
17	28.75	4.59	0.56	8.05	213.26	11.14	341.70	5.35	20.25
18	25.25	6.76	0.47	7.66	47.00	2.02	128.13	4.71	7.40
19	20.66	3.83	0.29	13.47	9.60	0.96	128.13	5.03	2.89
20	35.11	3.96	0.50	17.90	558.64	28.19	106.77	4.65	52.35
21	27.53	3.06	0.48	16.14	151.68	7.75	277.61	5.75	15.41
22	26.38	2.04	0.41	13.09	84.21	4.34	363.05	4.52	14.53
23	24.30	3.57	0.35	4.50	-	-	256.26	4.64	1.41

“-“: Not Detected, “#” Days of the irrigation water collected, Beryllium (Be), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Selenium (Se) were not detected. Al: Aluminum, As: Arsenic, Co: Cobalt Cu: Copper, Fe: Iron, Mn: Manganese, Pb: Lead, V: Vanadium, Zn: Zinc

Table A.19 Measured concentration levels of heavy metals (μg/L) in T_2 water samples collected from Texas A&M University RELLIS Campus

#	Al	As	Co	Cu	Fe	Mn	Pb	V	Zn
1	25.59	2.39	0.37	0.96	2.38	-	170.84	3.60	2.07
2	19.80	2.20	0.51	10.67	5.34	1.90	293.63	3.60	14.27
3	20.34	1.44	0.31	65.35	32.61	2.14	213.55	3.55	19.25
4	35.68	1.69	0.43	126.54	39.34	4.99	213.55	4.08	21.05
5	33.14	7.40	0.71	167.55	166.66	13.90	234.90	4.30	39.87
6	180.54	5.07	0.57	10.16	262.97	9.43	186.85	5.74	26.29
7	31.38	5.07	0.46	14.09	175.44	6.55	245.59	5.02	24.36
8	34.87	3.89	0.21	70.50	20.20	1.64	234.90	4.56	5.79
9	45.22	5.77	0.32	44.44	41.74	6.86	181.51	5.46	14.52
10	30.49	3.06	0.40	19.45	135.09	11.01	138.81	4.29	13.49
11	26.03	5.58	0.37	13.96	35.83	2.19	218.89	5.25	7.08
12	52.81	3.99	0.46	10.80	425.34	24.01	213.55	5.23	32.25
13	31.01	3.13	0.38	19.00	324.93	18.22	293.63	3.35	32.74
14	114.55	25.71	0.57	36.96	359.14	19.23	379.05	5.79	44.82
15	33.23	4.05	0.65	32.60	187.88	8.10	122.79	4.48	19.40
16	286.65	5.07	0.67	162.52	227.01	12.41	325.66	4.54	43.99
17	34.59	3.73	0.42	64.13	159.95	12.45	352.37	4.27	15.19
18	29.50	5.36	0.39	7.99	42.38	1.52	160.16	4.85	5.77
19	21.62	3.41	0.25	14.60	7.20	0.85	149.48	4.72	3.97
20	38.79	5.07	0.40	53.11	432.44	23.82	154.82	3.86	42.33
21	29.68	2.55	0.36	80.33	113.76	9.17	266.93	4.60	11.56
22	27.29	1.53	0.32	18.81	65.58	4.11	309.66	3.94	13.14
23	27.69	3.35	0.27	13.98	20.09	0.16	240.24	3.74	10.72

"-": Not Detected, "#" Days of the irrigation water collected, Beryllium (Be), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Selenium (Se) were not detected. Al: Aluminum, As: Arsenic, Co: Cobalt Cu: Copper, Fe: Iron, Mn: Manganese, Pb: Lead, V: Vanadium, Zn: Zinc

Table A.20 Measured concentration levels of heavy metals (μg/L) in T_3 water samples collected from Texas A&M University RELLIS Campus

#	Al	As	Co	Cu	Fe	Mn	Pb	V	Zn
1	35.19	1.59	0.25	1.91	4.75	-	170.84	2.72	1.38
2	22.63	1.47	0.35	21.33	10.68	3.33	245.58	2.72	12.99
3	23.41	0.96	0.22	130.70	65.23	4.28	234.90	2.90	20.12
4	55.35	1.21	0.31	253.08	78.68	9.98	277.61	3.07	14.23
5	47.13	10.34	0.51	331.94	177.44	17.00	213.55	3.17	31.09
6	250.62	3.76	0.41	13.30	300.08	7.86	202.87	4.82	17.53
7	40.75	3.38	0.31	26.09	120.55	5.71	192.20	3.63	17.63
8	51.37	2.81	0.17	141.00	40.39	3.27	234.90	3.56	4.44
9	70.71	5.42	0.32	88.43	83.48	13.73	149.48	4.75	18.67
10	37.97	2.04	0.27	31.85	125.51	17.28	149.48	2.97	9.62
11	26.07	3.89	0.26	22.65	31.29	4.37	224.22	3.73	9.79
12	67.78	3.13	0.34	9.27	310.00	16.01	192.19	4.40	21.50
13	30.25	2.55	0.26	28.53	223.71	12.15	266.93	2.42	28.19
14	196.36	46.83	0.62	67.09	287.37	16.08	288.29	7.37	50.47
15	37.20	3.25	0.69	59.42	160.04	7.42	138.81	3.43	17.06
16	293.86	4.78	0.72	319.38	241.25	13.87	309.64	4.47	63.09
17	40.42	2.87	0.28	120.20	106.63	13.76	363.04	3.18	10.13
18	33.75	3.96	0.32	8.32	37.77	1.01	192.19	4.99	4.14
19	22.58	3.00	0.22	15.74	4.80	0.75	170.84	4.40	5.05
20	42.46	6.19	0.31	88.32	306.24	19.46	202.87	3.07	32.30
21	31.84	2.04	0.24	144.52	75.84	10.58	256.26	3.44	7.70
22	28.20	1.02	0.22	24.54	46.95	3.88	256.27	3.37	11.74
23	31.07	3.13	0.18	23.45	40.19	0.31	224.22	2.84	20.02

“-“: Not Detected, “#” Days of the irrigation water collected, Beryllium (Be), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Selenium (Se) were not detected. Al: Aluminum, As: Arsenic, Co: Cobalt Cu: Copper, Fe: Iron, Mn: Manganese, Pb: Lead, V: Vanadium, Zn: Zinc

Table A.21 Measured concentration levels of heavy metals (μg/L) in T_4 water samples collected from Texas A&M University RELLIS Campus

#	Al	As	Co	Cu	Fe	Mn	Pb	V	Zn
1	44.78	0.80	0.12	2.87	7.13	-	170.84	1.83	0.69
2	25.45	0.73	0.19	32.00	16.02	4.75	197.53	1.84	11.71
3	26.49	0.48	0.13	196.05	97.84	6.42	256.26	2.26	20.99
4	75.01	0.73	0.20	379.62	118.03	14.97	341.67	2.07	7.42
5	61.12	13.27	0.30	496.32	188.22	20.09	192.19	2.04	22.31
6	320.70	2.46	0.24	16.45	337.18	6.30	218.89	3.89	8.76
7	50.13	1.69	0.15	38.08	65.66	4.88	138.81	2.24	10.90
8	67.87	1.72	0.12	211.50	60.59	4.91	234.90	2.55	3.10
9	96.20	5.07	0.32	132.42	125.22	20.59	117.45	4.04	22.83
10	45.44	1.02	0.14	44.25	115.92	23.54	160.16	1.66	5.75
11	26.12	2.20	0.14	31.33	26.76	6.56	229.56	2.20	12.50
12	82.75	2.26	0.22	7.74	194.66	8.00	170.84	3.57	10.75
13	29.48	1.98	0.13	38.07	122.49	6.07	240.24	1.49	23.65
14	278.17	67.95	0.66	97.22	215.59	12.93	197.53	8.95	56.12
15	41.17	2.46	0.73	86.25	132.19	6.74	154.82	2.39	14.72
16	301.07	4.50	0.77	476.24	255.49	15.33	293.63	4.39	82.19
17	46.26	2.01	0.14	176.28	53.32	15.08	373.71	2.09	5.06
18	38.00	2.55	0.25	8.66	33.15	0.51	224.22	5.12	2.51
19	23.54	2.58	0.18	16.87	2.40	0.65	192.19	4.08	6.12
20	46.13	7.30	0.21	123.53	180.03	15.10	250.92	2.28	22.27
21	34.00	1.53	0.13	208.70	37.92	12.00	245.58	2.29	3.85
22	29.11	0.51	0.13	30.27	28.31	3.65	202.87	2.79	10.35
23	34.46	2.90	0.09	32.92	60.28	0.47	208.21	1.94	29.32

"-": Not Detected, "#" Days of the irrigation water collected, Beryllium (Be), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Selenium (Se) were not detected.
Al: Aluminum, As: Arsenic, Co: Cobalt Cu: Copper, Fe: Iron, Mn: Manganese, Pb: Lead, V: Vanadium, Zn: Zinc

Table A.22 Measured concentration levels of heavy metals (μg/L) in T_5 water samples collected from Texas A&M University RELLIS Campus

#	Al	As	Co	Cu	Fe	Mn	Pb	V	Zn
1	54.38	-	-	3.83	9.51	-	170.84	0.95	-
2	28.28	-	0.03	42.66	21.36	6.17	149.48	0.96	10.43
3	29.56	-	0.03	261.40	130.46	8.56	277.61	1.61	21.87
4	94.68	0.26	0.08	506.16	157.37	19.96	405.74	1.06	0.61
5	75.11	16.20	0.10	660.71	199.00	23.19	170.84	0.91	13.53
6	390.78	1.15	0.07	19.59	374.29	4.74	234.90	2.97	-
7	59.51	-	-	50.08	10.78	4.04	85.42	0.85	4.17
8	84.37	0.64	0.08	282.00	80.78	6.54	234.90	1.55	1.75
9	121.69	4.72	0.32	176.40	166.96	27.45	85.42	3.33	26.98
10	52.91	-	0.00	56.65	106.34	29.81	170.84	0.34	1.88
11	26.16	0.51	0.03	40.01	22.22	8.75	234.90	0.68	15.21
12	97.73	1.40	0.10	6.21	79.33	-	149.48	2.74	-
13	28.71	1.40	-	47.60	21.27	0.00	213.55	0.57	19.11
14	359.98	89.06	0.70	127.36	143.81	9.78	106.77	10.54	61.78
15	45.14	1.66	0.77	113.07	104.35	6.06	170.84	1.34	12.38
16	308.28	4.21	0.82	633.10	269.74	16.79	277.61	4.31	101.28
17	52.09	1.15	0.01	232.35	-	16.39	384.38	1.00	-
18	42.25	1.15	0.18	8.99	28.53	-	256.26	5.26	0.87
19	24.50	2.17	0.14	18.01	-	0.55	213.55	3.77	7.20
20	49.80	8.42	0.12	158.74	53.83	10.73	298.97	1.49	12.25
21	36.15	1.02	0.01	272.89	-	13.41	234.90	1.14	-
22	30.03	-	0.04	36.00	9.68	3.42	149.48	2.21	8.95
23	37.84	2.68	-	42.39	80.38	0.62	192.19	1.04	38.63

"-": Not Detected, "#" Days of the irrigation water collected, Beryllium (Be), Cadmium (Cd), Chromium (Cr), Nickel (Ni), and Selenium (Se) were not detected. Al: Aluminum, As: Arsenic, Co: Cobalt Cu: Copper, Fe: Iron, Mn: Manganese, Pb: Lead, V: Vanadium, Zn: Zinc

Table A.23 Measured concentration levels of heavy metals (μg/kg) in root by treatments

#	Al	As	Be	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
T_0R_1	105.72	2.81	0.02	0.49	0.65	6.42	82.91	31.03	1.84	36.32	1.57	29.64
T_0R_1	46.52	1.84	0.00	0.38	0.39	4.78	37.91	22.97	1.23	23.68	0.87	22.92
T_0R_2	156.74	4.07	0.03	0.54	0.00	8.83	121.83	30.29	2.78	51.46	1.00	23.23
T_0R_2	323.92	4.92	0.02	0.77	0.40	9.79	244.39	50.72	1.39	61.07	2.11	22.04
T_0R_3	154.02	1.90	0.00	0.34	0.15	5.39	110.55	28.67	1.67	27.78	1.60	18.89
T_0R_3	100.10	1.90	0.02	0.28	0.06	3.96	72.39	22.15	1.40	22.97	1.18	15.43
T_1R_1	241.38	7.20	0.01	0.63	0.28	10.43	179.45	36.25	2.99	55.20	2.32	13.07
T_1R_1	204.38	6.41	0.02	0.66	0.14	9.75	152.87	34.93	1.98	55.38	1.87	13.47
T_1R_2	397.86	5.50	0.03	0.86	0.59	11.54	302.43	53.44	1.03	73.54	2.62	22.76
T_1R_2	208.76	4.59	0.03	0.60	0.21	7.92	161.12	36.09	0.94	43.45	1.60	16.24
T_1R_3	260.51	4.18	0.03	0.74	0.47	10.02	197.32	44.51	0.80	57.69	1.45	15.03
T_1R_3	114.64	2.25	0.02	0.32	0.05	5.17	86.27	26.82	0.44	37.03	0.76	11.47
T_2R_1	196.37	4.39	0.01	0.49	0.12	6.96	142.64	31.21	1.64	42.02	1.62	15.10
T_2R_1	264.00	6.50	0.02	0.60	0.25	8.14	190.53	37.05	1.38	46.47	2.17	13.19
T_2R_2	311.72	5.27	-	0.47	0.82	7.02	235.73	33.80	1.07	42.02	2.67	7.98
T_2R_2	315.75	5.62	0.03	0.42	0.62	6.09	226.21	35.25	1.67	40.42	2.81	8.16
T_2R_3	257.62	5.94	0.01	0.71	0.39	7.93	204.67	30.85	1.68	57.33	2.81	13.16
T_2R_3	317.85	5.65	0.00	0.77	0.58	7.76	245.29	34.15	1.71	51.46	2.97	13.07
T_3R_1	213.91	2.40	0.01	0.35	0.16	4.86	161.09	22.69	0.96	19.94	1.83	13.86
T_3R_1	142.92	2.93	0.01	0.28	0.08	6.74	101.82	17.53	1.01	23.68	1.26	11.52
T_3R_2	188.52	3.04	0.01	0.33	0.04	6.11	132.60	26.99	1.29	39.35	1.69	14.05
T_3R_2	201.72	3.48	0.00	0.34	-	6.44	142.50	28.10	1.05	50.75	2.01	12.18
T_3R_3	63.23	1.43	0.01	0.12	-	0.76	37.04	7.61	0.15	14.60	0.62	1.36
T_3R_3	308.64	3.45	0.01	0.46	0.48	6.61	225.39	26.58	1.73	42.38	2.84	10.27
T_4R_1	278.51	4.13	0.01	0.40	0.02	8.82	185.63	19.31	1.10	47.18	2.72	19.66
T_4R_1	309.06	3.89	0.01	0.46	0.20	9.39	208.10	21.69	1.10	37.57	2.87	16.02
T_4R_2	681.31	4.86	0.03	0.68	1.04	5.15	493.12	67.52	1.16	53.24	4.30	11.70
T_4R_2	779.08	5.21	0.05	0.67	1.28	6.12	571.60	78.02	1.27	51.28	4.97	14.27
T_4R_3	462.13	3.98	0.03	0.72	1.90	10.02	404.46	33.07	1.59	63.57	2.98	14.75
T_4R_3	469.34	3.75	0.02	0.63	0.66	8.44	371.17	32.96	1.94	68.20	2.94	13.80
T_5R_1	536.95	5.56	0.04	0.68	0.69	10.46	390.91	34.16	1.30	50.21	2.34	17.52
T_5R_1	301.10	6.53	0.02	0.50	0.24	8.13	208.84	24.17	0.58	38.46	1.59	15.12
T_5R_2	459.86	5.68	0.04	0.55	0.91	8.15	348.54	27.68	1.81	68.55	3.08	13.81
T_5R_2	386.66	5.06	0.01	0.47	0.49	7.30	283.71	24.05	1.26	53.59	2.55	14.49
T_5R_3	167.62	3.86	-	0.32	0.36	6.61	149.07	18.83	0.71	42.55	1.71	12.98
T_5R_3	120.96	3.57	0.00	0.30	0.31	4.91	102.85	17.79	0.70	40.42	1.39	10.81

T: Treatment, R: Replicate, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc,
“-“: Not Detected, Cadmium (Cd) and Selenium (Se) were not detected.

Table A.24 Measured concentration levels of heavy metals (μg/kg) in crown by treatments

#	Al	As	Be	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
T_0R_1	119.43	3.54	0.03	0.72	1.01	9.76	94.13	24.16	1.88	44.34	0.97	44.12
T_0R_2	126.96	2.52	0.03	0.55	0.07	9.89	93.34	26.58	0.78	51.64	0.51	39.80
T_0R_3	100.99	1.55	0.02	0.22	0.28	2.37	77.44	19.05	1.08	27.24	0.48	17.32
T_1R_1	206.57	6.15	0.02	0.56	0.98	10.82	198.14	22.69	1.77	58.40	0.72	19.57
T_1R_2	187.91	3.04	0.01	0.43	0.28	6.39	163.25	24.95	0.68	47.01	0.70	24.15
T_1R_3	194.62	4.39	0.01	0.73	0.06	8.84	144.71	30.21	0.95	51.99	1.01	24.00
T_2R_1	109.68	7.64	0.00	0.50	-	8.27	81.21	21.91	1.02	54.84	0.74	19.38
T_2R_2	729.29	4.89	0.05	0.68	1.14	9.77	619.18	37.49	2.10	52.88	2.37	12.30
T_2R_3	85.13	2.93	0.01	0.31	0.28	4.88	75.02	20.29	1.04	22.79	0.41	13.87
T_3R_1	166.96	2.52	0.02	0.34	0.01	5.83	121.16	18.19	0.42	35.79	0.63	20.09
T_3R_2	46.67	2.90	0.00	0.20	-	4.80	39.89	12.55	0.44	24.22	0.39	15.04
T_3R_3	73.88	1.64	0.00	0.20	-	2.44	53.28	11.83	0.16	25.28	0.36	7.52
T_4R_1	127.07	2.46	0.00	0.22	-	6.94	91.05	15.67	0.52	43.09	0.66	21.88
T_4R_2	323.13	2.46	-	0.44	0.92	4.20	252.56	32.94	1.25	38.28	0.98	11.31
T_4R_3	251.31	2.58	0.01	0.41	0.69	8.12	210.38	27.75	0.83	64.63	1.07	16.66
T_5R_1	302.02	5.74	0.03	0.43	1.02	9.25	217.44	16.83	1.06	44.69	0.89	21.56
T_5R_2	810.56	2.52	0.04	0.69	2.50	9.51	736.91	34.63	1.84	68.37	2.12	20.82
T_5R_3	390.17	4.57	0.02	0.93	3.52	9.55	483.90	18.87	2.26	45.76	0.97	22.33

T: Treatment, R: Replicate, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc,
"-": Not Detected, Cadmium (Cd) and Selenium (Se) were not detected.

Table A.25 Measured concentration levels of heavy metals (μg/kg) in lower stem by treatments

#	Al	As	Be	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
T_0R_1	17.78	0.89	0.00	0.39	-	8.18	-	11.49	0.30	29.61	0.10	37.39
T_0R_2	20.68	0.91	0.01	0.43	-	28.72	16.65	16.51	0.07	39.71	0.14	43.15
T_0R_3	20.25	1.01	0.02	0.34	-	6.42	21.60	11.70	0.12	28.37	0.13	29.49
T_1R_1	81.01	1.09	0.01	0.47	-	8.76	127.84	15.66	0.42	36.70	0.36	26.29
T_1R_2	64.29	1.38	0.01	0.37	-	5.48	66.39	17.83	0.22	38.12	0.27	16.88
T_1R_3	61.15	1.66	0.01	0.49	-	7.18	85.69	18.52	0.50	39.54	0.26	22.93
T_2R_1	35.83	1.24	0.01	0.42	-	11.21	38.58	13.98	0.27	39.18	0.20	25.51
T_2R_2	61.58	2.20	0.00	0.31	-	19.62	42.92	12.18	0.47	46.10	0.22	15.80
T_2R_3	58.35	1.09	0.01	0.48	-	6.58	100.81	19.74	0.21	35.10	0.30	22.17
T_3R_1	46.38	1.21	0.01	0.37	-	8.19	60.75	14.60	0.15	32.98	0.23	29.13
T_3R_2	21.48	0.96	0.16	0.57	-	7.41	32.34	8.99	0.85	22.87	0.28	20.24
T_3R_3	20.16	1.26	0.02	0.53	-	7.70	31.14	12.57	0.47	37.94	0.18	20.58
T_4R_1	16.94	1.59	0.23	0.31	-	8.91	12.24	9.31	0.24	31.69	0.22	18.40
T_4R_2	21.03	2.56	0.07	0.37	-	8.22	25.06	11.76	0.74	37.45	0.16	21.09
T_4R_3	16.71	1.55	0.04	0.33	-	7.94	12.87	10.78	0.38	31.69	0.13	27.22
T_5R_1	36.56	1.06	0.05	0.41	-	6.93	34.77	10.34	0.63	28.66	0.20	30.14
T_5R_2	19.73	1.55	0.03	0.25	-	6.94	15.29	10.64	0.23	30.33	0.19	13.93
T_5R_3	30.14	1.62	0.02	0.31	-	8.69	19.97	11.03	0.35	32.30	0.18	18.78

T: Treatment, R: Replicate, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc, "-": Not Detected, Cadmium (Cd) and Selenium (Se) were not detected.

Table A.26 Measured concentration levels of heavy metals (μg/kg) in upper stem by treatments

#	Al	As	Be	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
T_0R_1	21.24	0.77	0.01	0.39	-	3.59	-	24.70	0.51	28.72	0.07	15.91
T_0R_1	23.55	1.24	0.00	0.56	-	4.40	-	33.38	0.12	32.27	0.11	20.33
T_0R_2	20.80	0.96	0.00	0.45	-	4.46	8.60	30.97	0.41	29.25	0.10	17.00
T_0R_2	26.86	0.77	0.01	0.46	-	4.31	13.80	30.31	0.34	28.19	0.11	18.80
T_0R_3	18.48	0.86	0.00	0.42	-	3.17	1.92	26.88	0.06	31.73	0.10	13.36
T_0R_3	18.13	1.16	0.00	0.46	-	3.45	4.30	28.97	0.10	32.62	0.13	16.45
T_1R_1	25.95	1.01	0.01	0.35	-	3.65	10.62	29.82	0.12	33.51	0.11	9.77
T_1R_1	21.94	0.49	-	0.20	-	0.68	-	16.17	-	18.79	0.06	4.13
T_1R_2	21.54	1.14	0.00	0.46	-	2.77	3.71	35.87	0.06	28.54	0.11	11.24
T_1R_2	19.13	1.61	-	0.41	-	2.97	4.20	33.77	0.10	25.53	0.09	11.12
T_1R_3	37.36	1.46	0.00	0.61	-	3.95	41.70	45.70	0.31	34.04	0.20	12.04
T_1R_3	40.87	1.28	0.00	0.67	-	4.12	40.99	48.60	0.39	32.62	0.21	13.35
T_2R_1	29.67	1.83	-	0.42	-	4.39	9.66	34.85	0.38	39.54	0.13	10.50
T_2R_1	30.97	1.33	0.00	0.44	-	4.91	8.37	33.93	0.62	32.09	0.11	10.97
T_2R_2	19.28	1.88	0.00	0.23	-	3.59	4.95	22.36	0.13	36.52	0.12	8.29
T_2R_2	23.72	1.70	0.00	0.26	-	3.24	4.59	22.08	-	35.99	0.11	7.71
T_2R_3	22.40	1.46	0.00	0.49	-	3.56	14.55	34.79	0.14	27.48	0.14	26.53
T_2R_3	25.93	1.75	0.00	0.49	-	3.58	19.71	36.91	0.14	32.80	0.14	9.48
T_3R_1	26.59	2.05	0.76	1.31	-	5.57	35.54	37.96	1.37	34.57	0.96	16.56
T_3R_1	19.71	2.05	0.23	0.75	-	4.61	17.47	37.53	0.74	34.22	0.41	14.28
T_3R_2	18.55	0.49	0.12	0.42	-	3.57	11.94	28.87	0.24	34.22	0.23	9.97
T_3R_2	13.65	1.36	0.01	0.27	-	4.02	9.40	25.86	0.01	34.39	0.10	9.29
T_3R_3	15.68	0.74	0.02	0.37	-	3.52	8.66	25.09	0.00	34.04	0.15	7.88
T_3R_3	21.15	1.21	0.04	0.36	-	3.34	9.48	25.28	0.07	33.86	0.14	7.56
T_4R_1	16.15	1.41	0.15	0.26	-	3.30	2.26	30.95	0.07	36.70	0.13	12.74
T_4R_1	21.32	1.15	0.10	0.25	-	4.01	3.58	22.96	0.06	25.78	0.11	11.80
T_4R_2	20.69	1.58	0.06	0.26	-	5.60	2.31	24.11	0.13	35.18	0.08	14.82
T_4R_2	16.06	1.69	0.06	0.27	-	14.57	1.92	26.13	0.14	32.00	0.07	10.70
T_4R_3	19.35	1.48	0.05	0.32	-	6.10	3.07	30.77	0.65	33.06	0.10	12.39
T_4R_3	23.60	1.61	0.05	0.35	-	4.49	5.76	32.87	0.29	31.84	0.13	14.79
T_5R_1	12.77	0.90	0.03	0.26	-	3.29	0.25	22.61	0.25	20.17	0.08	7.84
T_5R_1	10.40	1.04	0.03	0.26	-	3.00	0.17	23.60	0.18	26.69	0.08	8.50
T_5R_2	15.22	1.33	0.01	0.22	-	4.88	2.51	17.26	0.25	27.14	0.13	11.76
T_5R_2	19.86	1.21	0.04	0.21	-	2.89	3.54	26.60	0.21	25.47	0.12	8.82
T_5R_3	17.26	1.58	0.02	0.34	-	4.86	4.51	28.56	0.26	34.27	0.12	14.20
T_5R_3	18.03	1.55	0.02	0.33	-	5.09	3.98	27.92	0.07	42.00	0.12	25.10

T: Treatment, R: Replicate, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc,
“-“: Not Detected, Cadmium (Cd) and Selenium (Se) were not detected.

Table A.27 Measured concentration levels of heavy metals (μg/kg) in leaf by treatments

#	Al	As	Be	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
T_0R_1	101.16	2.96	0.01	0.58	-	10.26	101.75	121.09	0.96	36.24	0.29	24.62
T_0R_1	111.53	3.03	0.01	0.55	-	10.49	103.64	123.59	1.17	41.55	0.31	27.29
T_0R_1	109.45	2.89	0.01	0.58	-	11.01	106.39	123.07	1.13	40.64	0.32	26.23
T_0R_2	135.17	2.93	0.01	0.47	-	8.19	106.30	113.93	1.02	38.67	0.37	23.70
T_0R_2	175.42	2.84	0.01	0.48	-	8.13	113.16	112.52	1.01	35.79	0.46	26.25
T_0R_2	177.55	2.85	0.01	0.44	-	7.82	112.20	112.54	1.07	40.79	0.42	22.03
T_0R_3	105.73	2.97	0.01	0.48	-	6.47	80.00	102.82	0.56	36.39	0.36	20.67
T_0R_3	103.75	2.77	0.01	0.45	-	6.04	75.05	96.38	0.66	35.33	0.33	19.54
T_0R_3	106.32	3.05	0.01	0.50	-	7.09	80.94	107.60	0.74	42.16	0.36	22.46
T_1R_1	93.73	2.55	0.02	0.40	-	8.10	91.40	100.59	0.55	43.07	0.30	17.63
T_1R_1	77.42	2.57	0.01	0.40	-	8.47	96.83	106.92	0.61	45.79	0.35	19.70
T_1R_1	91.74	2.38	0.01	0.41	-	8.03	95.16	101.89	0.60	42.00	0.34	18.05
T_1R_2	76.75	2.76	0.01	2.52	-	4.74	75.78	79.03	3.90	27.14	0.26	20.20
T_1R_2	71.34	2.73	0.01	0.39	-	4.93	79.55	82.98	0.18	31.39	0.26	21.12
T_1R_2	99.54	2.77	0.00	0.40	-	5.21	85.45	86.62	0.25	24.72	0.30	23.12
T_1R_3	207.43	3.45	0.01	0.62	-	6.89	230.14	128.03	0.66	42.31	0.76	19.27
T_1R_3	188.91	3.37	0.02	0.63	-	6.89	225.14	128.87	0.96	38.97	0.69	19.89
T_1R_3	190.14	3.48	0.02	0.64	-	7.31	229.55	131.66	0.66	42.46	0.73	20.66
T_2R_1	98.71	2.85	0.01	0.35	-	6.73	75.79	98.78	0.57	37.15	0.30	18.00
T_2R_1	79.43	3.07	0.00	0.38	-	8.03	75.82	103.87	0.51	35.48	0.28	17.84
T_2R_1	96.36	2.90	0.01	0.36	-	6.35	77.47	99.32	0.56	36.85	0.29	17.86
T_2R_2	60.76	3.60	0.01	0.25	-	4.05	66.64	66.32	0.35	41.55	0.22	11.64
T_2R_2	74.16	3.75	0.01	0.28	-	5.62	72.89	68.95	0.66	39.12	0.28	15.59
T_2R_2	79.48	3.81	0.01	0.26	-	6.68	76.21	72.25	0.46	45.04	0.29	14.39
T_2R_3	74.90	3.63	0.01	0.52	-	7.44	81.11	94.87	0.76	33.36	0.30	17.26
T_2R_3	71.54	3.60	0.00	0.52	-	5.62	82.76	96.30	0.53	27.45	0.28	18.04
T_2R_3	82.55	3.30	0.01	0.48	-	5.37	79.67	91.43	0.39	26.84	0.28	15.64

T: Treatment, R: Replicate, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc, "-": Not Detected, Cadmium (Cd) and Selenium (Se) were not detected.

Table A.27 continued

#	Al	As	Be	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
T_3R_1	157.25	4.59	0.27	0.55	-	11.70	93.39	121.34	0.72	44.69	0.30	22.36
T_3R_1	144.84	4.24	0.14	0.54	-	13.30	99.70	130.31	0.85	38.64	0.26	24.32
T_3R_1	171.88	4.10	0.12	0.49	-	12.41	101.30	125.54	1.08	42.20	0.41	25.85
T_3R_2	170.36	2.25	0.09	0.37	-	9.37	98.01	116.61	0.86	62.85	0.26	26.38
T_3R_2	165.24	2.78	0.10	0.35	-	9.21	99.15	113.82	0.72	65.52	0.31	20.18
T_3R_2	278.15	2.63	0.06	0.41	-	8.87	99.31	114.97	0.71	57.51	0.34	20.64
T_3R_3	175.96	2.63	0.06	0.51	-	7.56	99.70	100.19	0.56	43.80	0.39	18.15
T_3R_3	176.77	2.93	0.05	0.59	-	8.29	102.79	107.81	0.56	49.50	0.38	19.78
T_3R_3	197.20	2.84	0.01	0.54	-	8.23	110.61	107.64	0.49	47.72	0.33	17.60
T_4R_1	220.78	3.25	0.04	0.48	-	10.72	97.71	105.73	0.51	45.58	0.32	22.12
T_4R_1	250.37	3.25	0.04	0.36	-	11.51	95.49	104.27	0.77	48.97	0.30	22.78
T_4R_1	238.95	3.34	0.03	0.41	-	9.85	94.48	101.96	0.64	47.01	0.40	22.40
T_4R_2	213.66	4.01	0.02	0.33	-	6.83	80.76	96.20	0.60	47.72	0.26	21.62
T_4R_2	212.47	4.33	0.02	0.30	-	7.21	84.45	99.11	0.46	50.57	0.31	18.03
T_4R_2	223.26	3.95	0.02	0.33	-	7.62	83.09	100.00	0.60	49.68	0.33	19.71
T_4R_3	147.09	3.39	0.02	0.46	-	7.10	87.24	89.07	0.25	41.66	0.25	19.94
T_4R_3	129.76	3.39	0.02	0.37	-	47.87	82.87	86.89	0.25	41.84	0.25	18.58
T_4R_3	137.64	2.81	0.01	0.39	-	7.14	85.03	90.73	0.10	39.88	0.26	18.94
T_5R_1	328.08	3.98	0.02	0.47	-	10.08	203.86	111.36	0.77	45.40	0.69	49.04
T_5R_1	315.97	4.13	0.03	0.44	-	10.37	207.91	118.04	0.88	40.77	0.71	54.86
T_5R_1	247.12	3.60	0.03	0.38	-	9.83	176.44	105.72	0.78	47.72	0.52	48.14
T_5R_2	194.25	2.93	0.02	0.26	-	7.67	101.54	85.79	0.69	54.31	0.35	30.78
T_5R_2	209.68	2.69	0.02	0.37	-	7.40	97.42	81.42	0.65	48.43	0.34	25.38
T_5R_2	133.75	2.52	0.01	0.37	-	7.12	89.64	81.32	0.77	50.92	0.34	25.51
T_5R_3	213.73	3.75	0.02	0.47	-	8.98	155.96	98.85	0.84	55.02	0.43	17.23
T_5R_3	204.78	3.28	0.02	0.57	-	8.53	154.55	98.04	1.00	54.66	0.41	18.73
T_5R_3	195.06	4.33	0.01	0.52	-	9.06	153.80	102.08	0.88	62.85	0.45	17.40

T: Treatment, R: Replicate, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc, "-": Not Detected, Cadmium (Cd) and Selenium (Se) were not detected.

Table A.28 Measured concentration levels of heavy metals (µg/kg) in truss by treatments

#	Al	As	Be	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
T_0	41.97	0.56	-	0.30	-	2.13	11.92	33.73	0.41	27.95	0.07	10.54
T_1	143.72	0.91	-	0.38	-	3.78	79.98	43.77	0.35	41.49	0.24	10.01
T_2	38.58	1.05	-	0.18	-	1.62	7.85	19.34	0.21	30.45	0.06	5.26
T_3	52.28	0.47	-	0.24	-	3.04	16.77	29.65	0.12	35.97	0.06	11.22
T_4	31.49	0.70	-	0.19	-	3.50	11.66	26.76	0.04	25.82	0.11	12.07
T_5	30.36	0.97	-	0.19	-	3.24	18.85	29.66	0.40	26.35	0.08	10.95

T: Treatment, R: Replicate, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc, "-": Not Detected, Cadmium (Cd) and Selenium (Se) were not detected.

Table A.29 Measured concentration levels of heavy metals (µg/kg) in fruit by treatments

#	Al	As	Be	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
T_0R_1	21.69	0.13	0.02	0.13	-	7.74	22.67	9.55	0.12	3.94	0.05	23.75
T_0R_1	21.51	0.15	0.01	0.12	-	5.13	9.36	10.27	-	2.27	0.03	17.25
T_0R_2	21.69	0.19	0.02	0.12	-	5.16	14.19	9.51	-	3.18	0.03	17.74
T_0R_2	15.25	0.20	0.01	0.23	-	5.12	14.64	12.23	0.05	2.27	0.02	21.75
T_0R_2	15.21	0.26	0.01	0.37	-	4.76	16.85	12.21	0.24	0.76	0.03	20.13
T_0R_3	46.10	0.19	0.03	0.21	-	4.14	17.95	12.40	0.05	1.52	0.03	18.72
T_0R_3	11.11	0.22	0.02	0.26	-	2.82	8.16	13.42	0.01	3.94	0.02	16.92
T_1R_1	13.82	0.14	0.02	0.10	-	3.94	12.49	11.21	-	3.18	0.02	17.22
T_1R_1	13.71	0.16	0.01	0.13	-	4.64	12.98	12.09	-	4.09	0.02	16.81
T_1R_1	8.28	0.19	0.01	0.17	-	3.32	11.11	11.93	-	1.82	0.01	14.81
T_1R_2	24.35	0.11	0.01	0.08	-	3.05	12.57	8.00	-	2.58	0.02	18.00
T_1R_2	8.21	0.35	0.01	0.19	-	2.38	14.00	13.20	-	2.12	0.03	17.18
T_1R_3	14.37	0.20	0.03	0.13	-	7.09	21.29	11.11	-	3.34	0.03	24.65
T_1R_3	24.89	0.26	0.01	0.20	-	3.45	16.21	12.07	0.03	0.91	0.02	16.46
T_1R_3	13.58	0.28	0.01	0.45	-	3.01	20.18	14.57	-	0.91	0.02	16.02
T_2R_1	13.53	0.17	0.01	0.11	-	6.14	18.78	14.07	-	2.73	0.03	20.45
T_2R_1	35.88	0.28	0.01	0.18	-	5.71	58.82	14.61	-	3.49	0.12	24.31
T_2R_1	11.99	0.30	0.00	0.21	-	3.96	14.29	12.82	0.01	2.58	0.02	18.87
T_2R_2	30.45	0.14	0.01	0.06	-	4.32	35.91	9.05	-	4.09	0.09	19.18
T_2R_2	11.47	0.23	0.01	0.13	-	3.08	15.60	11.33	-	1.52	0.03	17.50
T_2R_2	15.23	0.33	0.02	0.13	-	2.60	18.31	11.75	-	2.73	0.04	13.34
T_2R_3	21.53	0.18	0.01	0.16	-	2.12	13.29	8.36	-	1.06	0.03	16.73
T_2R_3	9.61	0.22	0.01	0.23	-	2.48	19.82	9.03	-	2.12	0.04	15.75

T: Treatment, R: Replicate, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc, "-": Not Detected, Cadmium (Cd) and Selenium (Se) were not detected.

Table A.29 continued

#	Al	As	Be	Co	Cr	Cu	Fe	Mn	Ni	Pb	V	Zn
T_3R_1	12.21	0.22	0.02	0.12	-	5.19	17.75	12.75	0.12	3.79	0.03	18.76
T_3R_1	24.14	0.17	0.01	0.15	-	3.53	9.71	10.45	-	2.88	0.03	17.16
T_3R_1	22.40	0.38	0.01	0.29	-	9.32	54.15	26.16	0.23	1.36	0.09	41.13
T_3R_2	22.18	0.09	0.02	0.08	-	3.91	13.24	10.85	-	2.73	0.04	18.85
T_3R_2	10.36	0.15	0.00	0.10	-	3.89	13.22	12.99	-	4.40	0.03	17.37
T_3R_2	10.21	0.13	0.00	0.21	-	3.58	15.17	11.25	0.08	1.06	0.03	16.54
T_3R_3	21.20	0.19	0.01	0.10	-	6.57	19.40	12.54	-	3.64	0.04	24.65
T_3R_3	25.83	0.14	0.01	0.07	-	3.47	9.90	7.76	-	1.67	0.04	17.37
T_3R_3	19.81	0.22	0.01	0.29	-	9.09	39.49	13.14	0.04	0.45	0.06	24.26
T_4R_1	12.60	0.15	0.01	0.07	-	4.31	13.17	10.02	-	2.12	0.05	18.43
T_4R_1	29.79	0.21	0.01	0.14	-	3.98	20.58	15.89	-	2.88	0.04	18.06
T_4R_1	10.21	0.21	0.01	0.19	-	4.95	15.91	19.20	0.29	2.12	0.05	24.21
T_4R_2	11.14	0.16	0.01	0.26	-	14.34	31.37	22.96	0.25	4.40	0.06	35.14
T_4R_2	8.76	0.29	0.01	0.16	-	3.48	15.53	9.08	0.06	1.97	0.03	14.91
T_4R_2	14.21	0.15	0.01	0.14	-	3.38	13.01	10.49	-	2.12	0.02	15.77
T_4R_3	20.59	0.15	0.01	0.08	-	4.16	11.52	10.38	-	2.88	0.03	18.35
T_4R_3	7.52	0.24	0.01	0.13	-	2.66	11.45	8.16	-	0.76	0.04	17.07
T_4R_3	9.16	0.28	0.01	0.17	-	3.35	8.83	11.01	-	1.97	0.03	17.41
T_5R_1	11.64	0.17	0.01	0.09	-	6.12	15.04	12.85	-	2.88	0.04	21.24
T_5R_1	8.55	0.22	0.01	0.20	-	4.49	10.06	8.99	0.14	3.34	0.03	27.25
T_5R_1	15.18	0.22	0.01	0.19	-	4.76	18.32	14.06	0.09	3.18	0.04	18.69
T_5R_2	31.56	0.22	0.00	0.07	-	3.99	13.28	9.32	-	3.94	0.05	18.75
T_5R_3	16.99	0.12	0.01	0.09	-	5.40	9.55	10.10	0.05	3.94	0.03	18.58
T_5R_3	8.92	0.26	0.01	0.19	-	4.06	10.95	11.33	0.11	3.49	0.02	17.84
T_5R_3	16.18	0.16	0.02	0.14	-	4.45	9.43	9.05	0.07	3.94	0.02	17.45

T: Treatment, R: Replicate, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc,
“-“: Not Detected, Cadmium (Cd) and Selenium (Se) were not detected.

Table A.30 Accumulated heavy metal concentration level (μg/kg) of initial and final soil (0-10 cm depth) used in this study

Treatment	Al	As	Be	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Se	V	Zn
$T_{initial}$	5,742	4.79	0.750	-	3.96	11.64	4.64	14,396	534.8	19.49	63.74	0.184	14.51	26.27
T_0R_1	5,231	8.99	0.817	-	4.92	14.57	7.04	13,301	300.8	11.74	65.78	0.300	18.30	34.37
T_0R_2	5,529	10.01	0.716	-	5.07	15.84	6.46	13,984	312.5	12.51	69.68	-	19.91	37.42
T_0R_3	4,849	6.97	0.753	-	4.95	15.08	12.90	12,880	318.4	12.91	77.83	-	17.63	39.91
T_1R_1	5,544	11.32	0.756	-	5.69	15.76	9.02	15,130	355.7	13.77	79.78	-	19.40	37.47
T_1R_2	5,238	11.05	0.693	-	5.92	15.03	10.83	14,963	371.4	14.37	77.83	-	19.21	37.35
T_1R_3	6,056	8.52	0.782	-	5.77	17.61	12.46	15,477	377.1	14.16	79.25	0.060	21.96	42.01
T_2R_1	4,292	13.42	0.639	-	5.56	12.32	7.34	13,090	367.3	13.96	73.40	-	15.82	40.18
T_2R_2	5,536	12.16	0.684	-	5.83	15.59	7.64	15,497	371.6	14.33	75.53	-	20.12	52.55
T_2R_3	4,582	6.20	0.594	-	4.79	13.72	12.73	12,515	325.2	12.02	92.02	0.060	16.56	36.53
T_3R_1	4,484	10.58	0.693	-	4.90	12.97	6.16	12,919	321.7	12.33	72.69	0.420	15.87	36.54
T_3R_2	5,354	10.87	0.715	-	5.61	15.86	9.76	14,917	361.2	13.75	72.34	-	18.45	49.15
T_3R_3	4,989	8.08	0.600	-	5.08	14.65	16.73	13,402	338.7	13.00	89.00	0.060	17.46	39.22
T_4R_1	4,983	10.48	0.656	-	5.43	14.18	8.12	14,420	355.6	13.36	75.17	0.120	17.52	36.22
T_4R_2	5,964	8.92	0.759	-	5.94	16.92	8.46	16,147	394.2	14.40	76.41	0.120	20.85	38.83
T_4R_3	4,806	5.71	0.609	-	4.73	14.16	28.19	12,721	319.0	11.81	81.56	0.060	17.16	41.55
T_5R_1	3,799	8.55	0.491	-	3.98	10.52	6.21	10,816	260.5	9.69	57.80	0.120	13.18	26.75
T_5R_2	4,413	10.82	0.639	-	5.09	12.34	7.13	13,146	345.8	12.37	74.11	-	15.77	37.73
T_5R_3	5,032	6.15	0.629	-	5.22	14.77	13.42	13,594	352.4	12.38	90.60	0.120	18.56	40.40

T: Treatment, R: Replicate, Al: Aluminum, As: Arsenic, Be: Beryllium, Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc "-": Not Detected,

Table A.31 Accumulated heavy metal concentration level (μg/kg) of initial and final soil (10-20 cm depth) used in this study

Treatment	Al	As	Be	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Se	V	Zn
$T_{initial}$	5,742	4.79	0.750	-	3.96	11.64	4.64	14,396	534.8	19.49	63.74	0.184	14.51	26.27
T_0R_1	5,020	10.21	0.729	-	5.19	14.33	6.87	13,881	327.4	12.77	73.58	0.300	18.03	37.38
T_0R_2	5,605	10.60	0.690	-	5.30	15.77	7.24	14,601	330.1	12.94	75.53	-	20.20	39.16
T_0R_3	5,484	7.66	0.731	-	4.97	16.09	14.13	13,926	319.4	12.31	81.38	0.060	20.19	38.96
T_1R_1	5,157	10.63	0.629	-	5.39	14.67	7.32	14,277	352.5	13.45	71.80	0.360	18.67	38.79
T_1R_2	5,240	11.02	0.673	-	5.72	14.80	7.54	14,824	368.6	14.13	73.22	-	18.51	41.18
T_1R_3	3,843	6.77	0.551	-	4.76	11.13	11.68	10,990	319.1	11.33	68.61	0.060	13.66	35.33
T_2R_1	4,941	12.58	0.674	-	5.60	14.12	7.70	14,345	363.7	13.57	75.70	0.360	17.46	41.04
T_2R_2	4,062	9.66	0.529	-	5.23	11.43	7.94	12,304	344.1	12.93	69.14	0.060	14.96	40.41
T_2R_3	5,087	8.48	0.665	-	5.07	14.56	11.33	13,578	335.6	13.36	79.78	0.060	18.12	38.75
T_3R_1	5,365	12.01	0.750	-	6.01	14.93	8.50	15,699	387.8	14.54	80.49	0.120	18.44	38.95
T_3R_2	3,290	8.28	0.408	-	3.41	8.86	4.23	9,059	218.8	8.09	45.92	-	11.08	22.09
T_3R_3	5,946	9.36	0.643	-	5.58	17.28	18.01	15,228	369.7	13.97	91.48	0.060	21.58	42.06
T_4R_1	4,883	10.21	0.671	-	5.42	13.58	7.66	14,132	355.9	13.07	73.22	0.120	16.90	43.76
T_4R_2	4,787	11.54	0.569	-	4.95	13.39	6.39	13,353	320.8	11.71	68.79	-	16.65	33.92
T_4R_3	4,833	7.76	0.568	-	4.70	14.00	16.89	12,763	331.8	11.20	78.36	0.120	17.22	40.35
T_5R_1	4,923	10.48	0.600	-	5.02	13.67	6.65	13,953	336.3	12.03	68.08	0.120	17.00	32.23
T_5R_2	4,400	10.48	0.570	-	5.04	12.54	7.35	13,241	333.0	12.27	76.95	-	15.86	33.33
T_5R_3	4,461	6.57	0.557	-	4.27	13.59	13.35	11,954	309.1	10.21	71.63	0.120	16.61	34.63

T: Treatment, R: Replicate, Al: Aluminum, As: Arsenic, Be: Beryllium, Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc "-": Not Detected,

Table A.32 Accumulated heavy metal concentration level (μg/kg) of initial and final soil (in the saucer) used in this study

Treatment	Al	As	Be	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Se	V	Zn
$T_{initial}$	5,742	4.79	0.750	-	3.96	11.64	4.64	14,396	534.8	19.49	63.74	0.184	14.51	26.27
T_0R_1	6,070	12.01	0.764	-	5.61	17.37	7.44	15,639	356.6	13.54	76.41	0.300	21.39	43.85
T_0R_2	5,999	11.51	0.711	-	5.45	16.94	7.28	15,303	339.5	13.47	67.55	-	22.39	38.59
T_0R_3	4,358	7.02	0.588	-	4.76	13.25	14.19	12,219	322.0	11.35	74.29	0.060	16.75	36.70
T_1R_1	5,452	11.34	0.696	-	5.77	15.58	7.70	15,159	373.7	13.95	81.02	0.240	19.39	37.67
T_1R_2	6,728	14.50	0.767	-	6.97	19.05	10.09	18,445	453.3	17.28	95.74	-	24.57	55.71
T_1R_3	5,630	7.73	0.750	-	5.41	15.97	14.47	14,526	356.2	13.75	88.82	-	20.04	40.75
T_2R_1	5,179	10.75	0.598	-	5.26	14.98	6.84	14,383	335.7	12.87	67.90	-	17.99	37.02
T_2R_2	4,884	10.92	0.634	-	5.13	13.80	8.03	13,632	338.3	12.39	69.14	-	18.00	35.86
T_2R_3	4,933	7.14	0.559	-	4.87	14.71	13.28	13,034	320.9	12.11	74.46	0.060	17.51	38.54
T_3R_1	6,223	13.00	0.734	-	6.31	17.58	9.91	16,930	403.1	15.18	82.97	0.120	21.27	44.96
T_3R_2	5,801	12.73	0.681	-	6.26	16.73	9.55	16,635	406.1	15.44	80.31	-	19.85	43.23
T_3R_3	5,241	8.08	0.695	-	5.33	15.99	18.23	14,197	368.9	13.13	85.28	0.120	19.28	42.31
T_4R_1	5,051	11.00	0.675	-	5.43	14.54	7.13	14,684	351.5	12.89	71.45	0.120	17.61	37.44
T_4R_2	6,696	12.68	0.764	-	5.89	18.63	8.24	17,120	379.3	14.23	81.73	-	23.46	53.00
T_4R_3	4,732	6.23	0.613	-	5.02	13.59	14.88	13,211	354.0	12.27	79.78	0.120	16.80	37.39
T_5R_1	5,278	11.05	0.647	-	5.21	14.84	6.93	14,573	340.4	12.37	70.21	0.240	17.87	37.24
T_5R_2	5,711	13.00	0.660	-	6.03	16.11	8.05	16,271	403.7	14.65	81.91	0.120	19.69	41.72
T_5R_3	5,012	8.28	0.675	-	5.35	14.15	22.48	14,017	350.1	12.99	82.26	0.120	16.45	43.06

T: Treatment, R: Replicate, Al: Aluminum, As: Arsenic, Be: Beryllium, Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc "-": Not Detected,

Table A.33 Measured accumulated concentration level (µg/kg) of heavy metals in treatments by plant parts

Parts	T	Al	As	Be	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Se	V	Zn
Root	T_0	147.84	2.91	0.016	-	0.47	0.27	6.53	111.66	30.97	1.72	37.21	-	1.39	22.02
	T_1	237.92	5.02	0.024	-	0.63	0.29	9.14	179.91	38.67	1.36	53.71	-	1.77	15.34
	T_2	277.22	5.56	0.013	-	0.58	0.46	7.32	207.51	33.72	1.53	46.62	-	2.51	11.78
	T_3	186.49	2.79	0.009	-	0.31	0.13	5.25	133.41	21.58	1.03	31.78	-	1.71	10.54
	T_4	496.57	4.30	0.025	-	0.59	0.85	7.99	372.35	42.10	1.36	53.51	-	3.46	15.03
	T_5	328.86	5.04	0.019	-	0.47	0.50	7.60	247.32	24.45	1.06	48.97	-	2.11	14.12
Crown	T_0	115.79	2.54	0.027	-	0.50	0.46	7.34	88.30	23.26	1.25	41.07	-	0.65	33.75
	T_1	196.37	4.53	0.017	-	0.57	0.44	8.69	168.70	25.95	1.13	52.47	-	0.81	22.57
	T_2	308.03	5.15	0.021	-	0.49	0.47	7.64	258.47	26.56	1.39	43.50	-	1.18	15.18
	T_3	95.84	2.35	0.007	-	0.25	0.00	4.35	71.44	14.19	0.34	28.43	-	0.46	14.22
	T_4	233.84	2.50	0.004	-	0.36	0.54	6.42	184.66	25.46	0.87	48.67	-	0.91	16.62
	T_5	500.92	4.27	0.030	-	0.68	2.34	9.44	479.42	23.44	1.72	52.94	-	1.33	21.57
Lower Stem	T_0	19.57	0.94	0.009	-	0.39	-	14.44	12.75	13.23	0.16	32.56	-	0.12	36.68
	T_1	68.81	1.38	0.008	-	0.44	-	7.14	93.30	17.34	0.38	38.12	-	0.30	22.03
	T_2	51.92	1.51	0.007	-	0.40	-	12.47	60.77	15.30	0.32	40.13	-	0.24	21.16
	T_3	29.34	1.14	0.060	-	0.49	-	7.76	41.41	12.05	0.49	31.26	-	0.23	23.32
	T_4	18.23	1.90	0.111	-	0.34	-	8.36	16.73	10.62	0.45	33.61	-	0.17	22.24
	T_5	28.81	1.41	0.036	-	0.32	-	7.52	23.34	10.67	0.41	30.43	-	0.19	20.95

T: Treatment, Al: Aluminum, As: Arsenic, Be: Beryllium, Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc “-“: Not Detected,

Table A.33 continued

Parts	T	Al	As	Be	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Se	V	Zn
Upper Stem	T_0	21.51	0.96	0.003	-	0.46	-	3.90	4.77	29.20	0.26	30.46	-	0.10	16.98
	T_1	27.80	1.17	0.002	-	0.45	-	3.02	16.87	34.99	0.16	28.84	-	0.13	10.27
	T_2	25.33	1.66	0.002	-	0.39	-	3.88	10.31	30.82	0.23	34.07	-	0.12	12.25
	T_3	19.22	1.32	0.196	-	0.58	-	4.11	15.41	30.10	0.41	34.22	-	0.33	10.92
	T_4	19.53	1.49	0.078	-	0.29	-	6.34	3.15	27.96	0.22	32.43	-	0.10	12.87
	T_5	15.59	1.27	0.024	-	0.27	-	4.00	2.49	24.42	0.20	29.29	-	0.11	12.70
Leaf	T_0	125.12	2.92	0.008	-	0.50	-	8.39	97.72	112.62	0.92	38.62	-	0.36	23.64
	T_1	121.89	2.89	0.012	-	0.71	-	6.73	134.34	105.18	0.93	37.54	-	0.44	19.96
	T_2	79.77	3.39	0.008	-	0.38	-	6.21	76.49	88.01	0.53	35.87	-	0.28	16.25
	T_3	181.96	3.22	0.102	-	0.48	-	9.88	100.44	115.36	0.73	50.27	-	0.33	21.70
	T_4	197.11	3.52	0.025	-	0.38	-	12.87	87.90	97.11	0.47	45.88	-	0.30	20.46
	T_5	226.94	3.47	0.021	-	0.43	-	8.78	149.01	98.07	0.80	51.12	-	0.47	31.90
Truss	T_0	41.97	0.56	-	-	0.30	-	2.13	11.92	33.73	0.41	27.95	-	0.07	10.54
	T_1	143.72	0.91	-	-	0.38	-	3.78	79.98	43.77	0.35	41.49	-	0.24	10.01
	T_2	38.58	1.05	-	-	0.18	-	1.62	7.85	19.34	0.21	30.45	-	0.06	5.26
	T_3	52.28	0.47	-	-	0.24	-	3.04	16.77	29.65	0.12	35.97	-	0.06	11.22
	T_4	31.49	0.70	-	-	0.19	-	3.50	11.66	26.76	0.04	25.82	-	0.11	12.07
	T_5	30.36	0.97	-	-	0.19	-	3.24	18.85	29.66	0.40	26.35	-	0.08	10.95

T: Treatment, Al: Aluminum, As: Arsenic, Be: Beryllium, Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc “-“: Not Detected,

Table A.33 continued

Parts	T	Al	As	Be	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Se	V	Zn
Fruit	T_0	21.79	0.19	0.017	-	0.20	-	4.98	14.83	11.37	0.07	2.56	-	0.03	19.47
	T_1	15.15	0.21	0.015	-	0.18	-	3.86	15.11	11.77	0.00	2.37	-	0.02	17.64
	T_2	18.71	0.23	0.008	-	0.15	-	3.80	24.35	11.38	0.00	2.54	-	0.05	18.27
	T_3	18.70	0.19	0.009	-	0.16	-	5.39	21.34	13.10	0.05	2.44	-	0.04	21.79
	T_4	13.77	0.20	0.009	-	0.15	-	4.96	15.71	13.02	0.07	2.36	-	0.04	19.93
	T_5	15.57	0.20	0.009	-	0.14	-	4.75	12.38	10.81	0.07	3.53	-	0.03	19.97
Whole Plant	T_0	58.83	1.58	0.007	-	0.45	0.01	5.75	39.27	54.97	0.49	30.67	-	0.20	20.02
	T_1	59.83	1.63	0.008	-	0.49	0.01	4.47	56.82	51.38	0.40	28.13	-	0.24	14.68
	T_2	47.63	2.07	0.005	-	0.36	0.01	4.79	38.23	44.95	0.32	30.72	-	0.20	14.42
	T_3	69.18	1.74	0.136	-	0.49	0.00	6.03	43.14	51.98	0.46	34.45	-	0.30	15.76
	T_4	78.20	1.91	0.050	-	0.29	0.02	8.00	36.90	44.97	0.29	31.89	-	0.20	16.36
	T_5	94.72	1.92	0.021	-	0.31	0.05	5.80	61.57	45.73	0.42	33.52	-	0.26	20.02

T: Treatment, Al: Aluminum, As: Arsenic, Be: Beryllium, Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc “-“: Not Detected,

Table A.34 Measured accumulated concentration level (μg/kg) of heavy metals in plant parts by treatments

T	Part	Al	As	Be	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Se	V	Zn
T_0	Root	147.84	2.907	0.016	-	0.466	0.275	6.53	111.66	30.97	1.718	37.21	-	1.388	22.02
	Crown	115.79	2.536	0.027	-	0.497	0.456	7.34	88.30	23.26	1.246	41.07	-	0.653	33.75
	Lower Stem	19.57	0.939	0.009	-	0.386	-	14.44	12.75	13.23	0.161	32.56	-	0.124	36.68
	Upper Stem	21.51	0.960	0.003	-	0.457	-	3.90	4.77	29.20	0.257	30.46	-	0.104	16.98
	Leaf	125.12	2.920	0.008	-	0.503	-	8.39	97.72	112.62	0.924	38.62	-	0.358	23.64
	Truss	41.97	0.556	-	-	0.298	-	2.13	11.92	33.73	0.409	27.95	-	0.075	10.54
	Fruit	21.79	0.192	0.017	-	0.204	-	4.98	14.83	11.37	0.069	2.56	-	0.030	19.47
	Whole Plant	70.51	1.573	0.011	-	0.401	0.104	6.81	48.85	36.34	0.683	30.06	-	0.390	23.30
T_1	Root	237.92	5.023	0.024	-	0.635	0.291	9.14	179.91	38.67	1.363	53.71	-	1.770	15.34
	Crown	196.37	4.526	0.017	-	0.574	0.440	8.69	168.70	25.95	1.134	52.47	-	0.808	22.57
	Lower Stem	68.81	1.375	0.008	-	0.441	-	7.14	93.30	17.34	0.379	38.12	-	0.296	22.03
	Upper Stem	27.80	1.165	0.002	-	0.450	-	3.02	16.87	34.99	0.162	28.84	-	0.131	10.27
	Leaf	121.89	2.894	0.012	-	0.713	-	6.73	134.34	105.18	0.931	37.54	-	0.442	19.96
	Truss	143.72	0.907	-	-	0.376	-	3.78	79.98	43.77	0.346	41.49	-	0.237	10.01
	Fruit	15.15	0.212	0.015	-	0.182	-	3.86	15.11	11.77	0.003	2.37	-	0.022	17.64
	Whole Plant	115.95	2.301	0.011	-	0.481	0.105	6.05	98.31	39.67	0.617	36.36	-	0.530	16.83

T: Treatment, Al: Aluminum, As: Arsenic, Be: Beryllium, Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc "-": Not Detected,

Table A.34 continued

T	Part	Al	As	Be	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Se	V	Zn
T_2	Root	277.22	5.560	0.013	-	0.577	0.463	7.32	207.51	33.72	1.525	46.62	-	2.506	11.78
	Crown	308.03	5.150	0.021	-	0.494	0.474	7.64	258.47	26.56	1.387	43.50	-	1.176	15.18
	Lower Stem	51.92	1.507	0.007	-	0.400	-	12.47	60.77	15.30	0.317	40.13	-	0.237	21.16
	Upper Stem	25.33	1.660	0.002	-	0.389	-	3.88	10.31	30.82	0.235	34.07	-	0.124	12.25
	Leaf	79.77	3.391	0.008	-	0.379	-	6.21	76.49	88.01	0.532	35.87	-	0.279	16.25
	Truss	38.58	1.053	-	-	0.178	-	1.62	7.85	19.34	0.210	30.45	-	0.062	5.26
	Fruit	18.71	0.231	0.008	-	0.151	-	3.80	24.35	11.38	0.001	2.54	-	0.049	18.27
	Whole Plant	114.22	2.650	0.008	-	0.367	0.134	6.13	92.25	32.16	0.601	33.31	-	0.633	14.31
T_3	Root	186.49	2.790	0.009	-	0.314	0.128	5.25	133.41	21.58	1.032	31.78	-	1.707	10.54
	Crown	95.84	2.351	0.007	-	0.246	0.004	4.35	71.44	14.19	0.339	28.43	-	0.460	14.22
	Lower Stem	29.34	1.145	0.060	-	0.489	-	7.76	41.41	12.05	0.489	31.26	-	0.234	23.32
	Upper Stem	19.22	1.318	0.196	-	0.579	-	4.11	15.41	30.10	0.405	34.22	-	0.332	10.92
	Leaf	181.96	3.222	0.102	-	0.483	-	9.88	100.44	115.36	0.729	50.27	-	0.330	21.70
	Truss	52.28	0.468	-	-	0.244	-	3.04	16.77	29.65	0.115	35.97	-	0.062	11.22
	Fruit	18.70	0.188	0.009	-	0.157	-	5.39	21.34	13.10	0.051	2.44	-	0.042	21.79
	Whole Plant	83.40	1.640	0.055	-	0.359	0.019	5.68	57.17	33.72	0.451	30.62	-	0.453	16.24

T: Treatment, Al: Aluminum, As: Arsenic, Be: Beryllium, Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc “-“: Not Detected,

Table A.34 continued

T	Part	Al	As	Be	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Se	V	Zn
T_4	Root	496.57	4.302	0.025	-	0.593	0.850	7.99	372.35	42.10	1.360	53.51	-	3.464	15.03
	Crown	233.84	2.497	0.004	-	0.355	0.535	6.42	184.66	25.46	0.868	48.67	-	0.905	16.62
	Lower Stem	18.23	1.900	0.111	-	0.337	-	8.36	16.73	10.62	0.453	33.61	-	0.169	22.24
	Upper Stem	19.53	1.485	0.078	-	0.285	-	6.34	3.15	27.96	0.224	32.43	-	0.101	12.87
	Leaf	197.11	3.525	0.025	-	0.380	-	12.87	87.90	97.11	0.465	45.88	-	0.297	20.46
	Truss	31.49	0.702	-	-	0.187	-	3.50	11.66	26.76	0.042	25.82	-	0.112	12.07
	Fruit	13.77	0.205	0.009	-	0.147	-	4.96	15.71	13.02	0.066	2.36	-	0.039	19.93
	Whole Plant	144.36	2.088	0.036	-	0.326	0.198	7.21	98.88	34.72	0.497	34.61	-	0.727	17.03
T_5	Root	328.86	5.043	0.019	-	0.471	0.499	7.60	247.32	24.45	1.060	48.97	-	2.110	14.12
	Crown	500.92	4.272	0.030	-	0.684	2.345	9.44	479.42	23.44	1.724	52.94	-	1.326	21.57
	Lower Stem	28.81	1.410	0.036	-	0.321	-	7.52	23.34	10.67	0.406	30.43	-	0.189	20.95
	Upper Stem	15.59	1.267	0.024	-	0.269	-	4.00	2.49	24.42	0.203	29.29	-	0.107	12.70
	Leaf	226.94	3.466	0.021	-	0.428	-	8.78	149.01	98.07	0.804	51.12	-	0.471	31.90
	Truss	30.36	0.966	-	-	0.193	-	3.24	18.85	29.66	0.404	26.35	-	0.083	10.95
	Fruit	15.57	0.196	0.009	-	0.137	-	4.75	12.38	10.81	0.066	3.53	-	0.032	19.97
	Whole Plant	163.86	2.374	0.020	-	0.358	0.406	6.48	133.26	31.65	0.667	34.66	-	0.617	18.88

T: Treatment, Al: Aluminum, As: Arsenic, Be: Beryllium, Cd: Cadmium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc “-“: Not Detected,

APPENDIX B

STATISTICAL DATA

ONE-WAY ANOVA

Table B.1 One-way ANOVA results of measured heavy metals concentration levels (μg/kg) in soil (0-10 cm depth) by treatments

HM		Sum of Squares	dF	Mean Squares	F	Sig
Al	Between G	2.567	5	0.513	1.843	0.179
	Within G	3.342	12	0.279		
	Total	5.909	17			
As	Between G	0.000	5	0.000	0.521	0.756
	Within G	0.000	12	0.000		
	Total	0.000	17			
Be	Between G	0.000	5	0.000	3.343	0.040*
	Within G	0.000	12	0.000		
	Total	0.000	17			
Co	Between G	0.000	5	0.000	1.814	0.185
	Within G	0.000	12	0.000		
	Total	0.000	17			
Cr	Between G	0.000	5	0.000	1.964	0.157
	Within G	0.000	12	0.000		
	Total	0.000	17			
Cu	Between G	0.000	5	0.000	0.478	0.786
	Within G	0.000	12	0.000		
	Total	0.000	17			
Fe	Between G	12.438	5	2.488	1.635	0.225
	Within G	18.257	12	1.521		
	Total	30.695	17			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Cadmium (Cd) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.1 Continued

HM		Sum of Squares	dF	Mean Squares	F	Sig
Mn	Between G	0.008	5	0.002	1.724	0.204
	Within G	0.011	12	0.001		
	Total	0.018	17			
Ni	Between G	0.000	5	0.000	2.233	0.118
	Within G	0.000	12	0.000		
	Total	0.000	17			
Pb	Between G	0.000	5	0.000	0.411	0.832
	Within G	0.001	12	0.000		
	Total	0.001	17			
Se	Between G	0.000	5	0.000	0.576	0.718
	Within G	0.000	12	0.000		
	Total	0.000	17			
V	Between G	0.000	5	0.000	1.778	0.192
	Within G	0.000	12	0.000		
	Total	0.000	17			
Zn	Between G	0.000	5	0.000	0.821	0.558
	Within G	0.000	12	0.000		
	Total	0.001	17			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc,
Cadmium (Cd) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.2 One-way ANOVA results of measured heavy metals concentration levels (μg/kg) in soil (10-20 cm depth) by treatments

HM		Sum of Squares	dF	Mean Squares	F	Sig
Al	Between G	1.109	5	0.222	0.436	0.815
	Within G	6.101	12	0.508		
	Total	7.210	17			
As	Between G	0.000	5	0.000	0.103	0.990
	Within G	0.000	12	0.000		
	Total	0.000	17			
Be	Between G	0.000	5	0.000	0.947	0.486
	Within G	0.000	12	0.000		
	Total	0.000	17			
Co	Between G	0.000	5	0.000	0.277	0.917
	Within G	0.000	12	0.000		
	Total	0.000	17			
Cr	Between G	0.000	5	0.000	0.411	0.832
	Within G	0.000	12	0.000		
	Total	0.000	17			
Cu	Between G	0.000	5	0.000	0.060	0.997
	Within G	0.000	12	0.000		
	Total	0.000	17			
Fe	Between G	1.968	5	0.394	0.114	0.987
	Within G	41.506	12	3.459		
	Total	43.474	17			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Cadmium (Cd) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.2 Continued

HM		Sum of Squares	dF	Mean Squares	F	Sig
Mn	Between G	0.002	5	0.000	0.201	0.956
	Within G	0.020	12	0.002		
	Total	0.022	17			
Ni	Between G	0.000	5	0.000	0.454	0.803
	Within G	0.000	12	0.000		
	Total	0.000	17			
Pb	Between G	0.000	5	0.000	0.112	0.987
	Within G	0.001	12	0.000		
	Total	0.001	17			
Se	Between G	0.000	5	0.000	0.264	0.924
	Within G	0.000	12	0.000		
	Total	0.000	17			
V	Between G	0.000	5	0.000	0.509	0.765
	Within G	0.000	12	0.000		
	Total	0.000	17			
Zn	Between G	0.000	5	0.000	0.904	0.509
	Within G	0.000	12	0.000		
	Total	0.000	17			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc,
Cadmium (Cd) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.3 One-way ANOVA results of measured heavy metals concentration levels (μg/kg) in soil (in the saucer) by treatments

HM		Sum of Squares	dF	Mean Squares	F	Sig
Al	Between G	1.605	5	0.321	0.660	0.660
	Within G	5.836	12	0.486		
	Total	7.441	17			
As	Between G	0.000	5	0.000	0.175	0.967
	Within G	0.000	12	0.000		
	Total	0.000	17			
Be	Between G	0.000	5	0.000	2.269	0.114
	Within G	0.000	12	0.000		
	Total	0.000	17			
Co	Between G	0.000	5	0.000	1.656	0.220
	Within G	0.000	12	0.000		
	Total	0.000	17			
Cr	Between G	0.000	5	0.000	0.883	0.522
	Within G	0.000	12	0.000		
	Total	0.000	17			
Cu	Between G	0.000	5	0.000	0.227	0.944
	Within G	0.000	12	0.000		
	Total	0.000	17			
Fe	Between G	12.147	5	2.429	0.913	0.505
	Within G	31.928	12	2.661		
	Total	44.075	17			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper, Fe: Iron, Cadmium (Cd) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.3 Continued

HM		Sum of Squares	dF	Mean Squares	F	Sig
Mn	Between G	0.010	5	0.002	2.510	0.089
	Within G	0.010	12	0.001		
	Total	0.020	17			
Ni	Between G	0.000	5	0.000	1.924	0.164
	Within G	0.000	12	0.000		
	Total	0.000	17			
Pb	Between G	0.001	5	0.000	4.580	0.014*
	Within G	0.000	12	0.000		
	Total	0.001	17			
Se	Between G	0.000	5	0.000	0.660	0.660
	Within G	0.000	12	0.000		
	Total	0.000	17			
V	Between G	0.000	5	0.000	0.984	0.467
	Within G	0.000	12	0.000		
	Total	0.000	17			
Zn	Between G	0.000	5	0.000	0.688	0.642
	Within G	0.000	12	0.000		
	Total	0.001	17			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Mn: Manganese, Ni: Nickel, Pb: Lead, Se: Selenium, V: Vanadium, Zn: Zinc,
Cadmium (Cd) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.4 One-way ANOVA results of measured heavy metals concentration levels (μg/kg) in root by treatments

HM		Sum of Squares	dF	Mean Squares	F	Sig
Al	Between G	463,659.7	5	92,731.9	5.976	0.001**
	Within G	465,508.8	30	15,517.0		
	Total	929,168.4	35			
As	Between G	41.279	5	8.256	6.580	0.000**
	Within G	37.640	30	1.255		
	Total	78.919	35			
Be	Between G	0.001	5	0.000	1.655	0.176
	Within G	0.005	30	0.000		
	Total	0.006	35			
Co	Between G	0.413	5	0.083	3.694	0.010**
	Within G	0.671	30	0.022		
	Total	1.083	35			
Cr	Between G	1.895	5	0.379	2.972	0.027*
	Within G	3.826	30	0.128		
	Total	5.721	35			
Cu	Between G	52.388	5	10.478	2.669	0.041*
	Within G	117.754	30	3.925		
	Total	170.142	35			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper
Cadmium (Cd) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.4 Continued

HM		Sum of Squares	dF	Mean Squares	F	Sig
Fe	Between G	265,120.6	5	53,024.1	6.148	0.000**
	Within G	258,723.6	30	8,624.1		
	Total	523,844.2	35			
Mn	Between G	1,895.410	5	379.082	2.520	0.051
	Within G	4,512.631	30	150.421		
	Total	6,408.041	35			
Ni	Between G	2.112	5	0.422	1.336	0.276
	Within G	9.482	30	0.316		
	Total	11.593	35			
Pb	Between G	2,408.433	5	481.687	3.182	0.020*
	Within G	4,541.731	30	151.391		
	Total	6,950.164	35			
V	Between G	16.659	5	3.332	7.200	0.000**
	Within G	13.881	30	0.463		
	Total	30.540	35			
Zn	Between G	481.727	5	96.345	7.061	0.000**
	Within G	409.328	30	13.644		
	Total	891.054	35			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc,
Selenium (Se) was not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.5 One-way ANOVA results of measured heavy metals concentration levels (μg/kg) in crown by treatments

HM		Sum of Squares	dF	Mean Squares	F	Sig
Al	Between G	332,519.9	5	66,504.0	1.804	0.187
	Within G	442,358.5	12	36,863.2		
	Total	774,878.4	17			
As	Between G	22.830	5	4.566	2.267	0.114
	Within G	24.173	12	2.014		
	Total	47.003	17			
Be	Between G	0.002	5	0.000	2.169	0.126
	Within G	0.002	12	0.000		
	Total	0.003	17			
Co	Between G	0.362	5	0.072	2.104	0.135
	Within G	0.413	12	0.034		
	Total	0.775	17			
Cr	Between G	10.183	5	2.037	4.625	0.014*
	Within G	5.284	12	0.440		
	Total	15.467	17			
Cu	Between G	48.162	5	9.632	1.569	0.242
	Within G	73.653	12	6.138		
	Total	121.815	17			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper
Cadmium (Cd) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.5 Continued

HM		Sum of Squares	dF	Mean Squares	F	Sig
Fe	Between G	333,834.3	5	66,766.9	2.292	0.111
	Within G	349,617.7	12	29,134.8		
	Total	683,452.0	17			
Mn	Between G	315.379	5	63.076	1.239	0.350
	Within G	610.926	12	50.911		
	Total	926.306	17			
Ni	Between G	3.378	5	0.676	2.599	0.081
	Within G	3.119	12	0.260		
	Total	6.497	17			
Pb	Between G	1,269.385	5	253.877	1.640	0.223
	Within G	1,857.837	12	154.820		
	Total	3,127.223	17			
V	Between G	1.561	5	0.312	1.071	0.423
	Within G	3.498	12	0.291		
	Total	5.059	17			
Zn	Between G	790.927	5	158.185	3.205	0.046*
	Within G	592.331	12	49.361		
	Total	1,383.259	17			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc,
Selenium (Se) was not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.6 One-way ANOVA results of measured heavy metals concentration levels (μg/kg) in lower stem by treatments

HM		Sum of Squares	dF	Mean Squares	F	Sig
Al	Between G	6,036.179	5	1,207.236	11.887	0.000**
	Within G	1,218.686	12	101.557		
	Total	7,254.865	17			
As	Between G	1.612	5	0.322	2.160	0.127
	Within G	1.791	12	0.149		
	Total	3.403	17			
Be	Between G	0.026	5	0.005	1.714	0.206
	Within G	0.036	12	0.003		
	Total	0.061	17			
Co	Between G	0.060	5	0.012	2.243	0.117
	Within G	0.064	12	0.005		
	Total	0.124	17			
Cr	Between G	NA	5	NA	NA	NA
	Within G	NA	12	NA		
	Total	NA	17			
Cu	Between G	140.931	5	28.186	0.839	0.547
	Within G	403.280	12	33.607		
	Total	544.212	17			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group,
NA: Not Available, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper Cadmium (Cd) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.6 Continued

HM		Sum of Squares	dF	Mean Squares	F	Sig
Fe	Between G	14,474.783	5	2,894.957	6.295	0.004**
	Within G	5,518.650	12	459.887		
	Total	19,993.432	17			
Mn	Between G	107.804	5	21.561	3.632	0.031*
	Within G	71.240	12	5.937		
	Total	179.044	17			
Ni	Between G	0.207	5	0.041	0.879	0.523
	Within G	0.565	12	0.047		
	Total	0.772	17			
Pb	Between G	228.642	5	45.728	1.892	0.169
	Within G	289.980	12	24.165		
	Total	518.622	17			
V	Between G	0.055	5	0.011	6.086	0.005**
	Within G	0.022	12	0.002		
	Total	0.077	17			
Zn	Between G	553.608	5	110.722	3.177	0.047*
	Within G	418.209	12	34.851		
	Total	971.817	17			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc,
Selenium (Se) was not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.7 One-way ANOVA results of measured heavy metals concentration levels (μg/kg) in upper stem by treatments

HM		Sum of Squares	dF	Mean Squares	F	Sig
Al	Between G	590.130	5	118.026	4.565	0.003**
	Within G	775.647	30	25.855		
	Total	1,365.777	35			
As	Between G	1.792	5	0.358	2.788	0.035*
	Within G	3.855	30	0.128		
	Total	5.647	35			
Be	Between G	0.177	5	0.035	2.478	0.054
	Within G	0.429	30	0.014		
	Total	0.606	35			
Co	Between G	0.408	5	0.082	2.363	0.064
	Within G	1.036	30	0.035		
	Total	1.444	35			
Cr	Between G	NA	5	NA	NA	NA
	Within G	NA	30	NA		
	Total	NA	35			
Cu	Between G	37.391	5	7.478	2.096	0.093
	Within G	107.011	30	3.567		
	Total	144.402	35			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group,
NA: Not Available, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper Cadmium (Cd) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.7 Continued

HM		Sum of Squares	dF	Mean Squares	F	Sig
Fe	Between G	1,194.389	5	238.878	2.612	0.045*
	Within G	2,743.793	30	91.460		
	Total	3,938.182	35			
Mn	Between G	362.489	5	72.498	1.654	0.176
	Within G	1,315.318	30	43.844		
	Total	1,677.806	35			
Ni	Between G	0.210	5	0.042	0.545	0.741
	Within G	2.312	30	0.077		
	Total	2.522	35			
Pb	Between G	167.119	5	33.424	1.543	0.206
	Within G	649.710	30	21.657		
	Total	816.829	35			
V	Between G	0.243	5	0.049	2.643	0.043*
	Within G	0.551	30	0.018		
	Total	0.794	35			
Zn	Between G	165.306	5	33.061	1.580	0.196
	Within G	627.816	30	20.927		
	Total	793.122	35			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc,
Selenium (Se) was not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.8 One-way ANOVA results of measured heavy metals concentration levels (μg/kg) in leaf by treatments

HM		Sum of Squares	dF	Mean Squares	F	Sig
	Between G	137,907.1	5	27,581.4	14.205	0.000**
Al	Within G	93,197.3	48	1,941.6		
	Total	231,104.4	53			
	Between G	3.395	5	0.679	2.410	0.050*
As	Within G	13.524	48	0.282		
	Total	16.918	53			
	Between G	0.059	5	0.012	11.909	0.000**
Be	Within G	0.047	48	0.001		
	Total	0.106	53			
	Between G	0.698	5	0.140	1.649	0.165
Co	Within G	4.062	48	0.085		
	Total	4.759	53			
	Between G	NA	5	NA	NA	NA
Cr	Within G	NA	48	NA		
	Total	NA	53			
	Between G	260.266	5	52.053	1.664	0.161
Cu	Within G	1,501.506	48	31.281		
	Total	1,761.772	53			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group,
NA: Not Available, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper Cadmium (Cd) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.8 Continued

HM		Sum of Squares	dF	Mean Squares	F	Sig
Fe	Between G	35,413.975	5	7,082.795	5.832	0.000**
	Within G	58,294.581	48	1,214.470		
	Total	93,708.557	53			
Mn	Between G	4,799.004	5	959.801	5.633	0.000**
	Within G	8,179.108	48	170.398		
	Total	12,978.112	53			
Ni	Between G	1.737	5	0.347	1.436	0.229
	Within G	11.617	48	0.242		
	Total	13.355	53			
Pb	Between G	2,040.184	5	408.037	9.771	0.000**
	Within G	2,004.516	48	41.761		
	Total	4,044.700	53			
V	Between G	0.272	5	0.054	4.276	0.003**
	Within G	0.611	48	0.013		
	Total	0.883	53			
Zn	Between G	1,257.346	5	251.469	6.053	0.000**
	Within G	1,994.185	48	41.546		
	Total	3,251.530	53			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc,
Selenium (Se) was not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.9 One-way ANOVA results of measured heavy metals concentration levels (μg/kg) in fruit by treatments

HM		Sum of Squares	dF	Mean Squares	F	Sig
	Between G	343.938	5	68.788	1.029	0.413
Al	Within G	2,806.793	42	66.828		
	Total	3,150.731	47			
	Between G	0.010	5	0.002	0.486	0.785
As	Within G	0.181	42	0.004		
	Total	0.191	47			
	Between G	0.001	5	0.000	3.035	0.020*
Be	Within G	0.002	42	0.000		
	Total	0.002	47			
	Between G	0.023	5	0.005	0.722	0.610
Co	Within G	0.270	42	0.006		
	Total	0.293	47			
	Between G	NA	5	NA	NA	NA
Cr	Within G	NA	42	NA		
	Total	NA	47			
	Between G	17.435	5	3.487	0.748	0.592
Cu	Within G	195.742	42	4.661		
	Total	213.177	47			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group,
NA: Not Available, Al: Aluminum, As: Arsenic, Be: Beryllium, Co: Cobalt, Cr: Chromium, Cu: Copper Cadmium (Cd) were not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

Table B.9 Continued

HM		Sum of Squares	dF	Mean Squares	F	Sig
Fe	Between G	816.689	5	163.338	1.614	0.177
	Within G	4,251.587	42	101.228		
	Total	5,068.276	47			
Mn	Between G	36.439	5	7.288	0.578	0.717
	Within G	529.721	42	12.612		
	Total	566.160	47			
Ni	Between G	0.041	5	0.008	1.530	0.201
	Within G	0.224	42	0.005		
	Total	0.265	47			
Pb	Between G	7.278	5	1.456	1.260	0.299
	Within G	48.534	42	1.156		
	Total	55.813	47			
V	Between G	0.004	5	0.001	2.199	0.072
	Within G	0.015	42	0.000		
	Total	0.018	47			
Zn	Between G	89.903	5	17.981	0.715	0.616
	Within G	1,056.877	42	25.164		
	Total	1,146.780	47			

HM: Heavy Metal, df: Degree of Freedom, Sig: Significance, G: Group
Fe: Iron, Mn: Manganese, Ni: Nickel, Pb: Lead, V: Vanadium, Zn: Zinc,
Selenium (Se) was not detected.
*, ** significant at 0.05 and 0.01 probability levels, respectively.

APPENDIX C

STATISTICAL DATA

TUKEY POST-HOC MULTIPLE COMPARISONS

Table C.1 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of soil pH

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.20	0.15	0.740	-0.69	0.29	-0.83	0.43
	T_2	-0.07	0.15	0.997	-0.55	0.42	-0.69	0.56
	T_3	-0.27	0.15	0.481	-0.75	0.22	-0.89	0.36
	T_4	-0.20	0.15	0.740	-0.69	0.29	-0.83	0.43
	T_5	-0.47	0.15	0.064	-0.95	0.02	-1.09	0.16
T_1	T_0	0.20	0.15	0.740	-0.29	0.69	-0.43	0.83
	T_2	0.13	0.15	0.934	-0.35	0.62	-0.49	0.76
	T_3	-0.07	0.15	0.997	-0.55	0.42	-0.69	0.56
	T_4	0.00	0.15	1.000	-0.49	0.49	-0.63	0.63
	T_5	-0.27	0.15	0.481	-0.75	0.22	-0.89	0.36
T_2	T_0	0.07	0.15	0.997	-0.42	0.55	-0.56	0.69
	T_1	-0.13	0.15	0.934	-0.62	0.35	-0.76	0.49
	T_3	-0.20	0.15	0.740	-0.69	0.29	-0.83	0.43
	T_4	-0.13	0.15	0.934	-0.62	0.35	-0.76	0.49
	T_5	-0.40	0.15	0.135	-0.89	0.09	-1.03	0.23
T_3	T_0	0.27	0.15	0.481	-0.22	0.75	-0.36	0.89
	T_1	0.07	0.15	0.997	-0.42	0.55	-0.56	0.69
	T_2	0.20	0.15	0.740	-0.29	0.69	-0.43	0.83
	T_4	0.07	0.15	0.997	-0.42	0.55	-0.56	0.69
	T_5	-0.20	0.15	0.740	-0.69	0.29	-0.83	0.43
T_4	T_0	0.20	0.15	0.740	-0.29	0.69	-0.43	0.83
	T_1	0.00	0.15	1.000	-0.49	0.49	-0.63	0.63
	T_2	0.13	0.15	0.934	-0.35	0.62	-0.49	0.76
	T_3	-0.07	0.15	0.997	-0.55	0.42	-0.69	0.56
	T_5	-0.27	0.15	0.481	-0.75	0.22	-0.89	0.36
T_5	T_0	0.47	0.15	0.064	-0.02	0.95	-0.16	1.09
	T_1	0.27	0.15	0.481	-0.22	0.75	-0.36	0.89
	T_2	0.40	0.15	0.135	-0.09	0.89	-0.23	1.03
	T_3	0.20	0.15	0.740	-0.29	0.69	-0.43	0.83
	T_4	0.27	0.15	0.481	-0.22	0.75	-0.36	0.89

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.2 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of soil's electrical conductivity (EC)

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-22.67	226.15	1.000	-782.27	736.94	-998.30	952.96
	T_2	-490.33	226.15	0.318	-1249.94	269.27	-1465.96	485.30
	T_3	-747.00	226.15	0.055	-1506.61	12.61	-1722.63	228.63
	T_4	-891.67	226.15	0.019*	-1651.27	-132.06	-1867.30	83.96
	T_5	-614.00	226.15	0.143	-1373.61	145.61	-1589.63	361.63
T_1	T_0	22.67	226.15	1.000	-736.94	782.27	-952.96	998.30
	T_2	-467.67	226.15	0.363	-1227.27	291.94	-1443.30	507.96
	T_3	-724.33	226.15	0.065	-1483.94	35.27	-1699.96	251.30
	T_4	-869.00	226.15	0.022*	-1628.61	-109.39	-1844.63	106.63
	T_5	-591.33	226.15	0.167	-1350.94	168.27	-1566.96	384.30
T_2	T_0	490.33	226.15	0.318	-269.27	1249.94	-485.30	1465.96
	T_1	467.67	226.15	0.363	-291.94	1227.27	-507.96	1443.30
	T_3	-256.67	226.15	0.858	-1016.27	502.94	-1232.30	718.96
	T_4	-401.33	226.15	0.514	-1160.94	358.27	-1376.96	574.30
	T_5	-123.67	226.15	0.993	-883.27	635.94	-1099.30	851.96
T_3	T_0	747.00	226.15	0.055	-12.61	1506.61	-228.63	1722.63
	T_1	724.33	226.15	0.065	-35.27	1483.94	-251.30	1699.96
	T_2	256.67	226.15	0.858	-502.94	1016.27	-718.96	1232.30
	T_4	-144.67	226.15	0.985	-904.27	614.94	-1120.30	830.96
	T_5	133.00	226.15	0.990	-626.61	892.61	-842.63	1108.63
T_4	T_0	891.67	226.15	0.019*	132.06	1651.27	-83.96	1867.30
	T_1	869.00	226.15	0.022*	109.39	1628.61	-106.63	1844.63
	T_2	401.33	226.15	0.514	-358.27	1160.94	-574.30	1376.96
	T_3	144.67	226.15	0.985	-614.94	904.27	-830.96	1120.30
	T_5	277.67	226.15	0.816	-481.94	1037.27	-697.96	1253.30
T_5	T_0	614.00	226.15	0.143	-145.61	1373.61	-361.63	1589.63
	T_1	591.33	226.15	0.167	-168.27	1350.94	-384.30	1566.96
	T_2	123.67	226.15	0.993	-635.94	883.27	-851.96	1099.30
	T_3	-133.00	226.15	0.990	-892.61	626.61	-1108.63	842.63
	T_4	-277.67	226.15	0.816	-1037.27	481.94	-1253.30	697.96

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.3 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of soil's nitrate-nitrogen (NO_3-N)

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-15.67	37.48	0.998	-141.55	110.21	-177.35	146.01
	T_2	-80.00	37.48	0.333	-205.88	45.88	-241.68	81.68
	T_3	-91.00	37.48	0.221	-216.88	34.88	-252.68	70.68
	T_4	-102.00	37.48	0.141	-227.88	23.88	-263.68	59.68
	T_5	-65.67	37.48	0.527	-191.55	60.21	-227.35	96.01
T_1	T_0	15.67	37.48	0.998	-110.21	141.55	-146.01	177.35
	T_2	-64.33	37.48	0.547	-190.21	61.55	-226.01	97.35
	T_3	-75.33	37.48	0.391	-201.21	50.55	-237.01	86.35
	T_4	-86.33	37.48	0.264	-212.21	39.55	-248.01	75.35
	T_5	-50.00	37.48	0.762	-175.88	75.88	-211.68	111.68
T_2	T_0	80.00	37.48	0.333	-45.88	205.88	-81.68	241.68
	T_1	64.33	37.48	0.547	-61.55	190.21	-97.35	226.01
	T_3	-11.00	37.48	1.000	-136.88	114.88	-172.68	150.68
	T_4	-22.00	37.48	0.990	-147.88	103.88	-183.68	139.68
	T_5	14.33	37.48	0.999	-111.55	140.21	-147.35	176.01
T_3	T_0	91.00	37.48	0.221	-34.88	216.88	-70.68	252.68
	T_1	75.33	37.48	0.391	-50.55	201.21	-86.35	237.01
	T_2	11.00	37.48	1.000	-114.88	136.88	-150.68	172.68
	T_4	-11.00	37.48	1.000	-136.88	114.88	-172.68	150.68
	T_5	25.33	37.48	0.981	-100.55	151.21	-136.35	187.01
T_4	T_0	102.00	37.48	0.141	-23.88	227.88	-59.68	263.68
	T_1	86.33	37.48	0.264	-39.55	212.21	-75.35	248.01
	T_2	22.00	37.48	0.990	-103.88	147.88	-139.68	183.68
	T_3	11.00	37.48	1.000	-114.88	136.88	-150.68	172.68
	T_5	36.33	37.48	0.919	-89.55	162.21	-125.35	198.01
T_5	T_0	65.67	37.48	0.527	-60.21	191.55	-96.01	227.35
	T_1	50.00	37.48	0.762	-75.88	175.88	-111.68	211.68
	T_2	-14.33	37.48	0.999	-140.21	111.55	-176.01	147.35
	T_3	-25.33	37.48	0.981	-151.21	100.55	-187.01	136.35
	T_4	-36.33	37.48	0.919	-162.21	89.55	-198.01	125.35

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.4 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of soil's phosphorus (P)

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	21.33	62.79	0.999	-189.56	232.23	-249.54	292.21
	T_2	34.33	62.79	0.993	-176.56	245.23	-236.54	305.21
	T_3	33.33	62.79	0.994	-177.56	244.23	-237.54	304.21
	T_4	59.33	62.79	0.927	-151.56	270.23	-211.54	330.21
	T_5	58.00	62.79	0.933	-152.90	268.90	-212.87	328.87
T_1	T_0	-21.33	62.79	0.999	-232.23	189.56	-292.21	249.54
	T_2	13.00	62.79	1.000	-197.90	223.90	-257.87	283.87
	T_3	12.00	62.79	1.000	-198.90	222.90	-258.87	282.87
	T_4	38.00	62.79	0.989	-172.90	248.90	-232.87	308.87
	T_5	36.67	62.79	0.990	-174.23	247.56	-234.21	307.54
T_2	T_0	-34.33	62.79	0.993	-245.23	176.56	-305.21	236.54
	T_1	-13.00	62.79	1.000	-223.90	197.90	-283.87	257.87
	T_3	-1.00	62.79	1.000	-211.90	209.90	-271.87	269.87
	T_4	25.00	62.79	0.998	-185.90	235.90	-245.87	295.87
	T_5	23.67	62.79	0.999	-187.23	234.56	-247.21	294.54
T_3	T_0	-33.33	62.79	0.994	-244.23	177.56	-304.21	237.54
	T_1	-12.00	62.79	1.000	-222.90	198.90	-282.87	258.87
	T_2	1.00	62.79	1.000	-209.90	211.90	-269.87	271.87
	T_4	26.00	62.79	0.998	-184.90	236.90	-244.87	296.87
	T_5	24.67	62.79	0.998	-186.23	235.56	-246.21	295.54
T_4	T_0	-59.33	62.79	0.927	-270.23	151.56	-330.21	211.54
	T_1	-38.00	62.79	0.989	-248.90	172.90	-308.87	232.87
	T_2	-25.00	62.79	0.998	-235.90	185.90	-295.87	245.87
	T_3	-26.00	62.79	0.998	-236.90	184.90	-296.87	244.87
	T_5	-1.33	62.79	1.000	-212.23	209.56	-272.21	269.54
T_5	T_0	-58.00	62.79	0.933	-268.90	152.90	-328.87	212.87
	T_1	-36.67	62.79	0.990	-247.56	174.23	-307.54	234.21
	T_2	-23.67	62.79	0.999	-234.56	187.23	-294.54	247.21
	T_3	-24.67	62.79	0.998	-235.56	186.23	-295.54	246.21
	T_4	1.33	62.79	1.000	-209.56	212.23	-269.54	272.21

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.5 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of soil's calcium (Ca)

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-8.00	121.82	1.000	-417.17	401.17	-533.53	517.53
	T_2	163.00	121.82	0.760	-246.17	572.17	-362.53	688.53
	T_3	32.33	121.82	1.000	-376.84	441.50	-493.20	557.87
	T_4	150.33	121.82	0.813	-258.84	559.50	-375.20	675.87
	T_5	226.00	121.82	0.470	-183.17	635.17	-299.53	751.53
T_1	T_0	8.00	121.82	1.000	-401.17	417.17	-517.53	533.53
	T_2	171.00	121.82	0.725	-238.17	580.17	-354.53	696.53
	T_3	40.33	121.82	0.999	-368.84	449.50	-485.20	565.87
	T_4	158.33	121.82	0.780	-250.84	567.50	-367.20	683.87
	T_5	234.00	121.82	0.435	-175.17	643.17	-291.53	759.53
T_2	T_0	-163.00	121.82	0.760	-572.17	246.17	-688.53	362.53
	T_1	-171.00	121.82	0.725	-580.17	238.17	-696.53	354.53
	T_3	-130.67	121.82	0.883	-539.84	278.50	-656.20	394.87
	T_4	-12.67	121.82	1.000	-421.84	396.50	-538.20	512.87
	T_5	63.00	121.82	0.994	-346.17	472.17	-462.53	588.53
T_3	T_0	-32.33	121.82	1.000	-441.50	376.84	-557.87	493.20
	T_1	-40.33	121.82	0.999	-449.50	368.84	-565.87	485.20
	T_2	130.67	121.82	0.883	-278.50	539.84	-394.87	656.20
	T_4	118.00	121.82	0.919	-291.17	527.17	-407.53	643.53
	T_5	193.67	121.82	0.619	-215.50	602.84	-331.87	719.20
T_4	T_0	-150.33	121.82	0.813	-559.50	258.84	-675.87	375.20
	T_1	-158.33	121.82	0.780	-567.50	250.84	-683.87	367.20
	T_2	12.67	121.82	1.000	-396.50	421.84	-512.87	538.20
	T_3	-118.00	121.82	0.919	-527.17	291.17	-643.53	407.53
	T_5	75.67	121.82	0.987	-333.50	484.84	-449.87	601.20
T_5	T_0	-226.00	121.82	0.470	-635.17	183.17	-751.53	299.53
	T_1	-234.00	121.82	0.435	-643.17	175.17	-759.53	291.53
	T_2	-63.00	121.82	0.994	-472.17	346.17	-588.53	462.53
	T_3	-193.67	121.82	0.619	-602.84	215.50	-719.20	331.87
	T_4	-75.67	121.82	0.987	-484.84	333.50	-601.20	449.87

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.6 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of soil's magnesium (Mg)

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	25.67	11.20	0.268	-11.95	63.28	-22.65	73.98
	T_2	28.33	11.20	0.190	-9.28	65.95	-19.98	76.65
	T_3	23.33	11.20	0.356	-14.28	60.95	-24.98	71.65
	T_4	27.33	11.20	0.217	-10.28	64.95	-20.98	75.65
	T_5	38.33	11.20	0.045*	0.72	75.95	-9.98	86.65
T_1	T_0	-25.67	11.20	0.268	-63.28	11.95	-73.98	22.65
	T_2	2.67	11.20	1.000	-34.95	40.28	-45.65	50.98
	T_3	-2.33	11.20	1.000	-39.95	35.28	-50.65	45.98
	T_4	1.67	11.20	1.000	-35.95	39.28	-46.65	49.98
	T_5	12.67	11.20	0.859	-24.95	50.28	-35.65	60.98
T_2	T_0	-28.33	11.20	0.190	-65.95	9.28	-76.65	19.98
	T_1	-2.67	11.20	1.000	-40.28	34.95	-50.98	45.65
	T_3	-5.00	11.20	0.997	-42.62	32.62	-53.31	43.31
	T_4	-1.00	11.20	1.000	-38.62	36.62	-49.31	47.31
	T_5	10.00	11.20	0.941	-27.62	47.62	-38.31	58.31
T_3	T_0	-23.33	11.20	0.356	-60.95	14.28	-71.65	24.98
	T_1	2.33	11.20	1.000	-35.28	39.95	-45.98	50.65
	T_2	5.00	11.20	0.997	-32.62	42.62	-43.31	53.31
	T_4	4.00	11.20	0.999	-33.62	41.62	-44.31	52.31
	T_5	15.00	11.20	0.759	-22.62	52.62	-33.31	63.31
T_4	T_0	-27.33	11.20	0.217	-64.95	10.28	-75.65	20.98
	T_1	-1.67	11.20	1.000	-39.28	35.95	-49.98	46.65
	T_2	1.00	11.20	1.000	-36.62	38.62	-47.31	49.31
	T_3	-4.00	11.20	0.999	-41.62	33.62	-52.31	44.31
	T_5	11.00	11.20	0.915	-26.62	48.62	-37.31	59.31
T_5	T_0	-38.33	11.20	0.045*	-75.95	-0.72	-86.65	9.98
	T_1	-12.67	11.20	0.859	-50.28	24.95	-60.98	35.65
	T_2	-10.00	11.20	0.941	-47.62	27.62	-58.31	38.31
	T_3	-15.00	11.20	0.759	-52.62	22.62	-63.31	33.31
	T_4	-11.00	11.20	0.915	-48.62	26.62	-59.31	37.31

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.7 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of soil's potassium (K)

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	13.00	9.80	0.766	-19.90	45.90	-29.26	55.26
	T_2	17.00	9.80	0.536	-15.90	49.90	-25.26	59.26
	T_3	-6.67	9.80	0.981	-39.57	26.24	-48.93	35.60
	T_4	-7.33	9.80	0.971	-40.24	25.57	-49.60	34.93
	T_5	4.67	9.80	0.996	-28.24	37.57	-37.60	46.93
T_1	T_0	-13.00	9.80	0.766	-45.90	19.90	-55.26	29.26
	T_2	4.00	9.80	0.998	-28.90	36.90	-38.26	46.26
	T_3	-19.67	9.80	0.392	-52.57	13.24	-61.93	22.60
	T_4	-20.33	9.80	0.359	-53.24	12.57	-62.60	21.93
	T_5	-8.33	9.80	0.951	-41.24	24.57	-50.60	33.93
T_2	T_0	-17.00	9.80	0.536	-49.90	15.90	-59.26	25.26
	T_1	-4.00	9.80	0.998	-36.90	28.90	-46.26	38.26
	T_3	-23.67	9.80	0.225	-56.57	9.24	-65.93	18.60
	T_4	-24.33	9.80	0.203	-57.24	8.57	-66.60	17.93
	T_5	-12.33	9.80	0.801	-45.24	20.57	-54.60	29.93
T_3	T_0	6.67	9.80	0.981	-26.24	39.57	-35.60	48.93
	T_1	19.67	9.80	0.392	-13.24	52.57	-22.60	61.93
	T_2	23.67	9.80	0.225	-9.24	56.57	-18.60	65.93
	T_4	-0.67	9.80	1.000	-33.57	32.24	-42.93	41.60
	T_5	11.33	9.80	0.848	-21.57	44.24	-30.93	53.60
T_4	T_0	7.33	9.80	0.971	-25.57	40.24	-34.93	49.60
	T_1	20.33	9.80	0.359	-12.57	53.24	-21.93	62.60
	T_2	24.33	9.80	0.203	-8.57	57.24	-17.93	66.60
	T_3	0.67	9.80	1.000	-32.24	33.57	-41.60	42.93
	T_5	12.00	9.80	0.817	-20.90	44.90	-30.26	54.26
T_5	T_0	-4.67	9.80	0.996	-37.57	28.24	-46.93	37.60
	T_1	8.33	9.80	0.951	-24.57	41.24	-33.93	50.60
	T_2	12.33	9.80	0.801	-20.57	45.24	-29.93	54.60
	T_3	-11.33	9.80	0.848	-44.24	21.57	-53.60	30.93
	T_4	-12.00	9.80	0.817	-44.90	20.90	-54.26	30.26

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.8 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of soil's sodium (Na)

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-2.00	2.60	0.968	-10.74	6.74	-13.23	9.23
	T_2	0.33	2.60	1.000	-8.41	9.08	-10.90	11.56
	T_3	-3.67	2.60	0.722	-12.41	5.08	-14.90	7.56
	T_4	-1.67	2.60	0.985	-10.41	7.08	-12.90	9.56
	T_5	-1.00	2.60	0.999	-9.74	7.74	-12.23	10.23
T_1	T_0	2.00	2.60	0.968	-6.74	10.74	-9.23	13.23
	T_2	2.33	2.60	0.940	-6.41	11.08	-8.90	13.56
	T_3	-1.67	2.60	0.985	-10.41	7.08	-12.90	9.56
	T_4	0.33	2.60	1.000	-8.41	9.08	-10.90	11.56
	T_5	1.00	2.60	0.999	-7.74	9.74	-10.23	12.23
T_2	T_0	-0.33	2.60	1.000	-9.08	8.41	-11.56	10.90
	T_1	-2.33	2.60	0.940	-11.08	6.41	-13.56	8.90
	T_3	-4.00	2.60	0.650	-12.74	4.74	-15.23	7.23
	T_4	-2.00	2.60	0.968	-10.74	6.74	-13.23	9.23
	T_5	-1.33	2.60	0.995	-10.08	7.41	-12.56	9.90
T_3	T_0	3.67	2.60	0.722	-5.08	12.41	-7.56	14.90
	T_1	1.67	2.60	0.985	-7.08	10.41	-9.56	12.90
	T_2	4.00	2.60	0.650	-4.74	12.74	-7.23	15.23
	T_4	2.00	2.60	0.968	-6.74	10.74	-9.23	13.23
	T_5	2.67	2.60	0.901	-6.08	11.41	-8.56	13.90
T_4	T_0	1.67	2.60	0.985	-7.08	10.41	-9.56	12.90
	T_1	-0.33	2.60	1.000	-9.08	8.41	-11.56	10.90
	T_2	2.00	2.60	0.968	-6.74	10.74	-9.23	13.23
	T_3	-2.00	2.60	0.968	-10.74	6.74	-13.23	9.23
	T_5	0.67	2.60	1.000	-8.08	9.41	-10.56	11.90
T_5	T_0	1.00	2.60	0.999	-7.74	9.74	-10.23	12.23
	T_1	-1.00	2.60	0.999	-9.74	7.74	-12.23	10.23
	T_2	1.33	2.60	0.995	-7.41	10.08	-9.90	12.56
	T_3	-2.67	2.60	0.901	-11.41	6.08	-13.90	8.56
	T_4	-0.67	2.60	1.000	-9.41	8.08	-11.90	10.56

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.9 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of soil's exchangeable sodium percentage (ESP)

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.041	0.048	0.953	-0.202	0.121	-0.248	0.167
	T_2	-0.001	0.048	1.000	-0.163	0.161	-0.208	0.206
	T_3	-0.071	0.048	0.684	-0.233	0.091	-0.278	0.136
	T_4	-0.039	0.048	0.961	-0.200	0.123	-0.246	0.169
	T_5	-0.029	0.048	0.988	-0.191	0.132	-0.237	0.178
T_1	T_0	0.041	0.048	0.953	-0.121	0.202	-0.167	0.248
	T_2	0.040	0.048	0.957	-0.122	0.201	-0.168	0.247
	T_3	-0.030	0.048	0.986	-0.192	0.131	-0.238	0.177
	T_4	0.002	0.048	1.000	-0.160	0.164	-0.205	0.209
	T_5	0.011	0.048	1.000	-0.150	0.173	-0.196	0.219
T_2	T_0	0.001	0.048	1.000	-0.161	0.163	-0.206	0.208
	T_1	-0.040	0.048	0.957	-0.201	0.122	-0.247	0.168
	T_3	-0.070	0.048	0.696	-0.232	0.092	-0.277	0.137
	T_4	-0.038	0.048	0.965	-0.199	0.124	-0.245	0.170
	T_5	-0.028	0.048	0.990	-0.190	0.133	-0.236	0.179
T_3	T_0	0.071	0.048	0.684	-0.091	0.233	-0.136	0.278
	T_1	0.030	0.048	0.986	-0.131	0.192	-0.177	0.238
	T_2	0.070	0.048	0.696	-0.092	0.232	-0.137	0.277
	T_4	0.032	0.048	0.982	-0.129	0.194	-0.175	0.240
	T_5	0.042	0.048	0.948	-0.120	0.203	-0.166	0.249
T_4	T_0	0.039	0.048	0.961	-0.123	0.200	-0.169	0.246
	T_1	-0.002	0.048	1.000	-0.164	0.160	-0.209	0.205
	T_2	0.038	0.048	0.965	-0.124	0.199	-0.170	0.245
	T_3	-0.032	0.048	0.982	-0.194	0.129	-0.240	0.175
	T_5	0.009	0.048	1.000	-0.152	0.171	-0.198	0.217
T_5	T_0	0.029	0.048	0.988	-0.132	0.191	-0.178	0.237
	T_1	-0.011	0.048	1.000	-0.173	0.150	-0.219	0.196
	T_2	0.028	0.048	0.990	-0.133	0.190	-0.179	0.236
	T_3	-0.042	0.048	0.948	-0.203	0.120	-0.249	0.166
	T_4	-0.009	0.048	1.000	-0.171	0.152	-0.217	0.198

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.10 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of soil's organic matter (OM)

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	0.004	0.002	0.369	-0.002	0.010	-0.004	0.011
	T_2	0.005	0.002	0.167	-0.001	0.011	-0.003	0.012
	T_3	0.006	0.002	0.068	0.000	0.012	-0.002	0.013
	T_4	0.006	0.002	0.068	0.000	0.012	-0.002	0.013
	T_5	0.006	0.002	0.036*	0.000	0.012	-0.001	0.014
T_1	T_0	-0.004	0.002	0.369	-0.010	0.002	-0.011	0.004
	T_2	0.001	0.002	0.992	-0.005	0.007	-0.007	0.009
	T_3	0.002	0.002	0.864	-0.004	0.008	-0.006	0.010
	T_4	0.002	0.002	0.864	-0.004	0.008	-0.006	0.010
	T_5	0.003	0.002	0.674	-0.003	0.009	-0.005	0.010
T_2	T_0	-0.005	0.002	0.167	-0.011	0.001	-0.012	0.003
	T_1	-0.001	0.002	0.992	-0.007	0.005	-0.009	0.007
	T_3	0.001	0.002	0.992	-0.005	0.007	-0.007	0.009
	T_4	0.001	0.002	0.992	-0.005	0.007	-0.007	0.009
	T_5	0.002	0.002	0.930	-0.004	0.008	-0.006	0.009
T_3	T_0	-0.006	0.002	0.068	-0.012	0.000	-0.013	0.002
	T_1	-0.002	0.002	0.864	-0.008	0.004	-0.010	0.006
	T_2	-0.001	0.002	0.992	-0.007	0.005	-0.009	0.007
	T_4	0.000	0.002	1.000	-0.006	0.006	-0.008	0.008
	T_5	0.001	0.002	0.999	-0.005	0.007	-0.007	0.008
T_4	T_0	-0.006	0.002	0.068	-0.012	0.000	-0.013	0.002
	T_1	-0.002	0.002	0.864	-0.008	0.004	-0.010	0.006
	T_2	-0.001	0.002	0.992	-0.007	0.005	-0.009	0.007
	T_3	0.000	0.002	1.000	-0.006	0.006	-0.008	0.008
	T_5	0.001	0.002	0.999	-0.005	0.007	-0.007	0.008
T_5	T_0	-0.006	0.002	0.036*	-0.012	0.000	-0.014	0.001
	T_1	-0.003	0.002	0.674	-0.009	0.003	-0.010	0.005
	T_2	-0.002	0.002	0.930	-0.008	0.004	-0.009	0.006
	T_3	-0.001	0.002	0.999	-0.007	0.005	-0.008	0.007
	T_4	-0.001	0.002	0.999	-0.007	0.005	-0.008	0.007

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.11 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of average fruit wet weight

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	12.07	11.15	0.879	-25.38	49.52	-36.04	60.17
	T_2	5.67	11.15	0.995	-31.78	43.12	-42.44	53.77
	T_3	6.30	11.15	0.992	-31.15	43.75	-41.80	54.40
	T_4	-11.00	11.15	0.914	-48.45	26.45	-59.10	37.10
	T_5	-13.20	11.15	0.836	-50.65	24.25	-61.30	34.90
T_1	T_0	-12.07	11.15	0.879	-49.52	25.38	-60.17	36.04
	T_2	-6.40	11.15	0.991	-43.85	31.05	-54.50	41.70
	T_3	-5.77	11.15	0.994	-43.22	31.68	-53.87	42.34
	T_4	-23.07	11.15	0.363	-60.52	14.38	-71.17	25.04
	T_5	-25.27	11.15	0.278	-62.72	12.18	-73.37	22.84
T_2	T_0	-5.67	11.15	0.995	-43.12	31.78	-53.77	42.44
	T_1	6.40	11.15	0.991	-31.05	43.85	-41.70	54.50
	T_3	0.63	11.15	1.000	-36.82	38.08	-47.47	48.74
	T_4	-16.67	11.15	0.674	-54.12	20.78	-64.77	31.44
	T_5	-18.87	11.15	0.561	-56.32	18.58	-66.97	29.24
T_3	T_0	-6.30	11.15	0.992	-43.75	31.15	-54.40	41.80
	T_1	5.77	11.15	0.994	-31.68	43.22	-42.34	53.87
	T_2	-0.63	11.15	1.000	-38.08	36.82	-48.74	47.47
	T_4	-17.30	11.15	0.641	-54.75	20.15	-65.40	30.80
	T_5	-19.50	11.15	0.529	-56.95	17.95	-67.60	28.60
T_4	T_0	11.00	11.15	0.914	-26.45	48.45	-37.10	59.10
	T_1	23.07	11.15	0.363	-14.38	60.52	-25.04	71.17
	T_2	16.67	11.15	0.674	-20.78	54.12	-31.44	64.77
	T_3	17.30	11.15	0.641	-20.15	54.75	-30.80	65.40
	T_5	-2.20	11.15	1.000	-39.65	35.25	-50.30	45.90
T_5	T_0	13.20	11.15	0.836	-24.25	50.65	-34.90	61.30
	T_1	25.27	11.15	0.278	-12.18	62.72	-22.84	73.37
	T_2	18.87	11.15	0.561	-18.58	56.32	-29.24	66.97
	T_3	19.50	11.15	0.529	-17.95	56.95	-28.60	67.60
	T_4	2.20	11.15	1.000	-35.25	39.65	-45.90	50.30

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.12 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of average fruit dry weight

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	0.54	0.80	0.982	-2.14	3.21	-2.90	3.97
	T_2	0.17	0.80	1.000	-2.51	2.85	-3.27	3.61
	T_3	0.39	0.80	0.996	-2.29	3.06	-3.05	3.82
	T_4	-0.73	0.80	0.934	-3.41	1.94	-4.17	2.70
	T_5	-0.90	0.80	0.860	-3.58	1.78	-4.34	2.54
T_1	T_0	-0.54	0.80	0.982	-3.21	2.14	-3.97	2.90
	T_2	-0.37	0.80	0.997	-3.04	2.31	-3.80	3.07
	T_3	-0.15	0.80	1.000	-2.83	2.53	-3.59	3.29
	T_4	-1.27	0.80	0.617	-3.95	1.41	-4.71	2.17
	T_5	-1.44	0.80	0.498	-4.11	1.24	-4.87	2.00
T_2	T_0	-0.17	0.80	1.000	-2.85	2.51	-3.61	3.27
	T_1	0.37	0.80	0.997	-2.31	3.04	-3.07	3.80
	T_3	0.22	0.80	1.000	-2.46	2.89	-3.22	3.65
	T_4	-0.90	0.80	0.858	-3.58	1.77	-4.34	2.53
	T_5	-1.07	0.80	0.757	-3.75	1.61	-4.51	2.37
T_3	T_0	-0.39	0.80	0.996	-3.06	2.29	-3.82	3.05
	T_1	0.15	0.80	1.000	-2.53	2.83	-3.29	3.59
	T_2	-0.22	0.80	1.000	-2.89	2.46	-3.65	3.22
	T_4	-1.12	0.80	0.723	-3.80	1.56	-4.56	2.32
	T_5	-1.29	0.80	0.604	-3.96	1.39	-4.72	2.15
T_4	T_0	0.73	0.80	0.934	-1.94	3.41	-2.70	4.17
	T_1	1.27	0.80	0.617	-1.41	3.95	-2.17	4.71
	T_2	0.90	0.80	0.858	-1.77	3.58	-2.53	4.34
	T_3	1.12	0.80	0.723	-1.56	3.80	-2.32	4.56
	T_5	-0.17	0.80	1.000	-2.84	2.51	-3.60	3.27
T_5	T_0	0.90	0.80	0.860	-1.78	3.58	-2.54	4.34
	T_1	1.44	0.80	0.498	-1.24	4.11	-2.00	4.87
	T_2	1.07	0.80	0.757	-1.61	3.75	-2.37	4.51
	T_3	1.29	0.80	0.604	-1.39	3.96	-2.15	4.72
	T_4	0.17	0.80	1.000	-2.51	2.84	-3.27	3.60

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.13 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of average fruit length

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	5.33	3.02	0.518	-4.80	15.47	-7.69	18.35
	T_2	1.60	3.02	0.994	-8.54	11.74	-11.42	14.62
	T_3	1.90	3.02	0.986	-8.24	12.04	-11.12	14.92
	T_4	0.27	3.02	1.000	-9.87	10.40	-12.75	13.29
	T_5	0.23	3.02	1.000	-9.90	10.37	-12.79	13.25
T_1	T_0	-5.33	3.02	0.518	-15.47	4.80	-18.35	7.69
	T_2	-3.73	3.02	0.811	-13.87	6.40	-16.75	9.29
	T_3	-3.43	3.02	0.857	-13.57	6.70	-16.45	9.59
	T_4	-5.07	3.02	0.568	-15.20	5.07	-18.09	7.95
	T_5	-5.10	3.02	0.562	-15.24	5.04	-18.12	7.92
T_2	T_0	-1.60	3.02	0.994	-11.74	8.54	-14.62	11.42
	T_1	3.73	3.02	0.811	-6.40	13.87	-9.29	16.75
	T_3	0.30	3.02	1.000	-9.84	10.44	-12.72	13.32
	T_4	-1.33	3.02	0.997	-11.47	8.80	-14.35	11.69
	T_5	-1.37	3.02	0.997	-11.50	8.77	-14.39	11.65
T_3	T_0	-1.90	3.02	0.986	-12.04	8.24	-14.92	11.12
	T_1	3.43	3.02	0.857	-6.70	13.57	-9.59	16.45
	T_2	-0.30	3.02	1.000	-10.44	9.84	-13.32	12.72
	T_4	-1.63	3.02	0.993	-11.77	8.50	-14.65	11.39
	T_5	-1.67	3.02	0.992	-11.80	8.47	-14.69	11.35
T_4	T_0	-0.27	3.02	1.000	-10.40	9.87	-13.29	12.75
	T_1	5.07	3.02	0.568	-5.07	15.20	-7.95	18.09
	T_2	1.33	3.02	0.997	-8.80	11.47	-11.69	14.35
	T_3	1.63	3.02	0.993	-8.50	11.77	-11.39	14.65
	T_5	-0.03	3.02	1.000	-10.17	10.10	-13.05	12.99
T_5	T_0	-0.23	3.02	1.000	-10.37	9.90	-13.25	12.79
	T_1	5.10	3.02	0.562	-5.04	15.24	-7.92	18.12
	T_2	1.37	3.02	0.997	-8.77	11.50	-11.65	14.39
	T_3	1.67	3.02	0.992	-8.47	11.80	-11.35	14.69
	T_4	0.03	3.02	1.000	-10.10	10.17	-12.99	13.05

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.14 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of average fruit width

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	0.47	2.90	1.000	-9.27	10.21	-12.04	12.98
	T_2	0.77	2.90	1.000	-8.97	10.51	-11.74	13.28
	T_3	-0.23	2.90	1.000	-9.97	9.51	-12.74	12.28
	T_4	-5.13	2.90	0.517	-14.87	4.61	-17.64	7.38
	T_5	-5.07	2.90	0.529	-14.81	4.67	-17.58	7.44
T_1	T_0	-0.47	2.90	1.000	-10.21	9.27	-12.98	12.04
	T_2	0.30	2.90	1.000	-9.44	10.04	-12.21	12.81
	T_3	-0.70	2.90	1.000	-10.44	9.04	-13.21	11.81
	T_4	-5.60	2.90	0.430	-15.34	4.14	-18.11	6.91
	T_5	-5.53	2.90	0.442	-15.27	4.21	-18.04	6.98
T_2	T_0	-0.77	2.90	1.000	-10.51	8.97	-13.28	11.74
	T_1	-0.30	2.90	1.000	-10.04	9.44	-12.81	12.21
	T_3	-1.00	2.90	0.999	-10.74	8.74	-13.51	11.51
	T_4	-5.90	2.90	0.379	-15.64	3.84	-18.41	6.61
	T_5	-5.83	2.90	0.390	-15.57	3.91	-18.34	6.68
T_3	T_0	0.23	2.90	1.000	-9.51	9.97	-12.28	12.74
	T_1	0.70	2.90	1.000	-9.04	10.44	-11.81	13.21
	T_2	1.00	2.90	0.999	-8.74	10.74	-11.51	13.51
	T_4	-4.90	2.90	0.562	-14.64	4.84	-17.41	7.61
	T_5	-4.83	2.90	0.575	-14.57	4.91	-17.34	7.68
T_4	T_0	5.13	2.90	0.517	-4.61	14.87	-7.38	17.64
	T_1	5.60	2.90	0.430	-4.14	15.34	-6.91	18.11
	T_2	5.90	2.90	0.379	-3.84	15.64	-6.61	18.41
	T_3	4.90	2.90	0.562	-4.84	14.64	-7.61	17.41
	T_5	0.07	2.90	1.000	-9.67	9.81	-12.44	12.58
T_5	T_0	5.07	2.90	0.529	-4.67	14.81	-7.44	17.58
	T_1	5.53	2.90	0.442	-4.21	15.27	-6.98	18.04
	T_2	5.83	2.90	0.390	-3.91	15.57	-6.68	18.34
	T_3	4.83	2.90	0.575	-4.91	14.57	-7.68	17.34
	T_4	-0.07	2.90	1.000	-9.81	9.67	-12.58	12.44

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.15 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of fruit per plant

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-2.33	1.73	0.755	-8.15	3.48	-9.81	5.14
	T_2	-2.00	1.73	0.849	-7.82	3.82	-9.47	5.47
	T_3	-2.33	1.73	0.755	-8.15	3.48	-9.81	5.14
	T_4	-2.00	1.73	0.849	-7.82	3.82	-9.47	5.47
	T_5	-1.33	1.73	0.968	-7.15	4.48	-8.81	6.14
T_1	T_0	2.33	1.73	0.755	-3.48	8.15	-5.14	9.81
	T_2	0.33	1.73	1.000	-5.48	6.15	-7.14	7.81
	T_3	0.00	1.73	1.000	-5.82	5.82	-7.47	7.47
	T_4	0.33	1.73	1.000	-5.48	6.15	-7.14	7.81
	T_5	1.00	1.73	0.991	-4.82	6.82	-6.47	8.47
T_2	T_0	2.00	1.73	0.849	-3.82	7.82	-5.47	9.47
	T_1	-0.33	1.73	1.000	-6.15	5.48	-7.81	7.14
	T_3	-0.33	1.73	1.000	-6.15	5.48	-7.81	7.14
	T_4	0.00	1.73	1.000	-5.82	5.82	-7.47	7.47
	T_5	0.67	1.73	0.999	-5.15	6.48	-6.81	8.14
T_3	T_0	2.33	1.73	0.755	-3.48	8.15	-5.14	9.81
	T_1	0.00	1.73	1.000	-5.82	5.82	-7.47	7.47
	T_2	0.33	1.73	1.000	-5.48	6.15	-7.14	7.81
	T_4	0.33	1.73	1.000	-5.48	6.15	-7.14	7.81
	T_5	1.00	1.73	0.991	-4.82	6.82	-6.47	8.47
T_4	T_0	2.00	1.73	0.849	-3.82	7.82	-5.47	9.47
	T_1	-0.33	1.73	1.000	-6.15	5.48	-7.81	7.14
	T_2	0.00	1.73	1.000	-5.82	5.82	-7.47	7.47
	T_3	-0.33	1.73	1.000	-6.15	5.48	-7.81	7.14
	T_5	0.67	1.73	0.999	-5.15	6.48	-6.81	8.14
T_5	T_0	1.33	1.73	0.968	-4.48	7.15	-6.14	8.81
	T_1	-1.00	1.73	0.991	-6.82	4.82	-8.47	6.47
	T_2	-0.67	1.73	0.999	-6.48	5.15	-8.14	6.81
	T_3	-1.00	1.73	0.991	-6.82	4.82	-8.47	6.47
	T_4	-0.67	1.73	0.999	-6.48	5.15	-8.14	6.81

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.16 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of weight per plant

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-106.40	109.50	0.919	-474.10	261.40	-578.68	365.94
	T_2	-95.10	109.50	0.947	-462.80	272.70	-567.38	377.24
	T_3	-131.20	109.50	0.830	-498.90	236.50	-603.51	341.11
	T_4	-191.30	109.50	0.530	-559.00	176.50	-663.58	281.04
	T_5	-109.70	109.50	0.909	-477.40	258.10	-581.98	362.64
T_1	T_0	106.40	109.50	0.919	-261.40	474.10	-365.94	578.68
	T_2	11.30	109.50	1.000	-356.40	379.00	-461.01	483.61
	T_3	-24.80	109.50	1.000	-392.60	342.90	-497.14	447.48
	T_4	-84.90	109.50	0.967	-452.60	282.80	-557.21	387.41
	T_5	-3.30	109.50	1.000	-371.00	364.40	-475.61	469.01
T_2	T_0	95.10	109.50	0.947	-272.70	462.80	-377.24	567.38
	T_1	-11.30	109.50	1.000	-379.00	356.40	-483.61	461.01
	T_3	-36.10	109.50	0.999	-403.90	331.60	-508.44	436.18
	T_4	-96.20	109.50	0.945	-463.90	271.50	-568.51	376.11
	T_5	-14.60	109.50	1.000	-382.30	353.10	-486.91	457.71
T_3	T_0	131.20	109.50	0.830	-236.50	498.90	-341.11	603.51
	T_1	24.80	109.50	1.000	-342.90	392.60	-447.48	497.14
	T_2	36.10	109.50	0.999	-331.60	403.90	-436.18	508.44
	T_4	-60.10	109.50	0.993	-427.80	307.70	-532.38	412.24
	T_5	21.50	109.50	1.000	-346.20	389.30	-450.78	493.84
T_4	T_0	191.30	109.50	0.530	-176.50	559.00	-281.04	663.58
	T_1	84.90	109.50	0.967	-282.80	452.60	-387.41	557.21
	T_2	96.20	109.50	0.945	-271.50	463.90	-376.11	568.51
	T_3	60.10	109.50	0.993	-307.70	427.80	-412.24	532.38
	T_5	81.60	109.50	0.972	-286.10	449.30	-390.71	553.91
T_5	T_0	109.70	109.50	0.909	-258.10	477.40	-362.64	581.98
	T_1	3.30	109.50	1.000	-364.40	371.00	-469.01	475.61
	T_2	14.60	109.50	1.000	-353.10	382.30	-457.71	486.91
	T_3	-21.50	109.50	1.000	-389.30	346.20	-493.84	450.78
	T_4	-81.60	109.50	0.972	-449.30	286.10	-553.91	390.71

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.17 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of root wet weight

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-2.72	1.04	0.165	-6.20	0.76	-7.19	1.75
	T_2	-0.06	1.04	1.000	-3.54	3.42	-4.53	4.41
	T_3	0.47	1.04	0.997	-3.01	3.95	-4.00	4.94
	T_4	-0.56	1.04	0.993	-4.04	2.92	-5.03	3.91
	T_5	-1.34	1.04	0.782	-4.82	2.14	-5.81	3.13
T_1	T_0	2.72	1.04	0.165	-0.76	6.20	-1.75	7.19
	T_2	2.65	1.04	0.181	-0.83	6.13	-1.82	7.12
	T_3	3.19	1.04	0.080	-0.29	6.67	-1.28	7.66
	T_4	2.16	1.04	0.355	-1.32	5.64	-2.31	6.63
	T_5	1.37	1.04	0.767	-2.11	4.85	-3.10	5.84
T_2	T_0	0.06	1.04	1.000	-3.42	3.54	-4.41	4.53
	T_1	-2.65	1.04	0.181	-6.13	0.83	-7.12	1.82
	T_3	0.53	1.04	0.995	-2.95	4.01	-3.94	5.00
	T_4	-0.49	1.04	0.996	-3.97	2.99	-4.96	3.98
	T_5	-1.28	1.04	0.812	-4.76	2.20	-5.75	3.19
T_3	T_0	-0.47	1.04	0.997	-3.95	3.01	-4.94	4.00
	T_1	-3.19	1.04	0.080	-6.67	0.29	-7.66	1.28
	T_2	-0.53	1.04	0.995	-4.01	2.95	-5.00	3.94
	T_4	-1.03	1.04	0.912	-4.51	2.45	-5.50	3.44
	T_5	-1.81	1.04	0.528	-5.29	1.67	-6.28	2.66
T_4	T_0	0.56	1.04	0.993	-2.92	4.04	-3.91	5.03
	T_1	-2.16	1.04	0.355	-5.64	1.32	-6.63	2.31
	T_2	0.49	1.04	0.996	-2.99	3.97	-3.98	4.96
	T_3	1.03	1.04	0.912	-2.45	4.51	-3.44	5.50
	T_5	-0.79	1.04	0.970	-4.27	2.69	-5.26	3.68
T_5	T_0	1.34	1.04	0.782	-2.14	4.82	-3.13	5.81
	T_1	-1.37	1.04	0.767	-4.85	2.11	-5.84	3.10
	T_2	1.28	1.04	0.812	-2.20	4.76	-3.19	5.75
	T_3	1.81	1.04	0.528	-1.67	5.29	-2.66	6.28
	T_4	0.79	1.04	0.970	-2.69	4.27	-3.68	5.26

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.18 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of root dry weight

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.65	0.42	0.649	-2.07	0.77	-2.47	1.17
	T_2	0.19	0.42	0.997	-1.23	1.61	-1.63	2.01
	T_3	0.33	0.42	0.967	-1.09	1.75	-1.50	2.15
	T_4	-0.12	0.42	1.000	-1.54	1.30	-1.94	1.71
	T_5	-0.13	0.42	1.000	-1.55	1.29	-1.95	1.70
T_1	T_0	0.65	0.42	0.649	-0.77	2.07	-1.17	2.47
	T_2	0.84	0.42	0.402	-0.58	2.26	-0.98	2.66
	T_3	0.98	0.42	0.261	-0.44	2.40	-0.85	2.80
	T_4	0.53	0.42	0.799	-0.89	1.95	-1.29	2.36
	T_5	0.52	0.42	0.811	-0.90	1.94	-1.30	2.35
T_2	T_0	-0.19	0.42	0.997	-1.61	1.23	-2.01	1.63
	T_1	-0.84	0.42	0.402	-2.26	0.58	-2.66	0.98
	T_3	0.14	0.42	0.999	-1.28	1.56	-1.69	1.96
	T_4	-0.31	0.42	0.975	-1.73	1.11	-2.13	1.52
	T_5	-0.32	0.42	0.971	-1.74	1.10	-2.14	1.51
T_3	T_0	-0.33	0.42	0.967	-1.75	1.09	-2.15	1.50
	T_1	-0.98	0.42	0.261	-2.40	0.44	-2.80	0.85
	T_2	-0.14	0.42	0.999	-1.56	1.28	-1.96	1.69
	T_4	-0.44	0.42	0.892	-1.86	0.98	-2.27	1.38
	T_5	-0.45	0.42	0.883	-1.87	0.97	-2.28	1.37
T_4	T_0	0.12	0.42	1.000	-1.30	1.54	-1.71	1.94
	T_1	-0.53	0.42	0.799	-1.95	0.89	-2.36	1.29
	T_2	0.31	0.42	0.975	-1.11	1.73	-1.52	2.13
	T_3	0.44	0.42	0.892	-0.98	1.86	-1.38	2.27
	T_5	-0.01	0.42	1.000	-1.43	1.41	-1.83	1.81
T_5	T_0	0.13	0.42	1.000	-1.29	1.55	-1.70	1.95
	T_1	-0.52	0.42	0.811	-1.94	0.90	-2.35	1.30
	T_2	0.32	0.42	0.971	-1.10	1.74	-1.51	2.14
	T_3	0.45	0.42	0.883	-0.97	1.87	-1.37	2.28
	T_4	0.01	0.42	1.000	-1.41	1.43	-1.81	1.83

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.19 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of crown wet weight

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-1.51	0.91	0.580	-4.58	1.55	-5.45	2.42
	T_2	-1.58	0.91	0.540	-4.64	1.49	-5.51	2.36
	T_3	-2.11	0.91	0.259	-5.18	0.95	-6.05	1.82
	T_4	-3.22	0.91	0.038*	-6.28	-0.16	-7.16	0.72
	T_5	-2.83	0.91	0.076	-5.90	0.23	-6.77	1.10
T_1	T_0	1.51	0.91	0.580	-1.55	4.58	-2.42	5.45
	T_2	-0.06	0.91	1.000	-3.13	3.00	-4.00	3.87
	T_3	-0.60	0.91	0.984	-3.66	2.46	-4.54	3.34
	T_4	-1.71	0.91	0.462	-4.77	1.36	-5.64	2.23
	T_5	-1.32	0.91	0.701	-4.38	1.74	-5.26	2.62
T_2	T_0	1.58	0.91	0.540	-1.49	4.64	-2.36	5.51
	T_1	0.06	0.91	1.000	-3.00	3.13	-3.87	4.00
	T_3	-0.54	0.91	0.990	-3.60	2.53	-4.47	3.40
	T_4	-1.64	0.91	0.499	-4.71	1.42	-5.58	2.29
	T_5	-1.26	0.91	0.739	-4.32	1.81	-5.19	2.68
T_3	T_0	2.11	0.91	0.259	-0.95	5.18	-1.82	6.05
	T_1	0.60	0.91	0.984	-2.46	3.66	-3.34	4.54
	T_2	0.54	0.91	0.990	-2.53	3.60	-3.40	4.47
	T_4	-1.11	0.91	0.823	-4.17	1.96	-5.04	2.83
	T_5	-0.72	0.91	0.964	-3.78	2.34	-4.66	3.22
T_4	T_0	3.22	0.91	0.038*	0.16	6.28	-0.72	7.16
	T_1	1.71	0.91	0.462	-1.36	4.77	-2.23	5.64
	T_2	1.64	0.91	0.499	-1.42	4.71	-2.29	5.58
	T_3	1.11	0.91	0.823	-1.96	4.17	-2.83	5.04
	T_5	0.39	0.91	0.998	-2.68	3.45	-3.55	4.32
T_5	T_0	2.83	0.91	0.076	-0.23	5.90	-1.10	6.77
	T_1	1.32	0.91	0.701	-1.74	4.38	-2.62	5.26
	T_2	1.26	0.91	0.739	-1.81	4.32	-2.68	5.19
	T_3	0.72	0.91	0.964	-2.34	3.78	-3.22	4.66
	T_4	-0.39	0.91	0.998	-3.45	2.68	-4.32	3.55

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.20 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of crown dry weight

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.59	0.37	0.606	-1.83	0.64	-2.18	0.99
	T_2	-0.54	0.37	0.684	-1.78	0.69	-2.13	1.04
	T_3	-0.93	0.37	0.193	-2.16	0.31	-2.51	0.66
	T_4	-1.44	0.37	0.020*	-2.67	-0.20	-3.02	0.15
	T_5	-1.25	0.37	0.047*	-2.48	-0.01	-2.83	0.34
T_1	T_0	0.59	0.37	0.606	-0.64	1.83	-0.99	2.18
	T_2	0.05	0.37	1.000	-1.19	1.29	-1.54	1.64
	T_3	-0.33	0.37	0.938	-1.57	0.90	-1.92	1.25
	T_4	-0.84	0.37	0.268	-2.08	0.39	-2.43	0.74
	T_5	-0.65	0.37	0.513	-1.89	0.58	-2.24	0.93
T_2	T_0	0.54	0.37	0.684	-0.69	1.78	-1.04	2.13
	T_1	-0.05	0.37	1.000	-1.29	1.19	-1.64	1.54
	T_3	-0.38	0.37	0.894	-1.62	0.85	-1.97	1.20
	T_4	-0.89	0.37	0.220	-2.13	0.34	-2.48	0.69
	T_5	-0.70	0.37	0.440	-1.94	0.53	-2.29	0.88
T_3	T_0	0.93	0.37	0.193	-0.31	2.16	-0.66	2.51
	T_1	0.33	0.37	0.938	-0.90	1.57	-1.25	1.92
	T_2	0.38	0.37	0.894	-0.85	1.62	-1.20	1.97
	T_4	-0.51	0.37	0.734	-1.75	0.73	-2.10	1.08
	T_5	-0.32	0.37	0.947	-1.56	0.92	-1.91	1.27
T_4	T_0	1.44	0.37	0.020*	0.20	2.67	-0.15	3.02
	T_1	0.84	0.37	0.268	-0.39	2.08	-0.74	2.43
	T_2	0.89	0.37	0.220	-0.34	2.13	-0.69	2.48
	T_3	0.51	0.37	0.734	-0.73	1.75	-1.08	2.10
	T_5	0.19	0.37	0.994	-1.05	1.43	-1.40	1.78
T_5	T_0	1.25	0.37	0.047*	0.01	2.48	-0.34	2.83
	T_1	0.65	0.37	0.513	-0.58	1.89	-0.93	2.24
	T_2	0.70	0.37	0.440	-0.53	1.94	-0.88	2.29
	T_3	0.32	0.37	0.947	-0.92	1.56	-1.27	1.91
	T_4	-0.19	0.37	0.994	-1.43	1.05	-1.78	1.40

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.21 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of lower stem wet weight

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	0.19	1.01	1.000	-3.20	3.58	-4.17	4.55
	T_2	0.00	1.01	1.000	-3.40	3.39	-4.36	4.36
	T_3	0.25	1.01	1.000	-3.14	3.65	-4.11	4.61
	T_4	2.94	1.01	0.105	-0.46	6.33	-1.42	7.30
	T_5	0.29	1.01	1.000	-3.10	3.69	-4.07	4.65
T_1	T_0	-0.19	1.01	1.000	-3.58	3.20	-4.55	4.17
	T_2	-0.19	1.01	1.000	-3.59	3.20	-4.55	4.17
	T_3	0.06	1.01	1.000	-3.33	3.46	-4.30	4.42
	T_4	2.75	1.01	0.142	-0.65	6.14	-1.61	7.11
	T_5	0.10	1.01	1.000	-3.29	3.50	-4.26	4.46
T_2	T_0	0.00	1.01	1.000	-3.39	3.40	-4.36	4.36
	T_1	0.19	1.01	1.000	-3.20	3.59	-4.17	4.55
	T_3	0.26	1.01	1.000	-3.14	3.65	-4.10	4.62
	T_4	2.94	1.01	0.105	-0.45	6.33	-1.42	7.30
	T_5	0.30	1.01	1.000	-3.10	3.69	-4.06	4.66
T_3	T_0	-0.25	1.01	1.000	-3.65	3.14	-4.61	4.11
	T_1	-0.06	1.01	1.000	-3.46	3.33	-4.42	4.30
	T_2	-0.26	1.01	1.000	-3.65	3.14	-4.62	4.10
	T_4	2.68	1.01	0.157	-0.71	6.08	-1.68	7.04
	T_5	0.04	1.01	1.000	-3.35	3.43	-4.32	4.40
T_4	T_0	-2.94	1.01	0.105	-6.33	0.46	-7.30	1.42
	T_1	-2.75	1.01	0.142	-6.14	0.65	-7.11	1.61
	T_2	-2.94	1.01	0.105	-6.33	0.45	-7.30	1.42
	T_3	-2.68	1.01	0.157	-6.08	0.71	-7.04	1.68
	T_5	-2.64	1.01	0.166	-6.04	0.75	-7.00	1.72
T_5	T_0	-0.29	1.01	1.000	-3.69	3.10	-4.65	4.07
	T_1	-0.10	1.01	1.000	-3.50	3.29	-4.46	4.26
	T_2	-0.30	1.01	1.000	-3.69	3.10	-4.66	4.06
	T_3	-0.04	1.01	1.000	-3.43	3.35	-4.40	4.32
	T_4	2.64	1.01	0.166	-0.75	6.04	-1.72	7.00

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.22 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of lower stem dry weight

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.10	0.36	1.000	-1.31	1.10	-1.65	1.44
	T_2	-0.43	0.36	0.828	-1.63	0.77	-1.97	1.11
	T_3	-0.44	0.36	0.811	-1.65	0.76	-1.99	1.10
	T_4	0.30	0.36	0.956	-0.91	1.50	-1.25	1.84
	T_5	-0.40	0.36	0.861	-1.61	0.80	-1.95	1.14
T_1	T_0	0.10	0.36	1.000	-1.10	1.31	-1.44	1.65
	T_2	-0.33	0.36	0.936	-1.53	0.88	-1.87	1.22
	T_3	-0.34	0.36	0.925	-1.54	0.86	-1.88	1.20
	T_4	0.40	0.36	0.865	-0.80	1.60	-1.14	1.94
	T_5	-0.30	0.36	0.954	-1.50	0.90	-1.84	1.24
T_2	T_0	0.43	0.36	0.828	-0.77	1.63	-1.11	1.97
	T_1	0.33	0.36	0.936	-0.88	1.53	-1.22	1.87
	T_3	-0.01	0.36	1.000	-1.22	1.19	-1.56	1.53
	T_4	0.73	0.36	0.381	-0.48	1.93	-0.82	2.27
	T_5	0.03	0.36	1.000	-1.18	1.23	-1.52	1.57
T_3	T_0	0.44	0.36	0.811	-0.76	1.65	-1.10	1.99
	T_1	0.34	0.36	0.925	-0.86	1.54	-1.20	1.88
	T_2	0.01	0.36	1.000	-1.19	1.22	-1.53	1.56
	T_4	0.74	0.36	0.363	-0.46	1.94	-0.80	2.28
	T_5	0.04	0.36	1.000	-1.16	1.24	-1.50	1.58
T_4	T_0	-0.30	0.36	0.956	-1.50	0.91	-1.84	1.25
	T_1	-0.40	0.36	0.865	-1.60	0.80	-1.94	1.14
	T_2	-0.73	0.36	0.381	-1.93	0.48	-2.27	0.82
	T_3	-0.74	0.36	0.363	-1.94	0.46	-2.28	0.80
	T_5	-0.70	0.36	0.418	-1.90	0.50	-2.24	0.84
T_5	T_0	0.40	0.36	0.861	-0.80	1.61	-1.14	1.95
	T_1	0.30	0.36	0.954	-0.90	1.50	-1.24	1.84
	T_2	-0.03	0.36	1.000	-1.23	1.18	-1.57	1.52
	T_3	-0.04	0.36	1.000	-1.24	1.16	-1.58	1.50
	T_4	0.70	0.36	0.418	-0.50	1.90	-0.84	2.24

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.23 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of upper stem wet weight

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-34.07	46.75	0.974	-191.11	122.97	-235.77	167.63
	T_2	-71.97	46.75	0.648	-229.01	85.07	-273.67	129.73
	T_3	-135.33	46.75	0.107	-292.37	21.71	-337.03	66.37
	T_4	-72.27	46.75	0.645	-229.31	84.77	-273.97	129.43
	T_5	-6.80	46.75	1.000	-163.84	150.24	-208.50	194.90
T_1	T_0	34.07	46.75	0.974	-122.97	191.11	-167.63	235.77
	T_2	-37.90	46.75	0.960	-194.94	119.14	-239.60	163.80
	T_3	-101.27	46.75	0.319	-258.31	55.77	-302.97	100.43
	T_4	-38.20	46.75	0.959	-195.24	118.84	-239.90	163.50
	T_5	27.27	46.75	0.990	-129.77	184.31	-174.43	228.97
T_2	T_0	71.97	46.75	0.648	-85.07	229.01	-129.73	273.67
	T_1	37.90	46.75	0.960	-119.14	194.94	-163.80	239.60
	T_3	-63.37	46.75	0.751	-220.41	93.67	-265.07	138.33
	T_4	-0.30	46.75	1.000	-157.34	156.74	-202.00	201.40
	T_5	65.17	46.75	0.730	-91.87	222.21	-136.53	266.87
T_3	T_0	135.33	46.75	0.107	-21.71	292.37	-66.37	337.03
	T_1	101.27	46.75	0.319	-55.77	258.31	-100.43	302.97
	T_2	63.37	46.75	0.751	-93.67	220.41	-138.33	265.07
	T_4	63.07	46.75	0.754	-93.97	220.11	-138.63	264.77
	T_5	128.53	46.75	0.135	-28.51	285.57	-73.17	330.23
T_4	T_0	72.27	46.75	0.645	-84.77	229.31	-129.43	273.97
	T_1	38.20	46.75	0.959	-118.84	195.24	-163.50	239.90
	T_2	0.30	46.75	1.000	-156.74	157.34	-201.40	202.00
	T_3	-63.07	46.75	0.754	-220.11	93.97	-264.77	138.63
	T_5	65.47	46.75	0.727	-91.57	222.51	-136.23	267.17
T_5	T_0	6.80	46.75	1.000	-150.24	163.84	-194.90	208.50
	T_1	-27.27	46.75	0.990	-184.31	129.77	-228.97	174.43
	T_2	-65.17	46.75	0.730	-222.21	91.87	-266.87	136.53
	T_3	-128.53	46.75	0.135	-285.57	28.51	-330.23	73.17
	T_4	-65.47	46.75	0.727	-222.51	91.57	-267.17	136.23

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.24 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of upper stem dry weight

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-4.20	8.02	0.994	-31.15	22.75	-38.82	30.42
	T_2	-9.33	8.02	0.846	-36.29	17.62	-43.95	25.29
	T_3	-19.97	8.02	0.202	-46.92	6.99	-54.59	14.65
	T_4	-12.07	8.02	0.669	-39.02	14.89	-46.69	22.55
	T_5	-10.90	8.02	0.749	-37.85	16.05	-45.52	23.72
T_1	T_0	4.20	8.02	0.994	-22.75	31.15	-30.42	38.82
	T_2	-5.13	8.02	0.985	-32.09	21.82	-39.75	29.49
	T_3	-15.77	8.02	0.413	-42.72	11.19	-50.39	18.85
	T_4	-7.87	8.02	0.916	-34.82	19.09	-42.49	26.75
	T_5	-6.70	8.02	0.955	-33.65	20.25	-41.32	27.92
T_2	T_0	9.33	8.02	0.846	-17.62	36.29	-25.29	43.95
	T_1	5.13	8.02	0.985	-21.82	32.09	-29.49	39.75
	T_3	-10.63	8.02	0.767	-37.59	16.32	-45.25	23.99
	T_4	-2.73	8.02	0.999	-29.69	24.22	-37.35	31.89
	T_5	-1.57	8.02	1.000	-28.52	25.39	-36.19	33.05
T_3	T_0	19.97	8.02	0.202	-6.99	46.92	-14.65	54.59
	T_1	15.77	8.02	0.413	-11.19	42.72	-18.85	50.39
	T_2	10.63	8.02	0.767	-16.32	37.59	-23.99	45.25
	T_4	7.90	8.02	0.914	-19.05	34.85	-26.72	42.52
	T_5	9.07	8.02	0.860	-17.89	36.02	-25.55	43.69
T_4	T_0	12.07	8.02	0.669	-14.89	39.02	-22.55	46.69
	T_1	7.87	8.02	0.916	-19.09	34.82	-26.75	42.49
	T_2	2.73	8.02	0.999	-24.22	29.69	-31.89	37.35
	T_3	-7.90	8.02	0.914	-34.85	19.05	-42.52	26.72
	T_5	1.17	8.02	1.000	-25.79	28.12	-33.45	35.79
T_5	T_0	10.90	8.02	0.749	-16.05	37.85	-23.72	45.52
	T_1	6.70	8.02	0.955	-20.25	33.65	-27.92	41.32
	T_2	1.57	8.02	1.000	-25.39	28.52	-33.05	36.19
	T_3	-9.07	8.02	0.860	-36.02	17.89	-43.69	25.55
	T_4	-1.17	8.02	1.000	-28.12	25.79	-35.79	33.45

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.25 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of leaf wet weight

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-6.47	40.91	1.000	-143.90	130.96	-182.98	170.05
	T_2	13.67	40.91	0.999	-123.76	151.10	-162.85	190.18
	T_3	-51.33	40.91	0.803	-188.76	86.10	-227.85	125.18
	T_4	17.83	40.91	0.997	-119.60	155.26	-158.68	194.35
	T_5	-14.60	40.91	0.999	-152.03	122.83	-191.11	161.91
T_1	T_0	6.47	40.91	1.000	-130.96	143.90	-170.05	182.98
	T_2	20.13	40.91	0.996	-117.30	157.56	-156.38	196.65
	T_3	-44.87	40.91	0.874	-182.30	92.56	-221.38	131.65
	T_4	24.30	40.91	0.990	-113.13	161.73	-152.21	200.81
	T_5	-8.13	40.91	1.000	-145.56	129.30	-184.65	168.38
T_2	T_0	-13.67	40.91	0.999	-151.10	123.76	-190.18	162.85
	T_1	-20.13	40.91	0.996	-157.56	117.30	-196.65	156.38
	T_3	-65.00	40.91	0.620	-202.43	72.43	-241.51	111.51
	T_4	4.17	40.91	1.000	-133.26	141.60	-172.35	180.68
	T_5	-28.27	40.91	0.980	-165.70	109.16	-204.78	148.25
T_3	T_0	51.33	40.91	0.803	-86.10	188.76	-125.18	227.85
	T_1	44.87	40.91	0.874	-92.56	182.30	-131.65	221.38
	T_2	65.00	40.91	0.620	-72.43	202.43	-111.51	241.51
	T_4	69.17	40.91	0.562	-68.26	206.60	-107.35	245.68
	T_5	36.73	40.91	0.940	-100.70	174.16	-139.78	213.25
T_4	T_0	-17.83	40.91	0.997	-155.26	119.60	-194.35	158.68
	T_1	-24.30	40.91	0.990	-161.73	113.13	-200.81	152.21
	T_2	-4.17	40.91	1.000	-141.60	133.26	-180.68	172.35
	T_3	-69.17	40.91	0.562	-206.60	68.26	-245.68	107.35
	T_5	-32.43	40.91	0.964	-169.86	105.00	-208.95	144.08
T_5	T_0	14.60	40.91	0.999	-122.83	152.03	-161.91	191.11
	T_1	8.13	40.91	1.000	-129.30	145.56	-168.38	184.65
	T_2	28.27	40.91	0.980	-109.16	165.70	-148.25	204.78
	T_3	-36.73	40.91	0.940	-174.16	100.70	-213.25	139.78
	T_4	32.43	40.91	0.964	-105.00	169.86	-144.08	208.95

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.26 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of leaf dry weight

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	2.00	4.64	0.998	-13.57	17.57	-18.00	22.00
	T_2	-0.70	4.64	1.000	-16.27	14.87	-20.70	19.30
	T_3	-4.20	4.64	0.938	-19.77	11.37	-24.20	15.80
	T_4	-0.67	4.64	1.000	-16.24	14.91	-20.67	19.34
	T_5	-5.93	4.64	0.790	-21.51	9.64	-25.94	14.07
T_1	T_0	-2.00	4.64	0.998	-17.57	13.57	-22.00	18.00
	T_2	-2.70	4.64	0.990	-18.27	12.87	-22.70	17.30
	T_3	-6.20	4.64	0.761	-21.77	9.37	-26.20	13.80
	T_4	-2.67	4.64	0.991	-18.24	12.91	-22.67	17.34
	T_5	-7.93	4.64	0.550	-23.51	7.64	-27.94	12.07
T_2	T_0	0.70	4.64	1.000	-14.87	16.27	-19.30	20.70
	T_1	2.70	4.64	0.990	-12.87	18.27	-17.30	22.70
	T_3	-3.50	4.64	0.970	-19.07	12.07	-23.50	16.50
	T_4	0.03	4.64	1.000	-15.54	15.61	-19.97	20.04
	T_5	-5.23	4.64	0.860	-20.81	10.34	-25.24	14.77
T_3	T_0	4.20	4.64	0.938	-11.37	19.77	-15.80	24.20
	T_1	6.20	4.64	0.761	-9.37	21.77	-13.80	26.20
	T_2	3.50	4.64	0.970	-12.07	19.07	-16.50	23.50
	T_4	3.53	4.64	0.969	-12.04	19.11	-16.47	23.54
	T_5	-1.73	4.64	0.999	-17.31	13.84	-21.74	18.27
T_4	T_0	0.67	4.64	1.000	-14.91	16.24	-19.34	20.67
	T_1	2.67	4.64	0.991	-12.91	18.24	-17.34	22.67
	T_2	-0.03	4.64	1.000	-15.61	15.54	-20.04	19.97
	T_3	-3.53	4.64	0.969	-19.11	12.04	-23.54	16.47
	T_5	-5.27	4.64	0.857	-20.84	10.31	-25.27	14.74
T_5	T_0	5.93	4.64	0.790	-9.64	21.51	-14.07	25.94
	T_1	7.93	4.64	0.550	-7.64	23.51	-12.07	27.94
	T_2	5.23	4.64	0.860	-10.34	20.81	-14.77	25.24
	T_3	1.73	4.64	0.999	-13.84	17.31	-18.27	21.74
	T_4	5.27	4.64	0.857	-10.31	20.84	-14.74	25.27

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.27 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of plant height

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-9.52	19.08	0.995	-73.60	54.55	-91.82	72.77
	T_2	-13.76	19.08	0.975	-77.83	50.32	-96.05	68.54
	T_3	-27.73	19.08	0.697	-91.80	36.35	-110.02	54.57
	T_4	-9.52	19.08	0.995	-73.60	54.55	-91.82	72.77
	T_5	-19.26	19.08	0.906	-83.33	44.81	-101.55	63.03
T_1	T_0	9.52	19.08	0.995	-54.55	73.60	-72.77	91.82
	T_2	-4.23	19.08	1.000	-68.31	59.84	-86.53	78.06
	T_3	-18.20	19.08	0.924	-82.28	45.87	-100.50	64.09
	T_4	0.00	19.08	1.000	-64.07	64.07	-82.29	82.29
	T_5	-9.74	19.08	0.995	-73.81	54.34	-92.03	72.56
T_2	T_0	13.76	19.08	0.975	-50.32	77.83	-68.54	96.05
	T_1	4.23	19.08	1.000	-59.84	68.31	-78.06	86.53
	T_3	-13.97	19.08	0.974	-78.04	50.10	-96.26	68.32
	T_4	4.23	19.08	1.000	-59.84	68.31	-78.06	86.53
	T_5	-5.50	19.08	1.000	-69.58	58.57	-87.80	76.79
T_3	T_0	27.73	19.08	0.697	-36.35	91.80	-54.57	110.02
	T_1	18.20	19.08	0.924	-45.87	82.28	-64.09	100.50
	T_2	13.97	19.08	0.974	-50.10	78.04	-68.32	96.26
	T_4	18.20	19.08	0.924	-45.87	82.28	-64.09	100.50
	T_5	8.47	19.08	0.997	-55.61	72.54	-73.83	90.76
T_4	T_0	9.52	19.08	0.995	-54.55	73.60	-72.77	91.82
	T_1	0.00	19.08	1.000	-64.07	64.07	-82.29	82.29
	T_2	-4.23	19.08	1.000	-68.31	59.84	-86.53	78.06
	T_3	-18.20	19.08	0.924	-82.28	45.87	-100.50	64.09
	T_5	-9.74	19.08	0.995	-73.81	54.34	-92.03	72.56
T_5	T_0	19.26	19.08	0.906	-44.81	83.33	-63.03	101.55
	T_1	9.74	19.08	0.995	-54.34	73.81	-72.56	92.03
	T_2	5.50	19.08	1.000	-58.57	69.58	-76.79	87.80
	T_3	-8.47	19.08	0.997	-72.54	55.61	-90.76	73.83
	T_4	9.74	19.08	0.995	-54.34	73.81	-72.56	92.03

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.28 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured aluminum (Al) concentration levels of treatment water

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-20.92	21.53	0.926	-83.19	41.34	-94.94	53.09
	T_2	-34.25	21.53	0.606	-96.51	28.02	-108.26	39.77
	T_3	-47.57	21.53	0.240	-109.84	14.70	-121.59	26.44
	T_4	-60.90	21.53	0.059	-123.16	1.37	-134.91	13.12
	T_5	-74.22	21.53	0.010**	-136.49	-11.95	-148.24	-0.21
T_1	T_0	20.92	21.53	0.926	-41.34	83.19	-53.09	94.94
	T_2	-13.32	21.53	0.989	-75.59	48.94	-87.34	60.69
	T_3	-26.65	21.53	0.817	-88.92	35.62	-100.66	47.37
	T_4	-39.97	21.53	0.434	-102.24	22.29	-113.99	34.04
	T_5	-53.30	21.53	0.139	-115.57	8.97	-127.31	20.71
T_2	T_0	34.25	21.53	0.606	-28.02	96.51	-39.77	108.26
	T_1	13.32	21.53	0.989	-48.94	75.59	-60.69	87.34
	T_3	-13.32	21.53	0.989	-75.59	48.94	-87.34	60.69
	T_4	-26.65	21.53	0.817	-88.92	35.62	-100.66	47.36
	T_5	-39.97	21.53	0.434	-102.24	22.29	-113.99	34.04
T_3	T_0	47.57	21.53	0.240	-14.70	109.84	-26.44	121.59
	T_1	26.65	21.53	0.817	-35.62	88.92	-47.37	100.66
	T_2	13.32	21.53	0.989	-48.94	75.59	-60.69	87.34
	T_4	-13.32	21.53	0.989	-75.59	48.94	-87.34	60.69
	T_5	-26.65	21.53	0.817	-88.92	35.62	-100.66	47.36
T_4	T_0	60.90	21.53	0.059	-1.37	123.16	-13.12	134.91
	T_1	39.97	21.53	0.434	-22.29	102.24	-34.04	113.99
	T_2	26.65	21.53	0.817	-35.62	88.92	-47.36	100.66
	T_3	13.32	21.53	0.989	-48.94	75.59	-60.69	87.34
	T_5	-13.32	21.53	0.989	-75.59	48.94	-87.34	60.69
T_5	T_0	74.22	21.53	0.010**	11.95	136.49	0.21	148.24
	T_1	53.30	21.53	0.139	-8.97	115.57	-20.71	127.31
	T_2	39.97	21.53	0.434	-22.29	102.24	-34.04	113.99
	T_3	26.65	21.53	0.817	-35.62	88.92	-47.36	100.66
	T_4	13.32	21.53	0.989	-48.94	75.59	-60.69	87.34

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.29 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured arsenic (As) concentration levels of treatment water

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-4.19	3.06	0.744	-13.04	4.65	-14.71	6.32
	T_2	-4.59	3.06	0.665	-13.44	4.26	-15.11	5.93
	T_3	-4.98	3.06	0.581	-13.83	3.86	-15.50	5.53
	T_4	-5.38	3.06	0.496	-14.23	3.47	-15.90	5.14
	T_5	-5.78	3.06	0.414	-14.62	3.07	-16.29	4.74
T_1	T_0	4.19	3.06	0.744	-4.65	13.04	-6.32	14.71
	T_2	-0.40	3.06	1.000	-9.24	8.45	-10.91	10.12
	T_3	-0.79	3.06	1.000	-9.64	8.06	-11.31	9.73
	T_4	-1.19	3.06	0.999	-10.03	7.66	-11.70	9.33
	T_5	-1.58	3.06	0.995	-10.43	7.27	-12.10	8.93
T_2	T_0	4.59	3.06	0.665	-4.26	13.44	-5.93	15.11
	T_1	0.40	3.06	1.000	-8.45	9.24	-10.12	10.91
	T_3	-0.40	3.06	1.000	-9.24	8.45	-10.91	10.12
	T_4	-0.79	3.06	1.000	-9.64	8.06	-11.31	9.73
	T_5	-1.19	3.06	0.999	-10.03	7.66	-11.70	9.33
T_3	T_0	4.98	3.06	0.581	-3.86	13.83	-5.53	15.50
	T_1	0.79	3.06	1.000	-8.06	9.64	-9.73	11.31
	T_2	0.40	3.06	1.000	-8.45	9.24	-10.12	10.91
	T_4	-0.40	3.06	1.000	-9.24	8.45	-10.91	10.12
	T_5	-0.79	3.06	1.000	-9.64	8.06	-11.31	9.73
T_4	T_0	5.38	3.06	0.496	-3.47	14.23	-5.14	15.90
	T_1	1.19	3.06	0.999	-7.66	10.03	-9.33	11.70
	T_2	0.79	3.06	1.000	-8.06	9.64	-9.73	11.31
	T_3	0.40	3.06	1.000	-8.45	9.24	-10.12	10.91
	T_5	-0.40	3.06	1.000	-9.24	8.45	-10.91	10.12
T_5	T_0	5.78	3.06	0.414	-3.07	14.62	-4.74	16.29
	T_1	1.58	3.06	0.995	-7.27	10.43	-8.93	12.10
	T_2	1.19	3.06	0.999	-7.66	10.03	-9.33	11.70
	T_3	0.79	3.06	1.000	-8.06	9.64	-9.73	11.31
	T_4	0.40	3.06	1.000	-8.45	9.24	-10.12	10.91

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.30 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured cobalt (Co) concentration levels of treatment water

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.52	0.05	0.000**	-0.66	-0.38	-0.69	-0.35
	T_2	-0.43	0.05	0.000**	-0.57	-0.29	-0.59	-0.26
	T_3	-0.34	0.05	0.000**	-0.48	-0.20	-0.51	-0.17
	T_4	-0.25	0.05	0.000**	-0.39	-0.11	-0.42	-0.08
	T_5	-0.16	0.05	0.020*	-0.30	-0.02	-0.33	0.01
T_1	T_0	0.52	0.05	0.000**	0.38	0.66	0.35	0.69
	T_2	0.09	0.05	0.445	-0.05	0.23	-0.08	0.26
	T_3	0.18	0.05	0.005*	0.04	0.32	0.01	0.35
	T_4	0.27	0.05	0.000**	0.13	0.41	0.10	0.44
	T_5	0.36	0.05	0.000**	0.22	0.50	0.19	0.53
T_2	T_0	0.43	0.05	0.000**	0.29	0.57	0.26	0.59
	T_1	-0.09	0.05	0.445	-0.23	0.05	-0.26	0.08
	T_3	0.09	0.05	0.445	-0.05	0.23	-0.08	0.26
	T_4	0.18	0.05	0.005*	0.04	0.32	0.01	0.35
	T_5	0.27	0.05	0.000**	0.13	0.41	0.10	0.44
T_3	T_0	0.34	0.05	0.000**	0.20	0.48	0.17	0.51
	T_1	-0.18	0.05	0.005*	-0.32	-0.04	-0.35	-0.01
	T_2	-0.09	0.05	0.445	-0.23	0.05	-0.26	0.08
	T_4	0.09	0.05	0.445	-0.05	0.23	-0.08	0.26
	T_5	0.18	0.05	0.005*	0.04	0.32	0.01	0.35
T_4	T_0	0.25	0.05	0.000**	0.11	0.39	0.08	0.42
	T_1	-0.27	0.05	0.000**	-0.41	-0.13	-0.44	-0.10
	T_2	-0.18	0.05	0.005*	-0.32	-0.04	-0.35	-0.01
	T_3	-0.09	0.05	0.445	-0.23	0.05	-0.26	0.08
	T_5	0.09	0.05	0.445	-0.05	0.23	-0.08	0.26
T_5	T_0	0.16	0.05	0.020*	0.02	0.30	-0.01	0.33
	T_1	-0.36	0.05	0.000**	-0.50	-0.22	-0.53	-0.19
	T_2	-0.27	0.05	0.000**	-0.41	-0.13	-0.44	-0.10
	T_3	-0.18	0.05	0.005*	-0.32	-0.04	-0.35	-0.01
	T_4	-0.09	0.05	0.445	-0.23	0.05	-0.26	0.08

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.31 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured copper (Cu) concentration levels of treatment water

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	109.27	33.56	0.018*	12.22	206.31	-6.09	224.62
	T_2	69.59	33.56	0.307	-27.45	166.63	-45.76	184.94
	T_3	29.91	33.56	0.948	-67.13	126.96	-85.44	145.27
	T_4	-9.76	33.56	1.000	-106.81	87.28	-125.12	105.59
	T_5	-49.44	33.56	0.682	-146.48	47.60	-164.79	65.91
T_1	T_0	-109.27	33.56	0.018*	-206.31	-12.22	-224.62	6.09
	T_2	-39.68	33.56	0.845	-136.72	57.37	-155.03	75.68
	T_3	-79.35	33.56	0.176	-176.40	17.69	-194.71	36.00
	T_4	-119.03	33.56	0.007**	-216.07	-21.99	-234.38	-3.68
	T_5	-158.71	33.56	0.000**	-255.75	-61.66	-274.06	-43.36
T_2	T_0	-69.59	33.56	0.307	-166.63	27.45	-184.94	45.76
	T_1	39.68	33.56	0.845	-57.37	136.72	-75.68	155.03
	T_3	-39.68	33.56	0.845	-136.72	57.37	-155.03	75.68
	T_4	-79.35	33.56	0.176	-176.40	17.69	-194.71	36.00
	T_5	-119.03	33.56	0.007**	-216.07	-21.99	-234.38	-3.68
T_3	T_0	-29.91	33.56	0.948	-126.96	67.13	-145.27	85.44
	T_1	79.35	33.56	0.176	-17.69	176.40	-36.00	194.71
	T_2	39.68	33.56	0.845	-57.37	136.72	-75.68	155.03
	T_4	-39.68	33.56	0.845	-136.72	57.37	-155.03	75.68
	T_5	-79.35	33.56	0.176	-176.40	17.69	-194.71	36.00
T_4	T_0	9.76	33.56	1.000	-87.28	106.81	-105.59	125.12
	T_1	119.03	33.56	0.007**	21.99	216.07	3.68	234.38
	T_2	79.35	33.56	0.176	-17.69	176.40	-36.00	194.71
	T_3	39.68	33.56	0.845	-57.37	136.72	-75.68	155.03
	T_5	-39.68	33.56	0.845	-136.72	57.37	-155.03	75.68
T_5	T_0	49.44	33.56	0.682	-47.60	146.48	-65.91	164.79
	T_1	158.71	33.56	0.000**	61.66	255.75	43.36	274.06
	T_2	119.03	33.56	0.007**	21.99	216.07	3.68	234.38
	T_3	79.35	33.56	0.176	-17.69	176.40	-36.00	194.71
	T_4	39.68	33.56	0.845	-57.37	136.72	-75.68	155.03

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.32 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured iron (Fe) concentration levels of treatment water

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-158.03	33.78	0.000**	-255.73	-60.34	-274.16	-41.91
	T_2	-140.45	33.78	0.001**	-238.14	-42.76	-256.57	-24.33
	T_3	-122.87	33.78	0.005**	-220.56	-25.17	-238.99	-6.74
	T_4	-105.28	33.78	0.027*	-202.97	-7.59	-221.40	10.84
	T_5	-87.70	33.78	0.105	-185.39	9.99	-203.82	28.43
T_1	T_0	158.03	33.78	0.000**	60.34	255.73	41.91	274.16
	T_2	17.58	33.78	0.995	-80.11	115.28	-98.54	133.71
	T_3	35.17	33.78	0.903	-62.52	132.86	-80.95	151.29
	T_4	52.75	33.78	0.625	-44.94	150.44	-63.37	168.88
	T_5	70.34	33.78	0.303	-27.35	168.03	-45.79	186.46
T_2	T_0	140.45	33.78	0.001**	42.76	238.14	24.33	256.57
	T_1	-17.58	33.78	0.995	-115.28	80.11	-133.71	98.54
	T_3	17.58	33.78	0.995	-80.11	115.28	-98.54	133.71
	T_4	35.17	33.78	0.903	-62.52	132.86	-80.95	151.29
	T_5	52.75	33.78	0.625	-44.94	150.44	-63.37	168.88
T_3	T_0	122.87	33.78	0.005**	25.17	220.56	6.74	238.99
	T_1	-35.17	33.78	0.903	-132.86	62.52	-151.29	80.95
	T_2	-17.58	33.78	0.995	-115.28	80.11	-133.71	98.54
	T_4	17.58	33.78	0.995	-80.11	115.28	-98.54	133.71
	T_5	35.17	33.78	0.903	-62.52	132.86	-80.95	151.29
T_4	T_0	105.28	33.78	0.027*	7.59	202.97	-10.84	221.40
	T_1	-52.75	33.78	0.625	-150.44	44.94	-168.88	63.37
	T_2	-35.17	33.78	0.903	-132.86	62.52	-151.29	80.95
	T_3	-17.58	33.78	0.995	-115.28	80.11	-133.71	98.54
	T_5	17.58	33.78	0.995	-80.11	115.28	-98.54	133.71
T_5	T_0	87.70	33.78	0.105	-9.99	185.39	-28.43	203.82
	T_1	-70.34	33.78	0.303	-168.03	27.35	-186.46	45.79
	T_2	-52.75	33.78	0.625	-150.44	44.94	-168.88	63.37
	T_3	-35.17	33.78	0.903	-132.86	62.52	-151.29	80.95
	T_4	-17.58	33.78	0.995	-115.28	80.11	-133.71	98.54

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.33 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured manganese (Mn) concentration levels of treatment water

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-7.07	2.15	0.016*	-13.29	-0.84	-14.47	0.34
	T_2	-7.39	2.15	0.010*	-13.62	-1.16	-14.79	0.02
	T_3	-7.71	2.15	0.006**	-13.94	-1.48	-15.12	-0.31
	T_4	-8.04	2.15	0.004**	-14.27	-1.81	-15.44	-0.63
	T_5	-8.36	2.15	0.002**	-14.59	-2.13	-15.76	-0.95
T_1	T_0	7.07	2.15	0.016*	0.84	13.29	-0.34	14.47
	T_2	-0.32	2.15	1.000	-6.55	5.91	-7.73	7.08
	T_3	-0.65	2.15	1.000	-6.88	5.58	-8.05	6.76
	T_4	-0.97	2.15	0.998	-7.20	5.26	-8.38	6.43
	T_5	-1.29	2.15	0.991	-7.52	4.93	-8.70	6.11
T_2	T_0	7.39	2.15	0.010*	1.16	13.62	-0.02	14.79
	T_1	0.32	2.15	1.000	-5.91	6.55	-7.08	7.73
	T_3	-0.32	2.15	1.000	-6.55	5.91	-7.73	7.08
	T_4	-0.65	2.15	1.000	-6.88	5.58	-8.05	6.76
	T_5	-0.97	2.15	0.998	-7.20	5.26	-8.37	6.43
T_3	T_0	7.71	2.15	0.006**	1.48	13.94	0.31	15.12
	T_1	0.65	2.15	1.000	-5.58	6.88	-6.76	8.05
	T_2	0.32	2.15	1.000	-5.91	6.55	-7.08	7.73
	T_4	-0.32	2.15	1.000	-6.55	5.91	-7.73	7.08
	T_5	-0.65	2.15	1.000	-6.88	5.58	-8.05	6.76
T_4	T_0	8.04	2.15	0.004**	1.81	14.27	0.63	15.44
	T_1	0.97	2.15	0.998	-5.26	7.20	-6.43	8.38
	T_2	0.65	2.15	1.000	-5.58	6.88	-6.76	8.05
	T_3	0.32	2.15	1.000	-5.91	6.55	-7.08	7.73
	T_5	-0.32	2.15	1.000	-6.55	5.91	-7.73	7.08
T_5	T_0	8.36	2.15	0.002**	2.13	14.59	0.95	15.76
	T_1	1.29	2.15	0.991	-4.93	7.52	-6.11	8.70
	T_2	0.97	2.15	0.998	-5.26	7.20	-6.43	8.37
	T_3	0.65	2.15	1.000	-5.58	6.88	-6.76	8.05
	T_4	0.32	2.15	1.000	-5.91	6.55	-7.08	7.73

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.34 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured lead (Pb) concentration levels of treatment water

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-72.42	22.13	0.017*	-136.43	-8.41	-148.51	3.66
	T_2	-66.16	22.13	0.038*	-130.17	-2.14	-142.24	9.93
	T_3	-59.89	22.13	0.081	-123.90	4.12	-135.98	16.20
	T_4	-53.62	22.13	0.156	-117.63	10.39	-129.71	22.47
	T_5	-47.35	22.13	0.274	-111.36	16.66	-123.44	28.73
T_1	T_0	72.42	22.13	0.017*	8.41	136.43	-3.66	148.51
	T_2	6.27	22.13	1.000	-57.74	70.28	-69.82	82.35
	T_3	12.54	22.13	0.993	-51.47	76.55	-63.55	88.62
	T_4	18.80	22.13	0.957	-45.21	82.81	-57.28	94.89
	T_5	25.07	22.13	0.867	-38.94	89.08	-51.02	101.16
T_2	T_0	66.16	22.13	0.038*	2.14	130.17	-9.93	142.24
	T_1	-6.27	22.13	1.000	-70.28	57.74	-82.35	69.82
	T_3	6.27	22.13	1.000	-57.74	70.28	-69.82	82.36
	T_4	12.54	22.13	0.993	-51.47	76.55	-63.55	88.62
	T_5	18.80	22.13	0.957	-45.21	82.81	-57.28	94.89
T_3	T_0	59.89	22.13	0.081	-4.12	123.90	-16.20	135.98
	T_1	-12.54	22.13	0.993	-76.55	51.47	-88.62	63.55
	T_2	-6.27	22.13	1.000	-70.28	57.74	-82.36	69.82
	T_4	6.27	22.13	1.000	-57.74	70.28	-69.82	82.36
	T_5	12.54	22.13	0.993	-51.47	76.55	-63.55	88.62
T_4	T_0	53.62	22.13	0.156	-10.39	117.63	-22.47	129.71
	T_1	-18.80	22.13	0.957	-82.81	45.21	-94.89	57.28
	T_2	-12.54	22.13	0.993	-76.55	51.47	-88.62	63.55
	T_3	-6.27	22.13	1.000	-70.28	57.74	-82.36	69.82
	T_5	6.27	22.13	1.000	-57.74	70.28	-69.82	82.35
T_5	T_0	47.35	22.13	0.274	-16.66	111.36	-28.73	123.44
	T_1	-25.07	22.13	0.867	-89.08	38.94	-101.16	51.02
	T_2	-18.80	22.13	0.957	-82.81	45.21	-94.89	57.28
	T_3	-12.54	22.13	0.993	-76.55	51.47	-88.62	63.55
	T_4	-6.27	22.13	1.000	-70.28	57.74	-82.35	69.82

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.35 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured vanadium (V) concentration levels of treatment water

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-5.18	0.38	0.000**	-6.29	-4.08	-6.49	-3.87
	T_2	-4.43	0.38	0.000**	-5.53	-3.33	-5.74	-3.12
	T_3	-3.67	0.38	0.000**	-4.77	-2.57	-4.98	-2.36
	T_4	-2.92	0.38	0.000**	-4.02	-1.81	-4.23	-1.60
	T_5	-2.16	0.38	0.000**	-3.26	-1.06	-3.47	-0.85
T_1	T_0	5.18	0.38	0.000**	4.08	6.29	3.87	6.49
	T_2	0.76	0.38	0.358	-0.35	1.86	-0.56	2.07
	T_3	1.51	0.38	0.002**	0.41	2.62	0.20	2.82
	T_4	2.27	0.38	0.000**	1.17	3.37	0.96	3.58
	T_5	3.02	0.38	0.000**	1.92	4.13	1.71	4.34
T_2	T_0	4.43	0.38	0.000**	3.33	5.53	3.12	5.74
	T_1	-0.76	0.38	0.358	-1.86	0.35	-2.07	0.56
	T_3	0.76	0.38	0.358	-0.35	1.86	-0.55	2.07
	T_4	1.51	0.38	0.002**	0.41	2.62	0.20	2.83
	T_5	2.27	0.38	0.000**	1.17	3.37	0.96	3.58
T_3	T_0	3.67	0.38	0.000**	2.57	4.77	2.36	4.98
	T_1	-1.51	0.38	0.002**	-2.62	-0.41	-2.82	-0.20
	T_2	-0.76	0.38	0.358	-1.86	0.35	-2.07	0.55
	T_4	0.76	0.38	0.358	-0.35	1.86	-0.55	2.07
	T_5	1.51	0.38	0.002**	0.41	2.62	0.20	2.82
T_4	T_0	2.92	0.38	0.000**	1.81	4.02	1.60	4.23
	T_1	-2.27	0.38	0.000**	-3.37	-1.17	-3.58	-0.96
	T_2	-1.51	0.38	0.002**	-2.62	-0.41	-2.83	-0.20
	T_3	-0.76	0.38	0.358	-1.86	0.35	-2.07	0.55
	T_5	0.76	0.38	0.358	-0.35	1.86	-0.56	2.07
T_5	T_0	2.16	0.38	0.000**	1.06	3.26	0.85	3.47
	T_1	-3.02	0.38	0.000**	-4.13	-1.92	-4.34	-1.71
	T_2	-2.27	0.38	0.000**	-3.37	-1.17	-3.58	-0.96
	T_3	-1.51	0.38	0.002**	-2.62	-0.41	-2.82	-0.20
	T_4	-0.76	0.38	0.358	-1.86	0.35	-2.07	0.56

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.36 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured zinc (Zn) concentration levels of treatment water

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-18.15	4.79	0.003**	-31.99	-4.30	-34.60	-1.69
	T_2	-16.63	4.79	0.009**	-30.47	-2.78	-33.09	-0.17
	T_3	-15.10	4.79	0.024*	-28.95	-1.26	-31.56	1.35
	T_4	-13.58	4.79	0.058	-27.43	0.26	-30.04	2.88
	T_5	-12.06	4.79	0.126	-25.91	1.79	-28.52	4.40
T_1	T_0	18.15	4.79	0.003**	4.30	31.99	1.69	34.60
	T_2	1.52	4.79	1.000	-12.32	15.37	-14.94	17.98
	T_3	3.04	4.79	0.988	-10.80	16.89	-13.42	19.50
	T_4	4.57	4.79	0.931	-9.28	18.41	-11.89	21.02
	T_5	6.09	4.79	0.800	-7.76	19.93	-10.37	22.54
T_2	T_0	16.63	4.79	0.009**	2.78	30.47	0.17	33.09
	T_1	-1.52	4.79	1.000	-15.37	12.32	-17.98	14.94
	T_3	1.52	4.79	1.000	-12.32	15.37	-14.93	17.98
	T_4	3.04	4.79	0.988	-10.80	16.89	-13.41	19.50
	T_5	4.57	4.79	0.931	-9.28	18.41	-11.89	21.03
T_3	T_0	15.10	4.79	0.024*	1.26	28.95	-1.35	31.56
	T_1	-3.04	4.79	0.988	-16.89	10.80	-19.50	13.42
	T_2	-1.52	4.79	1.000	-15.37	12.32	-17.98	14.93
	T_4	1.52	4.79	1.000	-12.32	15.37	-14.94	17.98
	T_5	3.04	4.79	0.988	-10.80	16.89	-13.41	19.50
T_4	T_0	13.58	4.79	0.058	-0.26	27.43	-2.88	30.04
	T_1	-4.57	4.79	0.931	-18.41	9.28	-21.02	11.89
	T_2	-3.04	4.79	0.988	-16.89	10.80	-19.50	13.41
	T_3	-1.52	4.79	1.000	-15.37	12.32	-17.98	14.94
	T_5	1.52	4.79	1.000	-12.32	15.37	-14.94	17.98
T_5	T_0	12.06	4.79	0.126	-1.79	25.91	-4.40	28.52
	T_1	-6.09	4.79	0.800	-19.93	7.76	-22.54	10.37
	T_2	-4.57	4.79	0.931	-18.41	9.28	-21.03	11.89
	T_3	-3.04	4.79	0.988	-16.89	10.80	-19.50	13.41
	T_4	-1.52	4.79	1.000	-15.37	12.32	-17.98	14.94

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.37 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured aluminum (Al) concentration levels of soil

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	103.66	251.99	0.998	-742.76	950.09	-983.47	1190.80
	T_2	535.93	251.99	0.336	-310.50	1382.36	-551.21	1623.07
	T_3	378.20	251.99	0.670	-468.22	1224.63	-708.93	1465.34
	T_4	242.18	251.99	0.922	-604.25	1088.61	-844.96	1329.32
	T_5	778.34	251.99	0.078	-68.09	1624.77	-308.80	1865.48
T_1	T_0	-103.66	251.99	0.998	-950.09	742.76	-1190.80	983.47
	T_2	432.27	251.99	0.547	-414.16	1278.69	-654.87	1519.41
	T_3	274.54	251.99	0.877	-571.89	1120.97	-812.60	1361.68
	T_4	138.51	251.99	0.993	-707.91	984.94	-948.62	1225.65
	T_5	674.68	251.99	0.151	-171.75	1521.10	-412.46	1761.81
T_2	T_0	-535.93	251.99	0.336	-1382.36	310.50	-1623.07	551.21
	T_1	-432.27	251.99	0.547	-1278.69	414.16	-1519.41	654.87
	T_3	-157.73	251.99	0.987	-1004.15	688.70	-1244.87	929.41
	T_4	-293.75	251.99	0.844	-1140.18	552.68	-1380.89	793.39
	T_5	242.41	251.99	0.922	-604.02	1088.84	-844.73	1329.55
T_3	T_0	-378.20	251.99	0.670	-1224.63	468.22	-1465.34	708.93
	T_1	-274.54	251.99	0.877	-1120.97	571.89	-1361.68	812.60
	T_2	157.73	251.99	0.987	-688.70	1004.15	-929.41	1244.87
	T_4	-136.02	251.99	0.993	-982.45	710.40	-1223.16	951.11
	T_5	400.14	251.99	0.620	-446.29	1246.56	-687.00	1487.28
T_4	T_0	-242.18	251.99	0.922	-1088.61	604.25	-1329.32	844.96
	T_1	-138.51	251.99	0.993	-984.94	707.91	-1225.65	948.62
	T_2	293.75	251.99	0.844	-552.68	1140.18	-793.39	1380.89
	T_3	136.02	251.99	0.993	-710.40	982.45	-951.11	1223.16
	T_5	536.16	251.99	0.336	-310.27	1382.59	-550.98	1623.30
T_5	T_0	-778.34	251.99	0.078	-1624.77	68.09	-1865.48	308.80
	T_1	-674.68	251.99	0.151	-1521.10	171.75	-1761.81	412.46
	T_2	-242.41	251.99	0.922	-1088.84	604.02	-1329.55	844.73
	T_3	-400.14	251.99	0.620	-1246.56	446.29	-1487.28	687.00
	T_4	-536.16	251.99	0.336	-1382.59	310.27	-1623.30	550.98

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.38 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured arsenic (As) concentration levels of soil

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.812	1.676	0.996	-6.44	4.82	-8.04	6.42
	T_2	-1.333	1.676	0.963	-6.96	4.30	-8.56	5.90
	T_3	-0.792	1.676	0.996	-6.42	4.84	-8.02	6.44
	T_4	-0.028	1.676	1.000	-5.66	5.60	-7.26	7.20
	T_5	0.227	1.676	1.000	-5.40	5.86	-7.00	7.46
T_1	T_0	0.812	1.676	0.996	-4.82	6.44	-6.42	8.04
	T_2	-0.521	1.676	1.000	-6.15	5.11	-7.75	6.71
	T_3	0.020	1.676	1.000	-5.61	5.65	-7.21	7.25
	T_4	0.785	1.676	0.996	-4.85	6.42	-6.45	8.02
	T_5	1.039	1.676	0.987	-4.59	6.67	-6.19	8.27
T_2	T_0	1.333	1.676	0.963	-4.30	6.96	-5.90	8.56
	T_1	0.521	1.676	1.000	-5.11	6.15	-6.71	7.75
	T_3	0.541	1.676	0.999	-5.09	6.17	-6.69	7.77
	T_4	1.305	1.676	0.966	-4.32	6.94	-5.93	8.54
	T_5	1.560	1.676	0.931	-4.07	7.19	-5.67	8.79
T_3	T_0	0.792	1.676	0.996	-4.84	6.42	-6.44	8.02
	T_1	-0.020	1.676	1.000	-5.65	5.61	-7.25	7.21
	T_2	-0.541	1.676	0.999	-6.17	5.09	-7.77	6.69
	T_4	0.765	1.676	0.997	-4.87	6.39	-6.47	8.00
	T_5	1.019	1.676	0.988	-4.61	6.65	-6.21	8.25
T_4	T_0	0.028	1.676	1.000	-5.60	5.66	-7.20	7.26
	T_1	-0.785	1.676	0.996	-6.42	4.85	-8.02	6.45
	T_2	-1.305	1.676	0.966	-6.94	4.32	-8.54	5.93
	T_3	-0.765	1.676	0.997	-6.39	4.87	-8.00	6.47
	T_5	0.254	1.676	1.000	-5.38	5.88	-6.98	7.49
T_5	T_0	-0.227	1.676	1.000	-5.86	5.40	-7.46	7.00
	T_1	-1.039	1.676	0.987	-6.67	4.59	-8.27	6.19
	T_2	-1.560	1.676	0.931	-7.19	4.07	-8.79	5.67
	T_3	-1.019	1.676	0.988	-6.65	4.61	-8.25	6.21
	T_4	-0.254	1.676	1.000	-5.88	5.38	-7.49	6.98

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.39 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured beryllium (Be) concentration levels of soil

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	0.058	0.036	0.591	-0.06	0.18	-0.10	0.21
	T_2	0.109	0.036	0.082	-0.01	0.23	-0.04	0.26
	T_3	0.104	0.036	0.103	-0.02	0.22	-0.05	0.26
	T_4	0.100	0.036	0.120	-0.02	0.22	-0.05	0.25
	T_5	0.158	0.036	0.008**	0.04	0.28	0.00	0.31
T_1	T_0	-0.058	0.036	0.591	-0.18	0.06	-0.21	0.10
	T_2	0.050	0.036	0.717	-0.07	0.17	-0.10	0.20
	T_3	0.046	0.036	0.789	-0.07	0.17	-0.11	0.20
	T_4	0.042	0.036	0.836	-0.08	0.16	-0.11	0.20
	T_5	0.099	0.036	0.126	-0.02	0.22	-0.05	0.25
T_2	T_0	-0.109	0.036	0.082	-0.23	0.01	-0.26	0.04
	T_1	-0.050	0.036	0.717	-0.17	0.07	-0.20	0.10
	T_3	-0.005	0.036	1.000	-0.12	0.11	-0.16	0.15
	T_4	-0.008	0.036	1.000	-0.13	0.11	-0.16	0.15
	T_5	0.049	0.036	0.739	-0.07	0.17	-0.10	0.20
T_3	T_0	-0.104	0.036	0.103	-0.22	0.02	-0.26	0.05
	T_1	-0.046	0.036	0.789	-0.17	0.07	-0.20	0.11
	T_2	0.005	0.036	1.000	-0.11	0.12	-0.15	0.16
	T_4	-0.003	0.036	1.000	-0.12	0.12	-0.16	0.15
	T_5	0.054	0.036	0.663	-0.07	0.17	-0.10	0.21
T_4	T_0	-0.100	0.036	0.120	-0.22	0.02	-0.25	0.05
	T_1	-0.042	0.036	0.836	-0.16	0.08	-0.20	0.11
	T_2	0.008	0.036	1.000	-0.11	0.13	-0.15	0.16
	T_3	0.003	0.036	1.000	-0.12	0.12	-0.15	0.16
	T_5	0.057	0.036	0.607	-0.06	0.18	-0.10	0.21
T_5	T_0	-0.158	0.036	0.008**	-0.28	-0.04	-0.31	0.00
	T_1	-0.099	0.036	0.126	-0.22	0.02	-0.25	0.05
	T_2	-0.049	0.036	0.739	-0.17	0.07	-0.20	0.10
	T_3	-0.054	0.036	0.663	-0.17	0.07	-0.21	0.10
	T_4	-0.057	0.036	0.607	-0.18	0.06	-0.21	0.10

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.40 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured cadmium (Cd) concentration levels of soil

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.479	0.286	0.571	-1.44	0.48	-1.71	0.76
	T_2	-0.277	0.286	0.920	-1.24	0.68	-1.51	0.96
	T_3	-0.033	0.286	1.000	-0.99	0.93	-1.27	1.20
	T_4	-0.127	0.286	0.997	-1.09	0.83	-1.36	1.11
	T_5	0.295	0.286	0.898	-0.67	1.26	-0.94	1.53
T_1	T_0	0.479	0.286	0.571	-0.48	1.44	-0.76	1.71
	T_2	0.202	0.286	0.978	-0.76	1.16	-1.03	1.44
	T_3	0.446	0.286	0.638	-0.52	1.41	-0.79	1.68
	T_4	0.352	0.286	0.814	-0.61	1.31	-0.88	1.59
	T_5	0.774	0.286	0.145	-0.19	1.74	-0.46	2.01
T_2	T_0	0.277	0.286	0.920	-0.68	1.24	-0.96	1.51
	T_1	-0.202	0.286	0.978	-1.16	0.76	-1.44	1.03
	T_3	0.243	0.286	0.951	-0.72	1.20	-0.99	1.48
	T_4	0.150	0.286	0.994	-0.81	1.11	-1.08	1.38
	T_5	0.572	0.286	0.396	-0.39	1.53	-0.66	1.81
T_3	T_0	0.033	0.286	1.000	-0.93	0.99	-1.20	1.27
	T_1	-0.446	0.286	0.638	-1.41	0.52	-1.68	0.79
	T_2	-0.243	0.286	0.951	-1.20	0.72	-1.48	0.99
	T_4	-0.093	0.286	0.999	-1.05	0.87	-1.33	1.14
	T_5	0.329	0.286	0.852	-0.63	1.29	-0.91	1.56
T_4	T_0	0.127	0.286	0.997	-0.83	1.09	-1.11	1.36
	T_1	-0.352	0.286	0.814	-1.31	0.61	-1.59	0.88
	T_2	-0.150	0.286	0.994	-1.11	0.81	-1.38	1.08
	T_3	0.093	0.286	0.999	-0.87	1.05	-1.14	1.33
	T_5	0.422	0.286	0.685	-0.54	1.38	-0.81	1.66
T_5	T_0	-0.295	0.286	0.898	-1.26	0.67	-1.53	0.94
	T_1	-0.774	0.286	0.145	-1.74	0.19	-2.01	0.46
	T_2	-0.572	0.286	0.396	-1.53	0.39	-1.81	0.66
	T_3	-0.329	0.286	0.852	-1.29	0.63	-1.56	0.91
	T_4	-0.422	0.286	0.685	-1.38	0.54	-1.66	0.81

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.41 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured cobalt (Co) concentration levels of soil

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	0.441	0.807	0.993	-2.27	3.15	-3.04	3.92
	T_2	1.659	0.807	0.369	-1.05	4.37	-1.82	5.14
	T_3	1.178	0.807	0.693	-1.53	3.89	-2.30	4.66
	T_4	0.907	0.807	0.863	-1.80	3.62	-2.57	4.39
	T_5	2.372	0.807	0.100	-0.34	5.08	-1.11	5.85
T_1	T_0	-0.441	0.807	0.993	-3.15	2.27	-3.92	3.04
	T_2	1.218	0.807	0.666	-1.49	3.93	-2.26	4.70
	T_3	0.737	0.807	0.936	-1.97	3.45	-2.74	4.22
	T_4	0.465	0.807	0.991	-2.24	3.18	-3.02	3.95
	T_5	1.931	0.807	0.232	-0.78	4.64	-1.55	5.41
T_2	T_0	-1.659	0.807	0.369	-4.37	1.05	-5.14	1.82
	T_1	-1.218	0.807	0.666	-3.93	1.49	-4.70	2.26
	T_3	-0.481	0.807	0.989	-3.19	2.23	-3.96	3.00
	T_4	-0.752	0.807	0.930	-3.46	1.96	-4.23	2.73
	T_5	0.713	0.807	0.943	-2.00	3.42	-2.77	4.19
T_3	T_0	-1.178	0.807	0.693	-3.89	1.53	-4.66	2.30
	T_1	-0.737	0.807	0.936	-3.45	1.97	-4.22	2.74
	T_2	0.481	0.807	0.989	-2.23	3.19	-3.00	3.96
	T_4	-0.271	0.807	0.999	-2.98	2.44	-3.75	3.21
	T_5	1.194	0.807	0.682	-1.52	3.90	-2.29	4.67
T_4	T_0	-0.907	0.807	0.863	-3.62	1.80	-4.39	2.57
	T_1	-0.465	0.807	0.991	-3.18	2.24	-3.95	3.02
	T_2	0.752	0.807	0.930	-1.96	3.46	-2.73	4.23
	T_3	0.271	0.807	0.999	-2.44	2.98	-3.21	3.75
	T_5	1.466	0.807	0.491	-1.24	4.18	-2.01	4.95
T_5	T_0	-2.372	0.807	0.100	-5.08	0.34	-5.85	1.11
	T_1	-1.931	0.807	0.232	-4.64	0.78	-5.41	1.55
	T_2	-0.713	0.807	0.943	-3.42	2.00	-4.19	2.77
	T_3	-1.194	0.807	0.682	-3.90	1.52	-4.67	2.29
	T_4	-1.466	0.807	0.491	-4.18	1.24	-4.95	2.01

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.42 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured chromium (Cr) concentration levels of soil

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.705	4.055	1.000	-14.32	12.91	-18.20	16.79
	T_2	-0.005	4.055	1.000	-13.62	13.61	-17.50	17.49
	T_3	-1.465	4.055	0.999	-15.08	12.15	-18.96	16.03
	T_4	-3.497	4.055	0.949	-17.12	10.12	-20.99	14.00
	T_5	0.070	4.055	1.000	-13.55	13.69	-17.42	17.56
T_1	T_0	0.705	4.055	1.000	-12.91	14.32	-16.79	18.20
	T_2	0.700	4.055	1.000	-12.92	14.32	-16.79	18.19
	T_3	-0.760	4.055	1.000	-14.38	12.86	-18.25	16.73
	T_4	-2.792	4.055	0.980	-16.41	10.83	-20.28	14.70
	T_5	0.776	4.055	1.000	-12.84	14.39	-16.72	18.27
T_2	T_0	0.005	4.055	1.000	-13.61	13.62	-17.49	17.50
	T_1	-0.700	4.055	1.000	-14.32	12.92	-18.19	16.79
	T_3	-1.460	4.055	0.999	-15.08	12.16	-18.95	16.03
	T_4	-3.492	4.055	0.949	-17.11	10.13	-20.98	14.00
	T_5	0.075	4.055	1.000	-13.54	13.69	-17.42	17.57
T_3	T_0	1.465	4.055	0.999	-12.15	15.08	-16.03	18.96
	T_1	0.760	4.055	1.000	-12.86	14.38	-16.73	18.25
	T_2	1.460	4.055	0.999	-12.16	15.08	-16.03	18.95
	T_4	-2.032	4.055	0.995	-15.65	11.59	-19.52	15.46
	T_5	1.535	4.055	0.999	-12.08	15.15	-15.96	19.03
T_4	T_0	3.497	4.055	0.949	-10.12	17.12	-14.00	20.99
	T_1	2.792	4.055	0.980	-10.83	16.41	-14.70	20.28
	T_2	3.492	4.055	0.949	-10.13	17.11	-14.00	20.98
	T_3	2.032	4.055	0.995	-11.59	15.65	-15.46	19.52
	T_5	3.567	4.055	0.944	-10.05	17.19	-13.92	21.06
T_5	T_0	-0.070	4.055	1.000	-13.69	13.55	-17.56	17.42
	T_1	-0.776	4.055	1.000	-14.39	12.84	-18.27	16.72
	T_2	-0.075	4.055	1.000	-13.69	13.54	-17.57	17.42
	T_3	-1.535	4.055	0.999	-15.15	12.08	-19.03	15.96
	T_4	-3.567	4.055	0.944	-17.19	10.05	-21.06	13.92

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.43 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured copper (Cu) concentration levels of soil

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-520.08	691.66	0.971	-2843.31	1803.16	-3504.01	2463.85
	T_2	209.74	691.66	1.000	-2113.49	2532.97	-2774.19	3193.67
	T_3	216.00	691.66	0.999	-2107.23	2539.24	-2767.92	3199.93
	T_4	-163.01	691.66	1.000	-2486.24	2160.22	-3146.94	2820.92
	T_5	970.24	691.66	0.725	-1352.99	3293.48	-2013.68	3954.17
T_1	T_0	520.08	691.66	0.971	-1803.16	2843.31	-2463.85	3504.01
	T_2	729.82	691.66	0.890	-1593.42	3053.05	-2254.11	3713.75
	T_3	736.08	691.66	0.886	-1587.15	3059.32	-2247.84	3720.01
	T_4	357.07	691.66	0.994	-1966.17	2680.30	-2626.86	3341.00
	T_5	1490.32	691.66	0.324	-832.91	3813.56	-1493.61	4474.25
T_2	T_0	-209.74	691.66	1.000	-2532.97	2113.49	-3193.67	2774.19
	T_1	-729.82	691.66	0.890	-3053.05	1593.42	-3713.75	2254.11
	T_3	6.26	691.66	1.000	-2316.97	2329.50	-2977.66	2990.19
	T_4	-372.75	691.66	0.993	-2695.98	1950.48	-3356.68	2611.18
	T_5	760.50	691.66	0.872	-1562.73	3083.74	-2223.42	3744.43
T_3	T_0	-216.00	691.66	0.999	-2539.24	2107.23	-3199.93	2767.92
	T_1	-736.08	691.66	0.886	-3059.32	1587.15	-3720.01	2247.84
	T_2	-6.26	691.66	1.000	-2329.50	2316.97	-2990.19	2977.66
	T_4	-379.01	691.66	0.993	-2702.25	1944.22	-3362.94	2604.91
	T_5	754.24	691.66	0.876	-1568.99	3077.47	-2229.69	3738.17
T_4	T_0	163.01	691.66	1.000	-2160.22	2486.24	-2820.92	3146.94
	T_1	-357.07	691.66	0.994	-2680.30	1966.17	-3341.00	2626.86
	T_2	372.75	691.66	0.993	-1950.48	2695.98	-2611.18	3356.68
	T_3	379.01	691.66	0.993	-1944.22	2702.25	-2604.91	3362.94
	T_5	1133.25	691.66	0.591	-1189.98	3456.49	-1850.67	4117.18
T_5	T_0	-970.24	691.66	0.725	-3293.48	1352.99	-3954.17	2013.68
	T_1	-1490.32	691.66	0.324	-3813.56	832.91	-4474.25	1493.61
	T_2	-760.50	691.66	0.872	-3083.74	1562.73	-3744.43	2223.42
	T_3	-754.24	691.66	0.876	-3077.47	1568.99	-3738.17	2229.69
	T_4	-1133.25	691.66	0.591	-3456.49	1189.98	-4117.18	1850.67

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.44 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured iron (Fe) concentration levels of soil

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-39.370	17.136	0.266	-96.93	18.19	-113.30	34.56
	T_2	-32.907	17.136	0.436	-90.47	24.65	-106.84	41.02
	T_3	-15.046	17.136	0.945	-72.61	42.51	-88.97	58.88
	T_4	-28.088	17.136	0.591	-85.65	29.47	-102.02	45.84
	T_5	-4.838	17.136	1.000	-62.40	52.72	-78.77	69.09
T_1	T_0	39.370	17.136	0.266	-18.19	96.93	-34.56	113.30
	T_2	6.462	17.136	0.999	-51.10	64.02	-67.47	80.39
	T_3	24.324	17.136	0.716	-33.24	81.88	-49.60	98.25
	T_4	11.281	17.136	0.983	-46.28	68.84	-62.65	85.21
	T_5	34.532	17.136	0.388	-23.03	92.09	-39.40	108.46
T_2	T_0	32.907	17.136	0.436	-24.65	90.47	-41.02	106.84
	T_1	-6.462	17.136	0.999	-64.02	51.10	-80.39	67.47
	T_3	17.862	17.136	0.894	-39.70	75.42	-56.07	91.79
	T_4	4.819	17.136	1.000	-52.74	62.38	-69.11	78.75
	T_5	28.069	17.136	0.592	-29.49	85.63	-45.86	102.00
T_3	T_0	15.046	17.136	0.945	-42.51	72.61	-58.88	88.97
	T_1	-24.324	17.136	0.716	-81.88	33.24	-98.25	49.60
	T_2	-17.862	17.136	0.894	-75.42	39.70	-91.79	56.07
	T_4	-13.042	17.136	0.969	-70.60	44.52	-86.97	60.89
	T_5	10.208	17.136	0.989	-47.35	67.77	-63.72	84.14
T_4	T_0	28.088	17.136	0.591	-29.47	85.65	-45.84	102.02
	T_1	-11.281	17.136	0.983	-68.84	46.28	-85.21	62.65
	T_2	-4.819	17.136	1.000	-62.38	52.74	-78.75	69.11
	T_3	13.042	17.136	0.969	-44.52	70.60	-60.89	86.97
	T_5	23.250	17.136	0.750	-34.31	80.81	-50.68	97.18
T_5	T_0	4.838	17.136	1.000	-52.72	62.40	-69.09	78.77
	T_1	-34.532	17.136	0.388	-92.09	23.03	-108.46	39.40
	T_2	-28.069	17.136	0.592	-85.63	29.49	-102.00	45.86
	T_3	-10.208	17.136	0.989	-67.77	47.35	-84.14	63.72
	T_4	-23.250	17.136	0.750	-80.81	34.31	-97.18	50.68

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.45 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured manganese (Mn) concentration levels of soil

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-1.010	0.711	0.716	-3.40	1.38	-4.08	2.06
	T_2	-0.828	0.711	0.845	-3.22	1.56	-3.90	2.24
	T_3	-0.092	0.711	1.000	-2.48	2.30	-3.16	2.98
	T_4	-0.063	0.711	1.000	-2.45	2.33	-3.13	3.01
	T_5	1.028	0.711	0.702	-1.36	3.42	-2.04	4.10
T_1	T_0	1.010	0.711	0.716	-1.38	3.40	-2.06	4.08
	T_2	0.181	0.711	1.000	-2.21	2.57	-2.89	3.25
	T_3	0.918	0.711	0.785	-1.47	3.31	-2.15	3.99
	T_4	0.946	0.711	0.764	-1.44	3.34	-2.12	4.02
	T_5	2.037	0.711	0.113	-0.35	4.43	-1.03	5.11
T_2	T_0	0.828	0.711	0.845	-1.56	3.22	-2.24	3.90
	T_1	-0.181	0.711	1.000	-2.57	2.21	-3.25	2.89
	T_3	0.736	0.711	0.897	-1.65	3.13	-2.33	3.81
	T_4	0.765	0.711	0.882	-1.62	3.15	-2.30	3.83
	T_5	1.856	0.711	0.168	-0.53	4.25	-1.21	4.93
T_3	T_0	0.092	0.711	1.000	-2.30	2.48	-2.98	3.16
	T_1	-0.918	0.711	0.785	-3.31	1.47	-3.99	2.15
	T_2	-0.736	0.711	0.897	-3.13	1.65	-3.81	2.33
	T_4	0.029	0.711	1.000	-2.36	2.42	-3.04	3.10
	T_5	1.120	0.711	0.629	-1.27	3.51	-1.95	4.19
T_4	T_0	0.063	0.711	1.000	-2.33	2.45	-3.01	3.13
	T_1	-0.946	0.711	0.764	-3.34	1.44	-4.02	2.12
	T_2	-0.765	0.711	0.882	-3.15	1.62	-3.83	2.30
	T_3	-0.029	0.711	1.000	-2.42	2.36	-3.10	3.04
	T_5	1.091	0.711	0.652	-1.30	3.48	-1.98	4.16
T_5	T_0	-1.028	0.711	0.702	-3.42	1.36	-4.10	2.04
	T_1	-2.037	0.711	0.113	-4.43	0.35	-5.11	1.03
	T_2	-1.856	0.711	0.168	-4.25	0.53	-4.93	1.21
	T_3	-1.120	0.711	0.629	-3.51	1.27	-4.19	1.95
	T_4	-1.091	0.711	0.652	-3.48	1.30	-4.16	1.98

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.46 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured nickel (Ni) concentration levels of soil

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-1.196	6.847	1.000	-24.19	21.80	-30.73	28.34
	T_2	-3.605	6.847	0.994	-26.60	19.39	-33.14	25.93
	T_3	-1.403	6.847	1.000	-24.40	21.60	-30.94	28.14
	T_4	-1.642	6.847	1.000	-24.64	21.36	-31.18	27.90
	T_5	0.738	6.847	1.000	-22.26	23.74	-28.80	30.28
T_1	T_0	1.196	6.847	1.000	-21.80	24.19	-28.34	30.73
	T_2	-2.410	6.847	0.999	-25.41	20.59	-31.95	27.13
	T_3	-0.207	6.847	1.000	-23.21	22.79	-29.75	29.33
	T_4	-0.446	6.847	1.000	-23.44	22.55	-29.98	29.09
	T_5	1.933	6.847	1.000	-21.06	24.93	-27.61	31.47
T_2	T_0	3.605	6.847	0.994	-19.39	26.60	-25.93	33.14
	T_1	2.410	6.847	0.999	-20.59	25.41	-27.13	31.95
	T_3	2.202	6.847	0.999	-20.80	25.20	-27.34	31.74
	T_4	1.964	6.847	1.000	-21.03	24.96	-27.57	31.50
	T_5	4.343	6.847	0.986	-18.66	27.34	-25.20	33.88
T_3	T_0	1.403	6.847	1.000	-21.60	24.40	-28.14	30.94
	T_1	0.207	6.847	1.000	-22.79	23.21	-29.33	29.75
	T_2	-2.202	6.847	0.999	-25.20	20.80	-31.74	27.34
	T_4	-0.239	6.847	1.000	-23.24	22.76	-29.78	29.30
	T_5	2.141	6.847	0.999	-20.86	25.14	-27.40	31.68
T_4	T_0	1.642	6.847	1.000	-21.36	24.64	-27.90	31.18
	T_1	0.446	6.847	1.000	-22.55	23.44	-29.09	29.98
	T_2	-1.964	6.847	1.000	-24.96	21.03	-31.50	27.57
	T_3	0.239	6.847	1.000	-22.76	23.24	-29.30	29.78
	T_5	2.379	6.847	0.999	-20.62	25.38	-27.16	31.92
T_5	T_0	-0.738	6.847	1.000	-23.74	22.26	-30.28	28.80
	T_1	-1.933	6.847	1.000	-24.93	21.06	-31.47	27.61
	T_2	-4.343	6.847	0.986	-27.34	18.66	-33.88	25.20
	T_3	-2.141	6.847	0.999	-25.14	20.86	-31.68	27.40
	T_4	-2.379	6.847	0.999	-25.38	20.62	-31.92	27.16

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.47 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured lead (Pb) concentration levels of soil

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	0.030	0.087	0.999	-0.26	0.32	-0.34	0.40
	T_2	0.020	0.087	1.000	-0.27	0.31	-0.35	0.39
	T_3	0.000	0.087	1.000	-0.29	0.29	-0.37	0.37
	T_4	0.020	0.087	1.000	-0.27	0.31	-0.35	0.39
	T_5	0.030	0.087	0.999	-0.26	0.32	-0.34	0.40
T_1	T_0	-0.030	0.087	0.999	-0.32	0.26	-0.40	0.34
	T_2	-0.010	0.087	1.000	-0.30	0.28	-0.38	0.36
	T_3	-0.030	0.087	0.999	-0.32	0.26	-0.40	0.34
	T_4	-0.010	0.087	1.000	-0.30	0.28	-0.38	0.36
	T_5	0.000	0.087	1.000	-0.29	0.29	-0.37	0.37
T_2	T_0	-0.020	0.087	1.000	-0.31	0.27	-0.39	0.35
	T_1	0.010	0.087	1.000	-0.28	0.30	-0.36	0.38
	T_3	-0.020	0.087	1.000	-0.31	0.27	-0.39	0.35
	T_4	0.000	0.087	1.000	-0.29	0.29	-0.37	0.37
	T_5	0.009	0.087	1.000	-0.28	0.30	-0.36	0.38
T_3	T_0	0.000	0.087	1.000	-0.29	0.29	-0.37	0.37
	T_1	0.030	0.087	0.999	-0.26	0.32	-0.34	0.40
	T_2	0.020	0.087	1.000	-0.27	0.31	-0.35	0.39
	T_4	0.020	0.087	1.000	-0.27	0.31	-0.35	0.39
	T_5	0.029	0.087	0.999	-0.26	0.32	-0.34	0.40
T_4	T_0	-0.020	0.087	1.000	-0.31	0.27	-0.39	0.35
	T_1	0.010	0.087	1.000	-0.28	0.30	-0.36	0.38
	T_2	0.000	0.087	1.000	-0.29	0.29	-0.37	0.37
	T_3	-0.020	0.087	1.000	-0.31	0.27	-0.39	0.35
	T_5	0.010	0.087	1.000	-0.28	0.30	-0.36	0.38
T_5	T_0	-0.030	0.087	0.999	-0.32	0.26	-0.40	0.34
	T_1	0.000	0.087	1.000	-0.29	0.29	-0.37	0.37
	T_2	-0.009	0.087	1.000	-0.30	0.28	-0.38	0.36
	T_3	-0.029	0.087	0.999	-0.32	0.26	-0.40	0.34
	T_4	-0.010	0.087	1.000	-0.30	0.28	-0.38	0.36

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.48 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured selenium (Se) concentration levels of soil

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	0.466	1.033	0.997	-3.00	3.94	-3.99	4.92
	T_2	1.873	1.033	0.493	-1.60	5.34	-2.58	6.33
	T_3	1.889	1.033	0.485	-1.58	5.36	-2.57	6.34
	T_4	1.324	1.033	0.789	-2.15	4.79	-3.13	5.78
	T_5	2.875	1.033	0.128	-0.59	6.34	-1.58	7.33
T_1	T_0	-0.466	1.033	0.997	-3.94	3.00	-4.92	3.99
	T_2	1.407	1.033	0.747	-2.06	4.88	-3.05	5.86
	T_3	1.423	1.033	0.739	-2.05	4.89	-3.03	5.88
	T_4	0.858	1.033	0.956	-2.61	4.33	-3.60	5.31
	T_5	2.409	1.033	0.254	-1.06	5.88	-2.05	6.87
T_2	T_0	-1.873	1.033	0.493	-5.34	1.60	-6.33	2.58
	T_1	-1.407	1.033	0.747	-4.88	2.06	-5.86	3.05
	T_3	0.016	1.033	1.000	-3.45	3.49	-4.44	4.47
	T_4	-0.549	1.033	0.994	-4.02	2.92	-5.00	3.91
	T_5	1.002	1.033	0.919	-2.47	4.47	-3.45	5.46
T_3	T_0	-1.889	1.033	0.485	-5.36	1.58	-6.34	2.57
	T_1	-1.423	1.033	0.739	-4.89	2.05	-5.88	3.03
	T_2	-0.016	1.033	1.000	-3.49	3.45	-4.47	4.44
	T_4	-0.565	1.033	0.993	-4.03	2.91	-5.02	3.89
	T_5	0.986	1.033	0.924	-2.48	4.46	-3.47	5.44
T_4	T_0	-1.324	1.033	0.789	-4.79	2.15	-5.78	3.13
	T_1	-0.858	1.033	0.956	-4.33	2.61	-5.31	3.60
	T_2	0.549	1.033	0.994	-2.92	4.02	-3.91	5.00
	T_3	0.565	1.033	0.993	-2.91	4.03	-3.89	5.02
	T_5	1.551	1.033	0.670	-1.92	5.02	-2.91	6.01
T_5	T_0	-2.875	1.033	0.128	-6.34	0.59	-7.33	1.58
	T_1	-2.409	1.033	0.254	-5.88	1.06	-6.87	2.05
	T_2	-1.002	1.033	0.919	-4.47	2.47	-5.46	3.45
	T_3	-0.986	1.033	0.924	-4.46	2.48	-5.44	3.47
	T_4	-1.551	1.033	0.670	-5.02	1.92	-6.01	2.91

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.49 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured vanadium (V) concentration levels of soil

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.845	2.422	0.999	-8.98	7.29	-11.29	9.60
	T_2	-3.682	2.422	0.659	-11.82	4.45	-14.13	6.77
	T_3	-0.155	2.422	1.000	-8.29	7.98	-10.60	10.29
	T_4	-1.248	2.422	0.994	-9.38	6.89	-11.70	9.20
	T_5	3.665	2.422	0.663	-4.47	11.80	-6.78	14.11
T_1	T_0	0.845	2.422	0.999	-7.29	8.98	-9.60	11.29
	T_2	-2.837	2.422	0.842	-10.97	5.30	-13.29	7.61
	T_3	0.690	2.422	1.000	-7.45	8.82	-9.76	11.14
	T_4	-0.404	2.422	1.000	-8.54	7.73	-10.85	10.05
	T_5	4.510	2.422	0.466	-3.63	12.65	-5.94	14.96
T_2	T_0	3.682	2.422	0.659	-4.45	11.82	-6.77	14.13
	T_1	2.837	2.422	0.842	-5.30	10.97	-7.61	13.29
	T_3	3.527	2.422	0.696	-4.61	11.66	-6.92	13.98
	T_4	2.434	2.422	0.908	-5.70	10.57	-8.02	12.88
	T_5	7.347	2.422	0.086	-0.79	15.48	-3.10	17.80
T_3	T_0	0.155	2.422	1.000	-7.98	8.29	-10.29	10.60
	T_1	-0.690	2.422	1.000	-8.82	7.45	-11.14	9.76
	T_2	-3.527	2.422	0.696	-11.66	4.61	-13.98	6.92
	T_4	-1.093	2.422	0.997	-9.23	7.04	-11.54	9.36
	T_5	3.820	2.422	0.626	-4.31	11.96	-6.63	14.27
T_4	T_0	1.248	2.422	0.994	-6.89	9.38	-9.20	11.70
	T_1	0.404	2.422	1.000	-7.73	8.54	-10.05	10.85
	T_2	-2.434	2.422	0.908	-10.57	5.70	-12.88	8.02
	T_3	1.093	2.422	0.997	-7.04	9.23	-9.36	11.54
	T_5	4.914	2.422	0.382	-3.22	13.05	-5.54	15.36
T_5	T_0	-3.665	2.422	0.663	-11.80	4.47	-14.11	6.78
	T_1	-4.510	2.422	0.466	-12.65	3.63	-14.96	5.94
	T_2	-7.347	2.422	0.086	-15.48	0.79	-17.80	3.10
	T_3	-3.820	2.422	0.626	-11.96	4.31	-14.27	6.63
	T_4	-4.914	2.422	0.382	-13.05	3.22	-15.36	5.54

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.50 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured zinc (Zn) concentration levels of soil

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.005	0.005	0.888	-0.02	0.01	-0.03	0.02
	T_2	0.003	0.005	0.993	-0.01	0.02	-0.02	0.02
	T_3	-0.004	0.005	0.962	-0.02	0.01	-0.02	0.02
	T_4	-0.003	0.005	0.988	-0.02	0.01	-0.02	0.02
	T_5	-0.001	0.005	1.000	-0.02	0.01	-0.02	0.02
T_1	T_0	0.005	0.005	0.888	-0.01	0.02	-0.02	0.03
	T_2	0.008	0.005	0.612	-0.01	0.02	-0.01	0.03
	T_3	0.001	0.005	1.000	-0.01	0.02	-0.02	0.02
	T_4	0.002	0.005	0.997	-0.01	0.02	-0.02	0.02
	T_5	0.004	0.005	0.950	-0.01	0.02	-0.02	0.02
T_2	T_0	-0.003	0.005	0.993	-0.02	0.01	-0.02	0.02
	T_1	-0.008	0.005	0.612	-0.02	0.01	-0.03	0.01
	T_3	-0.006	0.005	0.756	-0.02	0.01	-0.03	0.01
	T_4	-0.005	0.005	0.848	-0.02	0.01	-0.03	0.01
	T_5	-0.004	0.005	0.971	-0.02	0.01	-0.02	0.02
T_3	T_0	0.004	0.005	0.962	-0.01	0.02	-0.02	0.02
	T_1	-0.001	0.005	1.000	-0.02	0.01	-0.02	0.02
	T_2	0.006	0.005	0.756	-0.01	0.02	-0.01	0.03
	T_4	0.001	0.005	1.000	-0.01	0.02	-0.02	0.02
	T_5	0.003	0.005	0.989	-0.01	0.02	-0.02	0.02
T_4	T_0	0.003	0.005	0.988	-0.01	0.02	-0.02	0.02
	T_1	-0.002	0.005	0.997	-0.02	0.01	-0.02	0.02
	T_2	0.005	0.005	0.848	-0.01	0.02	-0.01	0.03
	T_3	-0.001	0.005	1.000	-0.02	0.01	-0.02	0.02
	T_5	0.002	0.005	0.998	-0.01	0.02	-0.02	0.02
T_5	T_0	0.001	0.005	1.000	-0.01	0.02	-0.02	0.02
	T_1	-0.004	0.005	0.950	-0.02	0.01	-0.02	0.02
	T_2	0.004	0.005	0.971	-0.01	0.02	-0.02	0.02
	T_3	-0.003	0.005	0.989	-0.02	0.01	-0.02	0.02
	T_4	-0.002	0.005	0.998	-0.02	0.01	-0.02	0.02

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.51 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured aluminum (Al) concentration levels of whole plant

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	0.178	10.688	1.000	-35.72	36.08	-45.93	46.29
	T_2	11.592	10.688	0.878	-24.31	47.49	-34.52	57.70
	T_3	-9.860	10.688	0.933	-45.76	26.04	-55.97	36.25
	T_4	-18.477	10.688	0.540	-54.38	17.42	-64.59	27.63
	T_5	-33.695	10.688	0.070	-69.60	2.20	-79.80	12.41
T_1	T_0	-0.178	10.688	1.000	-36.08	35.72	-46.29	45.93
	T_2	11.415	10.688	0.885	-24.49	47.31	-34.69	57.52
	T_3	-10.037	10.688	0.928	-45.94	25.86	-56.15	36.07
	T_4	-18.655	10.688	0.530	-54.55	17.24	-64.76	27.45
	T_5	-33.873	10.688	0.069	-69.77	2.03	-79.98	12.24
T_2	T_0	-11.592	10.688	0.878	-47.49	24.31	-57.70	34.52
	T_1	-11.415	10.688	0.885	-47.31	24.49	-57.52	34.69
	T_3	-21.452	10.688	0.392	-57.35	14.45	-67.56	24.66
	T_4	-30.070	10.688	0.122	-65.97	5.83	-76.18	16.04
	T_5	-45.288	10.688	0.011*	-81.19	-9.39	-91.40	0.82
T_3	T_0	9.860	10.688	0.933	-26.04	45.76	-36.25	55.97
	T_1	10.037	10.688	0.928	-25.86	45.94	-36.07	56.15
	T_2	21.452	10.688	0.392	-14.45	57.35	-24.66	67.56
	T_4	-8.618	10.688	0.961	-44.52	27.28	-54.73	37.49
	T_5	-23.836	10.688	0.292	-59.74	12.06	-69.94	22.27
T_4	T_0	18.477	10.688	0.540	-17.42	54.38	-27.63	64.59
	T_1	18.655	10.688	0.530	-17.24	54.55	-27.45	64.76
	T_2	30.070	10.688	0.122	-5.83	65.97	-16.04	76.18
	T_3	8.618	10.688	0.961	-27.28	44.52	-37.49	54.73
	T_5	-15.218	10.688	0.714	-51.12	20.68	-61.33	30.89
T_5	T_0	33.695	10.688	0.070	-2.20	69.60	-12.41	79.80
	T_1	33.873	10.688	0.069	-2.03	69.77	-12.24	79.98
	T_2	45.288	10.688	0.011*	9.39	81.19	-0.82	91.40
	T_3	23.836	10.688	0.292	-12.06	59.74	-22.27	69.94
	T_4	15.218	10.688	0.714	-20.68	51.12	-30.89	61.33

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.52 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured arsenic (As) concentration levels of whole plant

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.043	0.266	1.000	-0.94	0.85	-1.19	1.10
	T_2	-0.472	0.266	0.515	-1.36	0.42	-1.62	0.68
	T_3	-0.148	0.266	0.992	-1.04	0.75	-1.30	1.00
	T_4	-0.324	0.266	0.820	-1.22	0.57	-1.47	0.82
	T_5	-0.315	0.266	0.836	-1.21	0.58	-1.46	0.83
T_1	T_0	0.043	0.266	1.000	-0.85	0.94	-1.10	1.19
	T_2	-0.429	0.266	0.607	-1.32	0.46	-1.58	0.72
	T_3	-0.105	0.266	0.998	-1.00	0.79	-1.25	1.04
	T_4	-0.281	0.266	0.889	-1.17	0.61	-1.43	0.87
	T_5	-0.272	0.266	0.901	-1.17	0.62	-1.42	0.88
T_2	T_0	0.472	0.266	0.515	-0.42	1.36	-0.68	1.62
	T_1	0.429	0.266	0.607	-0.46	1.32	-0.72	1.58
	T_3	0.324	0.266	0.821	-0.57	1.22	-0.82	1.47
	T_4	0.148	0.266	0.992	-0.75	1.04	-1.00	1.30
	T_5	0.157	0.266	0.990	-0.74	1.05	-0.99	1.30
T_3	T_0	0.148	0.266	0.992	-0.75	1.04	-1.00	1.30
	T_1	0.105	0.266	0.998	-0.79	1.00	-1.04	1.25
	T_2	-0.324	0.266	0.821	-1.22	0.57	-1.47	0.82
	T_4	-0.176	0.266	0.983	-1.07	0.72	-1.32	0.97
	T_5	-0.167	0.266	0.987	-1.06	0.73	-1.31	0.98
T_4	T_0	0.324	0.266	0.820	-0.57	1.22	-0.82	1.47
	T_1	0.281	0.266	0.889	-0.61	1.17	-0.87	1.43
	T_2	-0.148	0.266	0.992	-1.04	0.75	-1.30	1.00
	T_3	0.176	0.266	0.983	-0.72	1.07	-0.97	1.32
	T_5	0.009	0.266	1.000	-0.88	0.90	-1.14	1.16
T_5	T_0	0.315	0.266	0.836	-0.58	1.21	-0.83	1.46
	T_1	0.272	0.266	0.901	-0.62	1.17	-0.88	1.42
	T_2	-0.157	0.266	0.990	-1.05	0.74	-1.30	0.99
	T_3	0.167	0.266	0.987	-0.73	1.06	-0.98	1.31
	T_4	-0.009	0.266	1.000	-0.90	0.88	-1.16	1.14

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.53 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured beryllium (Be) concentration levels of whole plant

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.001	0.053	1.000	-0.18	0.18	-0.23	0.23
	T_2	0.002	0.053	1.000	-0.18	0.18	-0.23	0.23
	T_3	-0.129	0.053	0.228	-0.31	0.05	-0.36	0.10
	T_4	-0.043	0.053	0.961	-0.22	0.14	-0.27	0.19
	T_5	-0.014	0.053	1.000	-0.19	0.17	-0.24	0.22
T_1	T_0	0.001	0.053	1.000	-0.18	0.18	-0.23	0.23
	T_2	0.003	0.053	1.000	-0.18	0.18	-0.23	0.23
	T_3	-0.128	0.053	0.234	-0.31	0.05	-0.36	0.10
	T_4	-0.042	0.053	0.964	-0.22	0.14	-0.27	0.19
	T_5	-0.013	0.053	1.000	-0.19	0.17	-0.24	0.22
T_2	T_0	-0.002	0.053	1.000	-0.18	0.18	-0.23	0.23
	T_1	-0.003	0.053	1.000	-0.18	0.18	-0.23	0.23
	T_3	-0.130	0.053	0.217	-0.31	0.05	-0.36	0.10
	T_4	-0.045	0.053	0.954	-0.22	0.13	-0.28	0.19
	T_5	-0.016	0.053	1.000	-0.20	0.16	-0.25	0.21
T_3	T_0	0.129	0.053	0.228	-0.05	0.31	-0.10	0.36
	T_1	0.128	0.053	0.234	-0.05	0.31	-0.10	0.36
	T_2	0.130	0.053	0.217	-0.05	0.31	-0.10	0.36
	T_4	0.085	0.053	0.614	-0.09	0.26	-0.15	0.32
	T_5	0.115	0.053	0.327	-0.06	0.29	-0.12	0.35
T_4	T_0	0.043	0.053	0.961	-0.14	0.22	-0.19	0.27
	T_1	0.042	0.053	0.964	-0.14	0.22	-0.19	0.27
	T_2	0.045	0.053	0.954	-0.13	0.22	-0.19	0.28
	T_3	-0.085	0.053	0.614	-0.26	0.09	-0.32	0.15
	T_5	0.029	0.053	0.993	-0.15	0.21	-0.20	0.26
T_5	T_0	0.014	0.053	1.000	-0.17	0.19	-0.22	0.24
	T_1	0.013	0.053	1.000	-0.17	0.19	-0.22	0.24
	T_2	0.016	0.053	1.000	-0.16	0.20	-0.21	0.25
	T_3	-0.115	0.053	0.327	-0.29	0.06	-0.35	0.12
	T_4	-0.029	0.053	0.993	-0.21	0.15	-0.26	0.20

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.54 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured cobalt (Co) concentration levels of whole plant

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.045	0.106	0.998	-0.40	0.31	-0.50	0.41
	T_2	0.086	0.106	0.960	-0.27	0.44	-0.37	0.54
	T_3	-0.038	0.106	0.999	-0.39	0.32	-0.49	0.42
	T_4	0.153	0.106	0.702	-0.20	0.51	-0.30	0.61
	T_5	0.134	0.106	0.796	-0.22	0.49	-0.32	0.59
T_1	T_0	0.045	0.106	0.998	-0.31	0.40	-0.41	0.50
	T_2	0.131	0.106	0.811	-0.22	0.49	-0.33	0.59
	T_3	0.008	0.106	1.000	-0.35	0.36	-0.45	0.46
	T_4	0.199	0.106	0.460	-0.16	0.55	-0.26	0.66
	T_5	0.180	0.106	0.558	-0.18	0.54	-0.28	0.64
T_2	T_0	-0.086	0.106	0.960	-0.44	0.27	-0.54	0.37
	T_1	-0.131	0.106	0.811	-0.49	0.22	-0.59	0.33
	T_3	-0.124	0.106	0.844	-0.48	0.23	-0.58	0.33
	T_4	0.067	0.106	0.986	-0.29	0.42	-0.39	0.52
	T_5	0.049	0.106	0.997	-0.31	0.40	-0.41	0.51
T_3	T_0	0.038	0.106	0.999	-0.32	0.39	-0.42	0.49
	T_1	-0.008	0.106	1.000	-0.36	0.35	-0.46	0.45
	T_2	0.124	0.106	0.844	-0.23	0.48	-0.33	0.58
	T_4	0.191	0.106	0.499	-0.17	0.55	-0.27	0.65
	T_5	0.172	0.106	0.600	-0.18	0.53	-0.29	0.63
T_4	T_0	-0.153	0.106	0.702	-0.51	0.20	-0.61	0.30
	T_1	-0.199	0.106	0.460	-0.55	0.16	-0.66	0.26
	T_2	-0.067	0.106	0.986	-0.42	0.29	-0.52	0.39
	T_3	-0.191	0.106	0.499	-0.55	0.17	-0.65	0.27
	T_5	-0.019	0.106	1.000	-0.37	0.34	-0.48	0.44
T_5	T_0	-0.134	0.106	0.796	-0.49	0.22	-0.59	0.32
	T_1	-0.180	0.106	0.558	-0.54	0.18	-0.64	0.28
	T_2	-0.049	0.106	0.997	-0.40	0.31	-0.51	0.41
	T_3	-0.172	0.106	0.600	-0.53	0.18	-0.63	0.29
	T_4	0.019	0.106	1.000	-0.34	0.37	-0.44	0.48

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.55 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured chromium (Cr) concentration levels of whole plant

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.003	0.011	1.000	-0.04	0.04	-0.05	0.05
	T_2	-0.003	0.011	1.000	-0.04	0.04	-0.05	0.05
	T_3	0.007	0.011	0.987	-0.03	0.05	-0.04	0.06
	T_4	-0.012	0.011	0.900	-0.05	0.03	-0.06	0.04
	T_5	-0.040	0.011	0.038*	-0.08	0.00	-0.09	0.01
T_1	T_0	0.003	0.011	1.000	-0.04	0.04	-0.05	0.05
	T_2	0.000	0.011	1.000	-0.04	0.04	-0.05	0.05
	T_3	0.010	0.011	0.941	-0.03	0.05	-0.04	0.06
	T_4	-0.009	0.011	0.970	-0.05	0.03	-0.06	0.04
	T_5	-0.037	0.011	0.060	-0.08	0.00	-0.09	0.01
T_2	T_0	0.003	0.011	1.000	-0.04	0.04	-0.05	0.05
	T_1	0.000	0.011	1.000	-0.04	0.04	-0.05	0.05
	T_3	0.010	0.011	0.949	-0.03	0.05	-0.04	0.06
	T_4	-0.009	0.011	0.965	-0.05	0.03	-0.06	0.04
	T_5	-0.037	0.011	0.057	-0.08	0.00	-0.09	0.01
T_3	T_0	-0.007	0.011	0.987	-0.05	0.03	-0.06	0.04
	T_1	-0.010	0.011	0.941	-0.05	0.03	-0.06	0.04
	T_2	-0.010	0.011	0.949	-0.05	0.03	-0.06	0.04
	T_4	-0.019	0.011	0.586	-0.06	0.02	-0.07	0.03
	T_5	-0.047	0.011	0.013*	-0.09	-0.01	-0.10	0.00
T_4	T_0	0.012	0.011	0.900	-0.03	0.05	-0.04	0.06
	T_1	0.009	0.011	0.970	-0.03	0.05	-0.04	0.06
	T_2	0.009	0.011	0.965	-0.03	0.05	-0.04	0.06
	T_3	0.019	0.011	0.586	-0.02	0.06	-0.03	0.07
	T_5	-0.028	0.011	0.200	-0.07	0.01	-0.08	0.02
T_5	T_0	0.040	0.011	0.038*	0.00	0.08	-0.01	0.09
	T_1	0.037	0.011	0.060	0.00	0.08	-0.01	0.09
	T_2	0.037	0.011	0.057	0.00	0.08	-0.01	0.09
	T_3	0.047	0.011	0.013*	0.01	0.09	0.00	0.10
	T_4	0.028	0.011	0.200	-0.01	0.07	-0.02	0.08

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.56 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured copper (Cu) concentration levels of whole plant

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	1.280	0.955	0.759	-1.93	4.49	-2.84	5.40
	T_2	0.950	0.955	0.911	-2.26	4.16	-3.17	5.07
	T_3	-0.259	0.955	1.000	-3.47	2.95	-4.38	3.86
	T_4	-2.216	0.955	0.258	-5.42	0.99	-6.34	1.90
	T_5	-0.029	0.955	1.000	-3.24	3.18	-4.15	4.09
T_1	T_0	-1.280	0.955	0.759	-4.49	1.93	-5.40	2.84
	T_2	-0.330	0.955	0.999	-3.54	2.88	-4.45	3.79
	T_3	-1.538	0.955	0.607	-4.75	1.67	-5.66	2.58
	T_4	-3.495	0.955	0.030*	-6.70	-0.29	-7.61	0.62
	T_5	-1.308	0.955	0.743	-4.52	1.90	-5.43	2.81
T_2	T_0	-0.950	0.955	0.911	-4.16	2.26	-5.07	3.17
	T_1	0.330	0.955	0.999	-2.88	3.54	-3.79	4.45
	T_3	-1.209	0.955	0.797	-4.42	2.00	-5.33	2.91
	T_4	-3.166	0.955	0.054	-6.37	0.04	-7.29	0.95
	T_5	-0.979	0.955	0.901	-4.19	2.23	-5.10	3.14
T_3	T_0	0.259	0.955	1.000	-2.95	3.47	-3.86	4.38
	T_1	1.538	0.955	0.607	-1.67	4.75	-2.58	5.66
	T_2	1.209	0.955	0.797	-2.00	4.42	-2.91	5.33
	T_4	-1.957	0.955	0.372	-5.16	1.25	-6.08	2.16
	T_5	0.230	0.955	1.000	-2.98	3.44	-3.89	4.35
T_4	T_0	2.216	0.955	0.258	-0.99	5.42	-1.90	6.34
	T_1	3.495	0.955	0.030*	0.29	6.70	-0.62	7.61
	T_2	3.166	0.955	0.054	-0.04	6.37	-0.95	7.29
	T_3	1.957	0.955	0.372	-1.25	5.16	-2.16	6.08
	T_5	2.187	0.955	0.269	-1.02	5.39	-1.93	6.31
T_5	T_0	0.029	0.955	1.000	-3.18	3.24	-4.09	4.15
	T_1	1.308	0.955	0.743	-1.90	4.52	-2.81	5.43
	T_2	0.979	0.955	0.901	-2.23	4.19	-3.14	5.10
	T_3	-0.230	0.955	1.000	-3.44	2.98	-4.35	3.89
	T_4	-2.187	0.955	0.269	-5.39	1.02	-6.31	1.93

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.57 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured iron (Fe) concentration levels of whole plant

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-16.482	12.057	0.745	-56.98	24.02	-68.50	35.53
	T_2	1.033	12.057	1.000	-39.46	41.53	-50.98	53.05
	T_3	-3.647	12.057	1.000	-44.14	36.85	-55.66	48.37
	T_4	2.560	12.057	1.000	-37.94	43.06	-49.45	54.58
	T_5	-21.008	12.057	0.532	-61.51	19.49	-73.02	31.01
T_1	T_0	16.482	12.057	0.745	-24.02	56.98	-35.53	68.50
	T_2	17.515	12.057	0.697	-22.98	58.01	-34.50	69.53
	T_3	12.835	12.057	0.886	-27.66	53.33	-39.18	64.85
	T_4	19.042	12.057	0.625	-21.46	59.54	-32.97	71.06
	T_5	-4.526	12.057	0.999	-45.02	35.97	-56.54	47.49
T_2	T_0	-1.033	12.057	1.000	-41.53	39.46	-53.05	50.98
	T_1	-17.515	12.057	0.697	-58.01	22.98	-69.53	34.50
	T_3	-4.680	12.057	0.999	-45.18	35.82	-56.69	47.33
	T_4	1.527	12.057	1.000	-38.97	42.02	-50.49	53.54
	T_5	-22.041	12.057	0.485	-62.54	18.46	-74.06	29.97
T_3	T_0	3.647	12.057	1.000	-36.85	44.14	-48.37	55.66
	T_1	-12.835	12.057	0.886	-53.33	27.66	-64.85	39.18
	T_2	4.680	12.057	0.999	-35.82	45.18	-47.33	56.69
	T_4	6.207	12.057	0.995	-34.29	46.71	-45.81	58.22
	T_5	-17.361	12.057	0.705	-57.86	23.14	-69.38	34.65
T_4	T_0	-2.560	12.057	1.000	-43.06	37.94	-54.58	49.45
	T_1	-19.042	12.057	0.625	-59.54	21.46	-71.06	32.97
	T_2	-1.527	12.057	1.000	-42.02	38.97	-53.54	50.49
	T_3	-6.207	12.057	0.995	-46.71	34.29	-58.22	45.81
	T_5	-23.568	12.057	0.418	-64.07	16.93	-75.58	28.45
T_5	T_0	21.008	12.057	0.532	-19.49	61.51	-31.01	73.02
	T_1	4.526	12.057	0.999	-35.97	45.02	-47.49	56.54
	T_2	22.041	12.057	0.485	-18.46	62.54	-29.97	74.06
	T_3	17.361	12.057	0.705	-23.14	57.86	-34.65	69.38
	T_4	23.568	12.057	0.418	-16.93	64.07	-28.45	75.58

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.58 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured manganese (Mn) concentration levels of whole plant

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	3.846	5.754	0.982	-15.48	23.17	-20.98	28.67
	T_2	9.426	5.754	0.592	-9.90	28.75	-15.40	34.25
	T_3	2.984	5.754	0.994	-16.34	22.31	-21.84	27.81
	T_4	10.044	5.754	0.530	-9.28	29.37	-14.78	34.87
	T_5	9.662	5.754	0.568	-9.67	28.99	-15.16	34.49
T_1	T_0	-3.846	5.754	0.982	-23.17	15.48	-28.67	20.98
	T_2	5.580	5.754	0.919	-13.75	24.91	-19.24	30.40
	T_3	-0.862	5.754	1.000	-20.19	18.47	-25.69	23.96
	T_4	6.197	5.754	0.881	-13.13	25.53	-18.63	31.02
	T_5	5.816	5.754	0.906	-13.51	25.14	-19.01	30.64
T_2	T_0	-9.426	5.754	0.592	-28.75	9.90	-34.25	15.40
	T_1	-5.580	5.754	0.919	-24.91	13.75	-30.40	19.24
	T_3	-6.442	5.754	0.864	-25.77	12.89	-31.27	18.38
	T_4	0.618	5.754	1.000	-18.71	19.95	-24.21	25.44
	T_5	0.236	5.754	1.000	-19.09	19.56	-24.59	25.06
T_3	T_0	-2.984	5.754	0.994	-22.31	16.34	-27.81	21.84
	T_1	0.862	5.754	1.000	-18.47	20.19	-23.96	25.69
	T_2	6.442	5.754	0.864	-12.89	25.77	-18.38	31.27
	T_4	7.060	5.754	0.816	-12.27	26.39	-17.76	31.88
	T_5	6.678	5.754	0.847	-12.65	26.01	-18.15	31.50
T_4	T_0	-10.044	5.754	0.530	-29.37	9.28	-34.87	14.78
	T_1	-6.197	5.754	0.881	-25.53	13.13	-31.02	18.63
	T_2	-0.618	5.754	1.000	-19.95	18.71	-25.44	24.21
	T_3	-7.060	5.754	0.816	-26.39	12.27	-31.88	17.76
	T_5	-0.382	5.754	1.000	-19.71	18.95	-25.21	24.44
T_5	T_0	-9.662	5.754	0.568	-28.99	9.67	-34.49	15.16
	T_1	-5.816	5.754	0.906	-25.14	13.51	-30.64	19.01
	T_2	-0.236	5.754	1.000	-19.56	19.09	-25.06	24.59
	T_3	-6.678	5.754	0.847	-26.01	12.65	-31.50	18.15
	T_4	0.382	5.754	1.000	-18.95	19.71	-24.44	25.21

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.59 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured nickel (Ni) concentration levels of whole plant

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	0.089	0.144	0.987	-0.39	0.57	-0.53	0.71
	T_2	0.162	0.144	0.860	-0.32	0.65	-0.46	0.78
	T_3	0.031	0.144	1.000	-0.45	0.51	-0.59	0.65
	T_4	0.194	0.144	0.752	-0.29	0.68	-0.43	0.81
	T_5	0.070	0.144	0.996	-0.41	0.55	-0.55	0.69
T_1	T_0	-0.089	0.144	0.987	-0.57	0.39	-0.71	0.53
	T_2	0.073	0.144	0.995	-0.41	0.56	-0.55	0.69
	T_3	-0.058	0.144	0.998	-0.54	0.42	-0.68	0.56
	T_4	0.105	0.144	0.974	-0.38	0.59	-0.51	0.73
	T_5	-0.019	0.144	1.000	-0.50	0.46	-0.64	0.60
T_2	T_0	-0.162	0.144	0.860	-0.65	0.32	-0.78	0.46
	T_1	-0.073	0.144	0.995	-0.56	0.41	-0.69	0.55
	T_3	-0.131	0.144	0.936	-0.61	0.35	-0.75	0.49
	T_4	0.032	0.144	1.000	-0.45	0.51	-0.59	0.65
	T_5	-0.092	0.144	0.985	-0.58	0.39	-0.71	0.53
T_3	T_0	-0.031	0.144	1.000	-0.51	0.45	-0.65	0.59
	T_1	0.058	0.144	0.998	-0.42	0.54	-0.56	0.68
	T_2	0.131	0.144	0.936	-0.35	0.61	-0.49	0.75
	T_4	0.163	0.144	0.858	-0.32	0.65	-0.46	0.78
	T_5	0.039	0.144	1.000	-0.44	0.52	-0.58	0.66
T_4	T_0	-0.194	0.144	0.752	-0.68	0.29	-0.81	0.43
	T_1	-0.105	0.144	0.974	-0.59	0.38	-0.73	0.51
	T_2	-0.032	0.144	1.000	-0.51	0.45	-0.65	0.59
	T_3	-0.163	0.144	0.858	-0.65	0.32	-0.78	0.46
	T_5	-0.125	0.144	0.948	-0.61	0.36	-0.74	0.50
T_5	T_0	-0.070	0.144	0.996	-0.55	0.41	-0.69	0.55
	T_1	0.019	0.144	1.000	-0.46	0.50	-0.60	0.64
	T_2	0.092	0.144	0.985	-0.39	0.58	-0.53	0.71
	T_3	-0.039	0.144	1.000	-0.52	0.44	-0.66	0.58
	T_4	0.125	0.144	0.948	-0.36	0.61	-0.50	0.74

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.60 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured lead (Pb) concentration levels of whole plant

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	2.814	3.153	0.941	-7.78	13.40	-10.79	16.42
	T_2	0.103	3.153	1.000	-10.49	10.69	-13.50	13.71
	T_3	-3.821	3.153	0.823	-14.41	6.77	-17.42	9.78
	T_4	-1.208	3.153	0.999	-11.80	9.38	-14.81	12.39
	T_5	-3.090	3.153	0.916	-13.68	7.50	-16.69	10.51
T_1	T_0	-2.814	3.153	0.941	-13.40	7.78	-16.42	10.79
	T_2	-2.710	3.153	0.949	-13.30	7.88	-16.31	10.89
	T_3	-6.634	3.153	0.346	-17.23	3.96	-20.24	6.97
	T_4	-4.021	3.153	0.792	-14.61	6.57	-17.62	9.58
	T_5	-5.903	3.153	0.461	-16.49	4.69	-19.51	7.70
T_2	T_0	-0.103	3.153	1.000	-10.69	10.49	-13.71	13.50
	T_1	2.710	3.153	0.949	-7.88	13.30	-10.89	16.31
	T_3	-3.924	3.153	0.808	-14.51	6.67	-17.53	9.68
	T_4	-1.311	3.153	0.998	-11.90	9.28	-14.91	12.29
	T_5	-3.193	3.153	0.905	-13.78	7.40	-16.80	10.41
T_3	T_0	3.821	3.153	0.823	-6.77	14.41	-9.78	17.42
	T_1	6.634	3.153	0.346	-3.96	17.23	-6.97	20.24
	T_2	3.924	3.153	0.808	-6.67	14.51	-9.68	17.53
	T_4	2.613	3.153	0.956	-7.98	13.20	-10.99	16.22
	T_5	0.731	3.153	1.000	-9.86	11.32	-12.87	14.33
T_4	T_0	1.208	3.153	0.999	-9.38	11.80	-12.39	14.81
	T_1	4.021	3.153	0.792	-6.57	14.61	-9.58	17.62
	T_2	1.311	3.153	0.998	-9.28	11.90	-12.29	14.91
	T_3	-2.613	3.153	0.956	-13.20	7.98	-16.22	10.99
	T_5	-1.882	3.153	0.989	-12.47	8.71	-15.48	11.72
T_5	T_0	3.090	3.153	0.916	-7.50	13.68	-10.51	16.69
	T_1	5.903	3.153	0.461	-4.69	16.49	-7.70	19.51
	T_2	3.193	3.153	0.905	-7.40	13.78	-10.41	16.80
	T_3	-0.731	3.153	1.000	-11.32	9.86	-14.33	12.87
	T_4	1.882	3.153	0.989	-8.71	12.47	-11.72	15.48

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.61 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured vanadium (V) concentration levels of whole plant

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	-0.033	0.062	0.993	-0.24	0.17	-0.30	0.23
	T_2	0.004	0.062	1.000	-0.20	0.21	-0.26	0.27
	T_3	-0.098	0.062	0.626	-0.31	0.11	-0.37	0.17
	T_4	0.005	0.062	1.000	-0.20	0.21	-0.26	0.27
	T_5	-0.051	0.062	0.959	-0.26	0.16	-0.32	0.22
T_1	T_0	0.033	0.062	0.993	-0.17	0.24	-0.23	0.30
	T_2	0.037	0.062	0.989	-0.17	0.25	-0.23	0.30
	T_3	-0.065	0.062	0.894	-0.27	0.14	-0.33	0.20
	T_4	0.038	0.062	0.988	-0.17	0.25	-0.23	0.31
	T_5	-0.017	0.062	1.000	-0.23	0.19	-0.28	0.25
T_2	T_0	-0.004	0.062	1.000	-0.21	0.20	-0.27	0.26
	T_1	-0.037	0.062	0.989	-0.25	0.17	-0.30	0.23
	T_3	-0.102	0.062	0.586	-0.31	0.11	-0.37	0.17
	T_4	0.000	0.062	1.000	-0.21	0.21	-0.27	0.27
	T_5	-0.055	0.062	0.944	-0.26	0.15	-0.32	0.21
T_3	T_0	0.098	0.062	0.626	-0.11	0.31	-0.17	0.37
	T_1	0.065	0.062	0.894	-0.14	0.27	-0.20	0.33
	T_2	0.102	0.062	0.586	-0.11	0.31	-0.17	0.37
	T_4	0.102	0.062	0.583	-0.11	0.31	-0.16	0.37
	T_5	0.047	0.062	0.969	-0.16	0.26	-0.22	0.31
T_4	T_0	-0.005	0.062	1.000	-0.21	0.20	-0.27	0.26
	T_1	-0.038	0.062	0.988	-0.25	0.17	-0.31	0.23
	T_2	0.000	0.062	1.000	-0.21	0.21	-0.27	0.27
	T_3	-0.102	0.062	0.583	-0.31	0.11	-0.37	0.16
	T_5	-0.055	0.062	0.942	-0.26	0.15	-0.32	0.21
T_5	T_0	0.051	0.062	0.959	-0.16	0.26	-0.22	0.32
	T_1	0.017	0.062	1.000	-0.19	0.23	-0.25	0.28
	T_2	0.055	0.062	0.944	-0.15	0.26	-0.21	0.32
	T_3	-0.047	0.062	0.969	-0.26	0.16	-0.31	0.22
	T_4	0.055	0.062	0.942	-0.15	0.26	-0.21	0.32

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

Table C.62 One-way ANOVA results along with the Tukey post-hoc multiple comparisons of measured zinc (Zn) concentration levels of whole plant

(I) T	(J) T	MD (I-J)	SE	Sig	95% CI		99% CI	
					Lower B	Upper B	Lower B	Upper B
T_0	T_1	5.322	2.062	0.176	-1.60	12.25	-3.57	14.22
	T_2	5.478	2.062	0.156	-1.45	12.40	-3.42	14.37
	T_3	4.303	2.062	0.354	-2.62	11.23	-4.59	13.20
	T_4	3.690	2.062	0.506	-3.24	10.62	-5.21	12.59
	T_5	0.463	2.062	1.000	-6.46	7.39	-8.43	9.36
T_1	T_0	-5.322	2.062	0.176	-12.25	1.60	-14.22	3.57
	T_2	0.155	2.062	1.000	-6.77	7.08	-8.74	9.05
	T_3	-1.019	2.062	0.995	-7.95	5.91	-9.92	7.88
	T_4	-1.633	2.062	0.964	-8.56	5.29	-10.53	7.26
	T_5	-4.859	2.062	0.245	-11.79	2.07	-13.76	4.04
T_2	T_0	-5.478	2.062	0.156	-12.40	1.45	-14.37	3.42
	T_1	-0.155	2.062	1.000	-7.08	6.77	-9.05	8.74
	T_3	-1.174	2.062	0.991	-8.10	5.75	-10.07	7.72
	T_4	-1.788	2.062	0.948	-8.71	5.14	-10.68	7.11
	T_5	-5.014	2.062	0.220	-11.94	1.91	-13.91	3.88
T_3	T_0	-4.303	2.062	0.354	-11.23	2.62	-13.20	4.59
	T_1	1.019	2.062	0.995	-5.91	7.95	-7.88	9.92
	T_2	1.174	2.062	0.991	-5.75	8.10	-7.72	10.07
	T_4	-0.614	2.062	1.000	-7.54	6.31	-9.51	8.28
	T_5	-3.840	2.062	0.466	-10.77	3.09	-12.74	5.06
T_4	T_0	-3.690	2.062	0.506	-10.62	3.24	-12.59	5.21
	T_1	1.633	2.062	0.964	-5.29	8.56	-7.26	10.53
	T_2	1.788	2.062	0.948	-5.14	8.71	-7.11	10.68
	T_3	0.614	2.062	1.000	-6.31	7.54	-8.28	9.51
	T_5	-3.226	2.062	0.634	-10.15	3.70	-12.12	5.67
T_5	T_0	-0.463	2.062	1.000	-7.39	6.46	-9.36	8.43
	T_1	4.859	2.062	0.245	-2.07	11.79	-4.04	13.76
	T_2	5.014	2.062	0.220	-1.91	11.94	-3.88	13.91
	T_3	3.840	2.062	0.466	-3.09	10.77	-5.06	12.74
	T_4	3.226	2.062	0.634	-3.70	10.15	-5.67	12.12

MD: Mean Difference, SE: Standard Error, Sig: Significance, CI: Confidence Interval, B: Bound, *, ** significant at 0.05 and 0.01 probability levels, respectively.

APPENDIX D

MATERIAL AND METHODS

Figure D. 1 On-Site Sewage Facilities (OSSF) Center at The Texas A&M University System RELLIS Campus

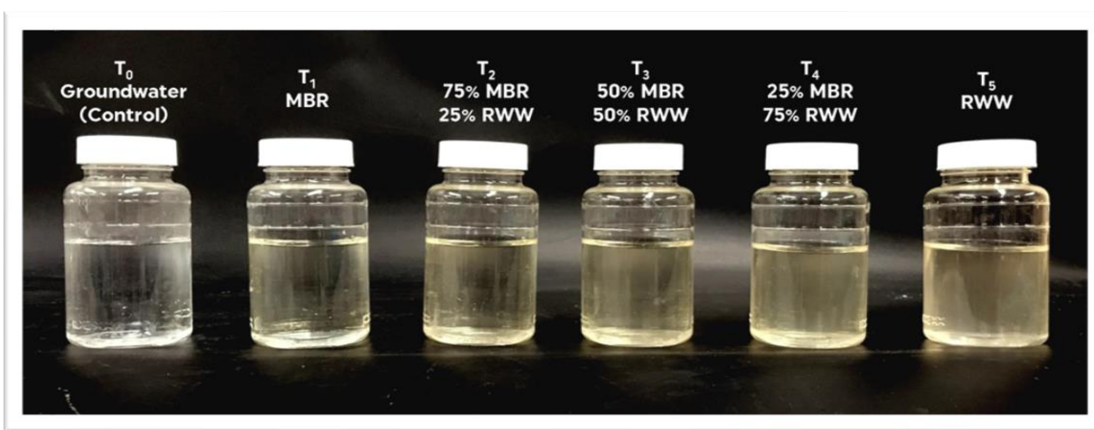

Figure D.2 Water samples were taken on 9 April.

Figure D.3 Collected water samples for heavy metal analysis

Figure D.4 Hanna HI98194 Multiparameter Meter

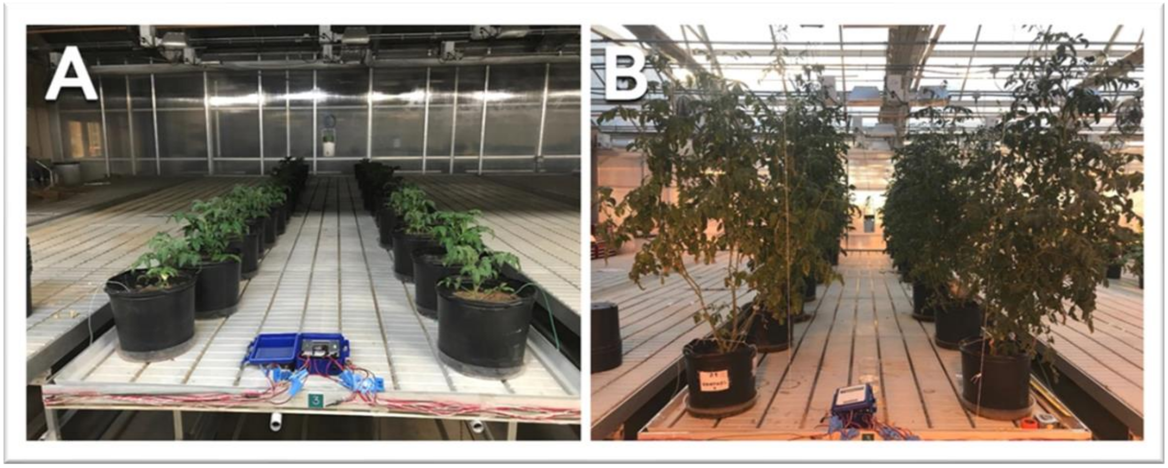

Figure D.5 A) First day of the study, B) Last day of the study

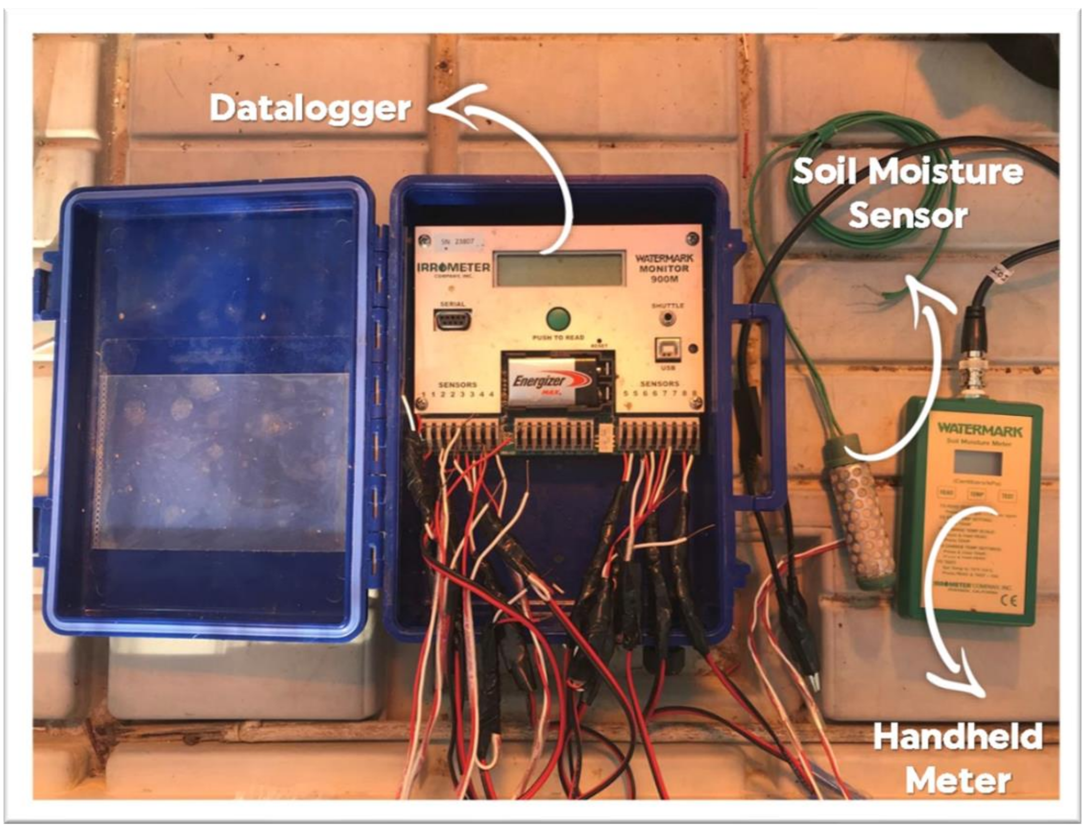

Figure D.6 Irrometer data collector and manual moisture reader

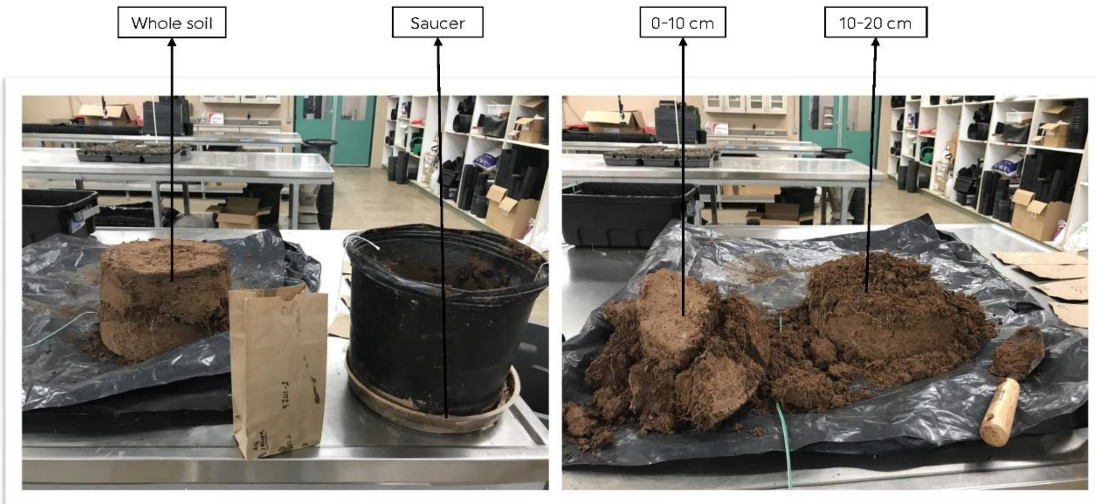

Figure D.7 Soil preparation for analysis

Figure D.8 Eliminating the root and crown from soil

Figure D.9 Harvested tomato fruits

Figure D.10 Lower and upper stem

Figure D.11 Tomatoes were sliced for oven-drying

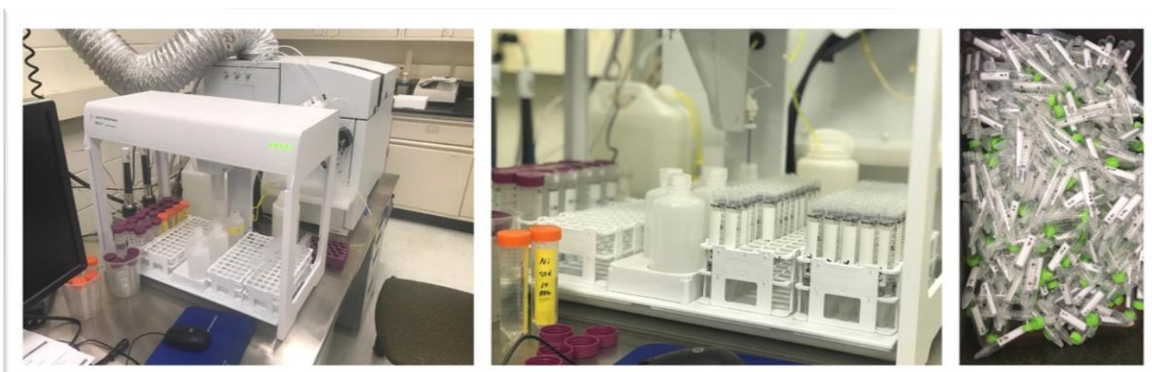

Figure D.12 Agilent Technologies 7700 Series ICP-MS

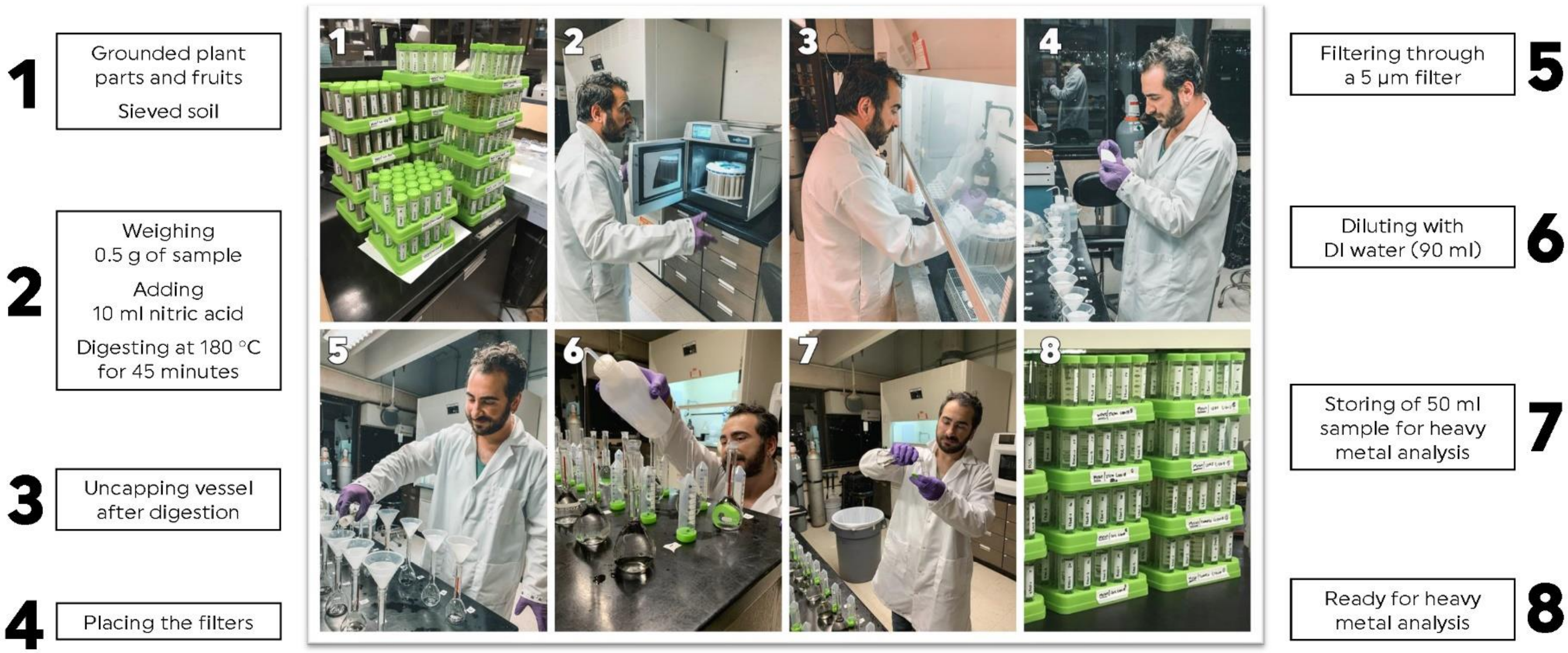

Figure D.13 Digestion process

Figure D.14 The day of the thesis defense; starting from left to right,
Dr. Terry J. Gentry, Mesut Ozdemir, Dr. Anish Jantrania, Dr. June E. Wolfe III