Deanship of Graduate Studies

Al-Quds University

The fate of Heavy Metals in Vegetables Irrigated with Raw Wastewater in Palestine: A Case Study of Al-Far'a Area

Mahmoud Khader Abed Driaat

M. Sc. Thesis

Jerusalem-Palestine

1441 – 2020

The fate of heavy metals in vegetables irrigated with raw wastewater in Palestine: A case study of Al-Far'a area

: Prepared by

Mahmoud Khader Abed Driaat

B.Sc.: Earth and Environmental Sciences, Faculty of Science and Technology, Al-Quds University – Palestine

Supervisor: Prof. Mutaz Ali Qutob

A thesis submitted in partial fulfillment of requirements for the degree of Master of Science in Environmental Studies

Department of Earth and Environmental Sciences, Al- Quds University.

1441 – 2020

Al- Quds University

Deanship of Graduate Studies

Environmental Studies Program

Thesis Approval

The fate of heavy metals in vegetables irrigated with raw wastewater in Palestine: A case study of Al-Far’a area

Student Name: Mahmoud Khader Abed Driaat

Registration No: 21520374

Supervisor: Prof. Mutaz Ali Kutob

Master Thesis submitted and accepted, on January 05th 2020

The name and signatures of the examining committee members are as follows:

Head of Committee, Prof. Mutaz Qutob Signature

Internal Examiner, Dr. Thameen Hijawi Signature

External Examiner, Prof. Rashed M. Al-Sa'ed Signature

Jerusalem- Palestine

1441 – 2020

Dedication

This work is dedicated to those who gave me life and grew me up, my parents who were always my supportive. I owe them each moment of my life.

To my beloved brothers and sisters.

To my valuable treasure my wife, for her endless love and support.

To my great professors who were always a constant source of knowledge and inspiration

إهداء

هذا العمل مقدم لأولئك الذين أعطوني الحياة ورعوني حتى كبرت، والداي الذين كانوا داعمين لي دائماً، أنا مدين لهم بكل لحظة من حياتي

لإخوتي وأخواتي

إلى كنزي الثمين زوجتي، لحبها ودعمها اللامتناهي

لأساتذتي العظماء الذين كانوا دائماً مصادر ثابتة للمعرفة والإلهام

Declaration

I Certify that this thesis entitled "The fate of heavy metals in vegetables irrigated with raw wastewater in Palestine: A case study of Al-Far'a area" submitted for the degree of Master is a result of my own research, except where otherwise acknowledged, and that this study (or any part of the same) has not been submitted for a higher degree to any other university or institute.

Name: Mahmoud Khader Driaat

Signed:

Date: January 05th 2020

Acknowledgement

I would like to thank my thesis supervisor Prof. Mutaz Ali Kutob, Faculty of Science and Technology at Al Quds University; for his constant guidance and support which without it I could not have completed this dissertation. I consider myself to be extremely privileged to be his student. I benefited enormously from his excellence as a teacher and as a researcher. He consistently allowed this paper to be my own work but led me in the right direction whenever he thought I needed it. It was a great honor to work under his supervision.

I would also like to express my deepest gratitude to my parents and to my wife for providing me with sincere support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them.

I am also grateful to the funding received through the scholarship program of the Konrad Adenauer Foundations EIZ (Europäische und Internationale Zusammenarbeit - European and International Cooperation).

رسالة شكر

أود أن أشكر مشرف الأطروحة البروفيسور معتز القطب ، كلية العلوم والتكنولوجيا في جامعة القدس. لتوجيهه الدائم ودعمه الذي بدونه ما كنت لأكمل هذه الرسالة. أنا أعتبر نفسي محظوظاً للغاية لأن أكون طالباً من طلابه. لقد استفدت بشكل كبير من تميزه كمدرس وباحث. لقد كان شرفا عظيما لي العمل تحت إشرافه.

كما أود أن أعرب عن امتناني العميق لوالدي ولزوجتي لتوفيرهم الدعم الخالص والتشجيع المستمر طوال سنوات دراستي وخلال عملية البحث وكتابة هذه الرسالة. لم يكن من الممكن تحقيق هذا الإنجاز لولاهم. شكرا لكم جميعاً.

كما أود أن أشكر مؤسسة كونراد اديناور – مكتب رام الله على المنحة التي قدمت لي ضمن برنامج كونراد ادينوار لدعم الدراسات العليا من خلال برنامج (التعاون الأوروبي والدولي).

Table of Contents:

List of Figures

List of Tables

List of Abbreviations	
Milligram per Liter	mg/L
Centimeter	cm
Milligram per Kilogram	mg/kg
Degree Celsius	^{o}C
Inductively Coupled Plasma Mass Spectrometry	ICP-MS
Microwave Digestion System	MARS
World Health Organization	WHO
Gram	g
Not Detected	ND
Potential Hydrogen	pH
Parts-per-million, 10^{-6}	ppm
Geographical Information System	GIS
Palestinian Central Bureau of Statistics	PCBS
Cellulose Acetate syringe	CA syringe
Micro meter	µm
Millimeter	mm
Food and Agricultural Organization	FAO

تراكيز المعادن الثقيلة في الخضار المروية بمياه الصرف الصحي الغير معالجة في فلسطين: دراسة حالة لمنطقة الفارعة

اعداد: محمود خضر عبد دريعات
إشراف: البروفيسور معتز علي القطب

الملخص

من المعروف أن مياه الصرف الصحي والمياه الصناعية على وجه الخصوص مصدر رئيسي للتلوث بالمعادن الثقيلة. إن تصريف المياه العادمة الغير معالجة إلى البيئة يخلق احتمالية تلوث بالمعادن الثقيلة للأراضي الزراعية القريبة من مصدر التلوث. الخضروات التي تم دراستها في هذا المشروع بنوعيها الجذرية والثمريه هي أنواع مهمة في النظام الغذائي البشري. هذه الانواع من الخضروات غنية بالفيتامينات والعناصر الغذائية. حيث يمكن ان تحتوي على تراكيز من المعادن الثقيلة بشكل طبيعي التي يمكن ان تحصل عليها من التربة او المياه، ومع ذلك يجب ألا تحتوي هذه خضراوات على هذه المعادن الثقيلة بتراكيز عالية التي يمكن أن تشكل خطرًا صحيًا محتملاً على المستهلكين.

يعتبر التلوث بالمعادن الثقيلة تهديداً بيئياً وصحياً، حيث أن بعض هذه المعادن سامة حتى عند وجودها بتركيزات منخفضة. أجريت هذه الدراسة لتحديد تركيز المعادن الثقيلة في الخضراوات الجذرية والثمريه في منطقة الدراسة الواقعة في منطقة غور الأردن في فلسطين والتي تشمل الجزء الشرقي من مدينة نابلس، وقرية الجفتلك في الضفة الغربية.

تم جمع عينات من أربعة انواع من الخضروات، هي البطاطس والكوسا والباذنجان والبصل، من مزارع مختلفة في منطقة الدراسة، وتم تحليلها لمجموعة من المعادن الثقيلة وهي الحديد، الكروم، الرصاص، الكوبالت، الكادميوم، المنغنيز، النكل، الباريوم، والفناديوم (Fe، Pb، Cr، Co، Cd، Mn، Ni، V، Ba) باستخدام جهاز ICP-MS. بالنسبة لبعض العينات من الخضروات، تبين أن النتائج تتجاوز الحد

المسموح به للاستهلاك البشري من قبل منظمة الصحة العالمية ومنظمة الغذاء والزراعة، في حين تم العثور على عينات أخرى ضمن الحد الآمن المسموح به.

من خلال تحليل نتائج الكروم في عينات الخضار كانت الأعلى في التركيز بينما كانت تراكيز المنغنيز، الكوبالت، النكل، الحديد، والكادميوم هي الأقل. تراوحت تركيزات الباريوم والفناديوم بين عالية في بعض العينات ومنخفضة في أخرى، ثم تأتي تراكيز الرصاص الذي أظهر متوسط قريب من الحد الآمن لمنظمة الصحة العالمية. كما تم تحليل عينات التربة بالإضافة إلى عينات المياه من حيث محتواها من المعادن الثقيلة من أجل ربط العوامل البيئية بتلوث هذه الترب والمياه بالمعادن الثقيلة. ومع ذلك، كانت معظم التركيزات أقل من الحد الذي وضعته منظمة الصحة العالمية ومنظمة الغذاء والزراعة، وكان من الصعب في بعض الاحيان بناء علاقة بين تركيز المعادن الثقيلة في التربة والمياه لتلك التراكيز في الخضروات. وقد لوحظ أن تراكيز النكل، المنغنيز، والكوبالت، كعناصر أساسية، منخفضة للغاية في التربة وعينات المياه، وبالتالي كان تراكيزها منخفضاً في معظم عينات الخضار.

لقد أظهر عنصر الكادميوم تركيزًا منخفضًا جداً، وحتى أقل من مستويات الاكتشاف في بعض عينات المياه والتربة والخضروات. كما كان تركيز الرصاص منخفضاً جداً في معظم عينات التربة والمياه، بينما كان تركيز الرصاص في عينات الخضروات أقل بقليل من المستوى المسموح به من منظمة الصحة العالمية، مما يشير إلى أنه حتى عند التركيز المنخفض للرصاص في نظام التربة والماء، قد تكون الخضروات قادرة على تراكم الرصاص في ثمارها. ومن خلال هذه الدراسة، استنتج أن التلوث الموجود في عينات الخضار في منطقة الدراسة له علاقة بالتلوث الناجم عن تصريف مياه الصرف الغير معالجة إلى البيئة كما هو الحال في وادي الباذان في منطقة الدراسة في غور الأردن في فلسطين.

Abstract

Wastewater, and industrial wastewater, is known to be a major source of pollution with heavy metals. The discharge of raw wastewater to the environment without any advance treatment creates the potential for heavy metals contamination to the nearby agricultural lands.

Root and fruit vegetables are important kinds of vegetables in the human food diet. These kind of vegetables are rich in vitamins and nutrients. However, root and fruit vegetables should not contain heavy metals over a range of concentrations, which could pose potential health risk to the consumers. Contamination with heavy metals is considered an environmental threat, as these metals are toxic even at low concentrations. This study was conducted to determine heavy metals concentration in root and fruit vegetables in the central Jordan Valley region in Palestine, which includes Nablus east, and Al-Jiftlik village in the West Bank. Thus, vegetable samples, particularly Potato, Zucchini, Eggplants, and Onions, had been collected from different farms, and analysed for different heavy metals (Fe, Pb, Cr, Co, Cd, Mn, Ni, V, and Ba) by using ICP-MS. For some samples, the results were found to be exceeding WHO/FAO permissible limit for human consumption, while other samples were found to be within the safe allowable limit. Cr was found to be the highest in concentration while Mn, Co, Ni, Fe, and Cd were the lowest. Ba and V concentrations varied between high in some samples and low in other, then comes Pb that showed a concertation close to the safe limit of the (WHO). Soil samples in addition to water samples had been also analysed for their content of heavy metals in order to correlate the environmental factors to heavy metal contamination. However, most of concentrations were below the limit set by WHO/FAO and it was hard to build a relationship of soil/water to plant transfer of heavy metals. It was noticed that the Ni, Mn, Co, as an essential elements were found to be very low concentrations in soil, and water samples, and thus their concentration were low in most of the vegetables samples. Cd showed a very low concentration, Cd was very low and even below the detection levels in some of water/soil and vegetables samples. Pb was very low in most of the soil/water samples, while the concentration of Pb in the vegetable samples were little below the permission level, which suggest that even at a low concentration of Pb in soil/water system, the vegetables were able to accumulate Pb in their fruits. Thus it was concluded that the contamination found in the root samples and fruit samples vegetables samples

was related to the contamination caused by the discharge of raw wastewater to the environment as the case of Wadi Al-Bathan in Al-Fra' catchment in the central Jordan Valley.

Chapter One

Introduction

Wastewater, and more specifically industrial wastewater, is known to be a major source of pollution with heavy metals. The disposal of raw wastewater creates the potential for heavy metals contamination (Jiries, 2002). The heavy metals transferred from liquid phase to solid phase by adsorption, precipitation, and biological uptake act like a basin for metals however, many responses, both physicochemical and microbiological, can help to convert and reallocate the metals within the deposits and the water column (Daghrah, 2005).

Unplanned economic development might affect the stability of environment and can cause pressures on agricultural lands and water suitable for irrigation. To meet the food demand of a growing population, food crops are cultivated in unsuitable areas such as near wastewater streams or other contaminated sites (Sharma, 2016). There are a group of disadvantages of wastewater reuse which are mainly impacts on the environmental condition and health risks. These impacts are often related to the uncontrolled use of wastewater, which increase the spread of pathogens associated with waste, chemicals and other components. The negative effects that are often presented in the soil are salinization, and the possibility of the accumulation of these metals and compounds which can harmfully affect agricultural production in the long run (Gatto, 2010).

In most developing countries, industrial or domestic wastewaters are not treated, and in the cases of treatment, the process includes only primary processes that do not treat heavy metals from the wastewater in general. Longstanding use of raw wastewater for irrigation can lead to the accumulation of these heavy metals in the soil that can be transferred to food crops and thus enter the food chain (Arora, 2008).

According to the World Health Organization (WHO), food security can be achieved by securing that everyone and always have access to adequate and safe food. The amount of the intake of these heavy metals is reported through a worldwide diet, and the health risks related to the intake of these metals are also identified (Arora, 2008).

Vital organs can be affected in relation to the accumulation of heavy metals that exceeding permissible limits (Dorne, 2011). Kidneys, bones, blood and liver, can negatively be affected if the limit of heavy metals intake has been exceeded, and it might cause serious health risks. Health effects such as neurological disorders, cardiovascular problems, bone problems can be associated with heavy metals accumulation in the human body (Dorne, 2011). Heavy metals such as cadmium, copper, lead and chromium can cause a real negative effects on the healthiness of the human body be alerting its organs functions (Dorne, 2011). It is worth mention that because of heavy metals nature especially their water solubility, are toxic and can be acute or chronic depending on exposure time (Dorne, 2011).

Vegetables are an important component in a human daily diet, due to high nutritional value and antioxidant. Tuber vegetables can accumulate higher heavy metals comparing to other crops such as grains and fruits. Many studies around the world reported a high proportion of heavy metals in vegetables that are irrigated using raw or pre-treated wastewater (Boamponsem, 2012).

When these metals are present in sediments, these metals can reach the human body by the food chain through plants and animals (Ackah, 2013). The process of metals take up by vegetables can be through absorption from contaminated soil, and often in higher quantities that can be enough to cause negative effects and human body problems both to animals and human (Ackah, 2013).

1.1 Background

The study in general aim of this project is to determine, investigate and specify the impacts of the raw wastewater flow in Wadi Al-Bathan in the central Jordan Valley region and the quality of groundwater and surface water in this basin, as well as the socio-economic factors, and to put a finger on possible measures to improve the situation. This study presents the hypothesis that some of these goods and crop in West Bank region, Palestine, which are irrigated by the raw or mixed wastewater can be contaminated with heavy metals and can be reflected on the health of the people who consume these goods.

The phenomenon of irrigating open agricultural field using untreated wastewater is dangerous and alarming as it is one of the most dangerous environmental practices. Especially in the central Jordan Valley villages, which includes the villages of Al-Aqrabbaniya, Nasiriyah, and Al-Jiftlik. It has also an impact on polluting the soil and the vegetation and turning the area into a health-related disaster.

The study area characterized by a unique agricultural nature, in addition to the abundance of agricultural land, which covers an area of about two thousand donums, planted with open field plants in the central Jordan valleys. However, in parallel to the vast area of agricultural land, there is a huge problem because of water shortage in this area. This fact has forced many farmers in the area to rely on wastewater that comes from Nablus East area, which are consists of domestic and industrial wastewater.

1.2 Problem statement

Pollution and limited access to clean water and natural resources are considered major challenges that facing the Palestinians in the West Bank. The study area of this research (Central Jordan Valley) has a main Wadi with its boundaries that is called 'Bathan Wadi', which was considered as one of the fresh water stream that flows from the eastern part of Nablus city toward Al-Jiflik in the central Jordan Valley area.

Al-Far'a catchment represents one of the important groundwater resources located between the eastern and north eastern aquifers in the West Bank, which used to be a source for the fresh water for its surrounding area. The current situation represented by discharging of wastewater into the Wadi which prevents the local farmers and the population of the nearby villages form the benefit of this natural resource.

In addition, wastewater flow may infiltrate downward the groundwater and affect the nearby springs and water wells, which are supposed to be used by surrounding local farmers as primary water resources for agriculture purposes mainly. However, discharging wastewater into the stream body particularly from Nabuls East area has increased the dangerous effects on the environment and water resources such as water well that are located along the stream body. Additionally, the flow of wastewater may affect the economic aspect by decreasing the agricultural activities, and livestock production in the villages of (Al-Aqrabbaniya and

Nasiriyah), and Al-Jiftlik, and also may affect the environmental, natural and the aesthetic aspects of the study area.

Moreover, there is a noticeable lack of information about the study area, in terms of hydro-chemical parameters and the environmental consequences of discharging the raw wastewater to this water catchment as well as the chemical changes in the constituents to the water well that are located nearby the stream and are used by the local farmers for their agricultural activities. The study area currently is suffering from neglecting and lessening by related stakeholders, despite it creates a critical pollution source for the population and the bio-environment.

This catastrophic environmental damage requires an urgent assessment, in order to realize the dimensions of the problem, which could create a base for decision makers to rely on. This research study has been conducted in order to assess these problems, meet the need to conduct such researches and open prospects for additional studies that evaluating the environmental status of the rest issues in this catchment.

1.3 The project objectives

The aim of this research is to study the impact of using untreated wastewater or mixed water for irrigating agricultural fields in the Central Jordan Valley villages, the research will focus on the following objectives:

1 To establish an environmental study that focus on the raw wastewater impacts on the agricultural sector in Palestine.
2 To establish a study that will support the Palestinian decision – making level to improve the wastewater and water situation in the study area and to improve the environmental protection mechanisms by the application of environmental regulations to monitor, and develop the agricultural sector in the Jordan Valley area.
3 To measure heavy metals concentrations from water samples collected from agricultural water sources located near the wastewater stream that flow from Nablus East toward Al-Jiftilk village, in the central Jordan Valley region.
4 To measure the contamination level in the soil, using soil samples from different agricultural lands located near Al-Bathan stream.

5 To measure the contamination level in agricultural crops in the study area, and to compare it to national, regional, and international standards.

1.4 The project significance

This project will be of a major importance for the local citizens who consumes vegetables that can be sourced to this agricultural area, farmers who plant these crops in the study area particularly, and local Palestinian decision makers such as the ministry of agriculture, the Palestinian Water Authority, and the Environmental Quality Assurance, the decision makers can use the data presented in this project as a source of information at the project's study area. The results of this research is expected to be the spirit of a guides for farmers and consumers, grow and eat vegetables free from contamination and as healthy as possible. This research project will also provide interpretation of concentrations of Iron (Fe), Lead (Pb), Barium (Ba), Chromium (Cr), Manganese (Mn), Cobalt (Co), Nickle (Ni), Vanadium (V), and Cadmium (Cd) metals in the chosen vegetables which would be compared with the WHO standards for these metals safe limit content in vegetables. The research project would give a deeper understanding of the situation of agricultural activities and the effect of using raw wastewater for irrigation in the study area in the West Bank for further studies.

1.5 Methodology

In this research project two data bases have been use, which are primary and secondary data resources. The primary data are mainly from the direct interpretations from the study area. The data used are conceptual and provides evidence bases for future studies, it is also informatics and helps to comprehend the current situation. While the secondary data are built through circulations of the available data in the forms of archived studies, literature reviews, published documents, mapping, analysis and interpretation.

Mainly the methodologies of data gathering classified according to the aspects to be searched and purpose of this thesis research which is the heavy metals concentration in vegetables cultivated in wastewater contaminating conditions. In order to evaluate the different trends of water and wastewater quality mainly for the heavy metals concentration and its effects on the soil and vegetables qualities during the two periods. Methodology of water quality assessment in this research consisted of two samplings campaigns for the study area which are – The wet season (the farming season) which has been conducted in January 2019 and the dry season (non-farming season) which has been conducted in June 2019.

1.6 Heavy metals

Heavy metals are the element that has a relatively high density, and for some of these metals, it is toxic and poisonous even at low concentrations. Heavy metals are these elements that has high density, examples of these elements are Cadmium (Cd), Chromium (Cr), Lead (Pb), and Mercury.

Heavy metals can be found naturally in the deposits of the earth crust. But the issue of heavy metals is that they are non-degradable at most cases under certain conditions. For human body demand, some of the heavy metals considered to be essential such as the Copper (Cu), and Zink (Zn) but the intake of these element must be a low concentration for the human body safety. Poisoning with heavy metals can result from eating contaminated vegetables or by drinking contaminated water with a concentrations of heavy metals content that exceed the safe limit.

For example, (Michael, 2014) has suggested in their recent study that adverse health effects might occur with the cadmium exposure even at low concentrations than comparing to these previously predicted. The negative health effect that might occur associated with the high exposure of cadmium to human body are in the form of kidney damage and possibly negative effects on the bones. Other heavy metals can enter the human body by many other sources mainly through the food chain, mercury can enter the human body through the consumption of contaminated fishes that considered as the major source of mercury to human body (Michael, 2014). To reduce the exposure to these heavy metals such as cadmium and mercury, many regulation has been taken to reduce the possibility of these metals content in the food chain and other source that might enter the human body. Therefore, measures must be taken to reduce the exposure of to these metals by the total population in order to decrease any possible negative health effects associated with the intake of these metals to the human body with high concentration (Michael, 2014).

The major source of heavy metals to the environment is the human activities such as the industries, these industries can affect the environment by the discharge of these heavy metals that might result in water contamination, aquatic and animals' contamination. Human activities such as mining and the discharge of untreated wastewater to the environment through natural systems such as aquatic or by natural water stream can be a major source of heavy metals to the environment (Ammann & Chem, 2002).

Contamination with heavy metals either though water system or other natural system is a major problem in the growing cities in the developing countries, and this is due to the discharge of industrial wastewater to the natural systems that would lead to a huge environmental concerns (Maigari, 2018). Heavy metals by its nature are of a high bioaccumulation and bio magnification rates and potentials and with a very high long term persistence in environmental compartments. Therefore, attention must be given to the content of these metals in the natural system to avoid its entering to the food chain and to monitor its level to keep it within the safe limits (Isa, 2017). Monitoring of the heavy metals in the water system is important and significant to make sure these water systems are not contaminated and to insure the sustainability of these water system and the related ecosystems functions (Maigari, 2018).

Far apart from organic pollutants, heavy metals cannot be biodegraded when it enters the environment. Therefore, the purpose of pollution control strategies is to mitigate and reduce the bioavailability of these metals and their toxicity (Kapri, 2010). There are some methods for removing heavy metal contamination have been identified which include the physical removal, detoxification, ion exchange, bioremediation, and complexation (Kapri, 2010).

Some toxic metals have been studied extensively, for their entry roots and their reactions when entering the environment, such as arsenic, cadmium, mercury and lead. Regarding the entry routes of heavy metals, it includes inhalation, manual handling, water resources, ingestion of food and acid rain (Renuka, 2016). Skin absorption is rare. In fact, plants are mainly exposed to heavy metals through the contaminated water uptake or by the application of some fertilizers or pesticides (Radojevic, 1999).

1.6.1 Heavy metals in soils

For human being living and food dependency, soil is a basic source when it comes for agricultural production. And even when it comes to the relation between economics, soil is the most fundamental element for human production and economics. To keep healthy of the soil and thus the healthiness of these economies and humans, environmental pollution is a major concern especially the soil chemical pollution. Contamination of soil with heavy metals considered one of the biggest environmental concerns. And therefore, many work is taking place to monitor the content of heavy metals in the soil as the main element in the human economies and for agriculture in particular.

Heavy metals remain in the soil for a long period and have a residence time ranging from a few to several hundred years (Kabata-Pendias, 1995). The environmental contamination caused by heavy metals can be broadly grouped as follows: (1) The deficiency of cations of micronutrients and (2) the toxicity of heavy metals. The surface layers of the soil may accumulate large amounts of heavy metals, which later affect the sensitive plants that grow in the soil.

There are many factors that are used as indicators for soil fertility and healthiness, soil microbes are one of the most important element to be studied as an indicator of the soil quality and this this due to their high sensitivity of any environmental changes in the soil normal conditions grater to any other indicators comparing to large animals or plants (Chu, 2018). There are many effects associated with the changes in the soil normal conditions due to contamination with heavy metals, the soil microbial effects can include influences of heavy metals on the soil microbial essential activity in the soil which can alert the soil microbial ecosystem and the enzyme soil microbial activity which considered as one of the most important soil microbial activities (Chu, 2018).

Soil microbial ecosystem plays a major role in keeping the function of soil ecosystem at large, one of the most important soil microbial functions is the major role of elements and various nutrients transformation and storage (Chu, 2018). But at the main time, soil microbial ecosystem also plays a major role in the decomposition of the organic matter in the soil and thus enrich the soil with many important nutrients and also in the decomposition of mineral and nutrient release to soil ecosystem (Chu, 2018). The plant is also dependant on the soil microbial ecosystem due to the important roles that this ecosystem plays in the release of important nutrients to the soil profile and making them available to plant uptake (Chu, 2018). In the agricultural production, soil microbial ecosystem is a major important element for the agricultural production, there are two major effects for good soil microbial ecosystem, the first one is by the organisms themselves, which they contain a certain amount of essential element to the soil and plants which are considered as a major source of C, P, and N and by providing these elements to the soil it helps in adjusting the nutrients and their storage in the soil (Chu, 2018). The other major role of soil microbial ecosystem is the ability of the soil microbial ecosystem to transformations and the enhancement of the metabolism process in the soil profiles and thus can promote inorganic elements to flow (Chu, 2018).

1.6.2 Heavy metals in vegetables

For human diet, vegetables considered to be vital, and it particular considered as a main sources of nutrients in order to maintain the health of the human body and its physiological functions (Tsdale, 2004). Vegetables contamination with heavy metals is a series human health risk, the contamination with heavy metals can be caused through the prolonged use of some fertilizers and pesticides that would lead to heavy metals accumulation in the soil. Another sources of heavy metals accumulation in the soil can be through the discharge of raw wastewater to the environment that would reach the agricultural production system and thus affect the quality of vegetables (Tsdale, 2004).

Vegetables is considering as main source for many essential elements to the human body demand (Tsdale, 2004). It provides a major source of vitamins, fibres, and minerals, and also can play a major role in the ant-oxidative effects (Tsdale, 2004). Therefore, the intake of good vegetables diet is essential for maintaining a good health for human body, however, the intake of contaminated vegetables with heavy metals can cause a series negative health effect for the human body (Tsdale, 2004). In order to insure a good healthy food, there are many aspects to be considered for the quality of food to meet human body demand, regular checking of the quality of food is taking place to assure the quality of vegetables and most importantly the amount of heavy metals content in these vegetables (Tsdale, 2004).

Heavy metals can reach the food chain through the accumulation in the vegetables (Radwan, 2006). Urban and industrial development must be controlled in order to reduce the possibility of contamination resulted from these industries as the rapid and uncontrolled industries have been contributing to increasing the levels of heavy metals in the urban environments (Radwan, 2006). The discharge of the untreated wastewater and particularly the industrial wastewater can contribute to increasing the heavy metals in the water and soil systems through the transformation of these metals from the water to the soil systems (Radwan, 2006). Moreover, the effect of discharging untreated industrials or mixed wastewater to the environment and result in the accumulation of these heavy metals in the soil and then to the plants and vegetables which human can consume and this will affect the human body health (Farzana, 2009).

The concentration and accumulation of heavy metals in the vegetables can be through the plant uptake of these heavy metals through a contaminated soil, moreover, the uptake of these metals would be of much greater than the consideration of these metals in the soil solution (Calace, 2002). The plant can accumulate heavy metals in it tissues through the plant roots and foliage (Calace, 2002). But also the heavy metals can transform from the contaminated soil or water to the plant tissues through the plants roots as dissolved ions (Salariy, 2003).

Heavy metals accumulation in plant and vegetables irrigated by untreated wastewater has been considered as a serious environmental problem in many developing countries such as Palestine, where the irrigation of crops by treated wastewater has become a widespread agricultural practice in order to meet the development in the agricultural sector and the huge demand on water for irrigation. Thus, the irrigation of agricultural crops even by treated wastewater have to be controlled and monitored for its safety for crops irrigation (Iyengar, 2000).

Through the accumulation of heavy metals in vegetables, these metals can enter the human food chain through these contaminated vegetables and would huge a serious negative health effects on humans consuming these contaminated vegetables. The accumulation of heavy metals in the soil will not only affect the quality of these vegetables for human demand, but also it might deplete some of the essential element and nutrients in the human body as a result which this might affect further the immunological defences (Iyengar, 2000). The accumulation of heavy metals in the human body though the intake of contaminated vegetables can affect the intrauterine growth retardation and disabilities associated with malnutrition which might cause cancer for human (Iyengar, 2000).

1.6.3 Heavy metals in water

Heavy metals are toxic in general, but in aquatic life, heavy metals concentration in water system receives a real consideration because of the heavy metals nature of bioavailability and mobility in the aquatic system in particular and thus a high bioaccumulation rate (Mason, 1991). Anthropogenic human activities consider as the major source of heavy metals to enter the environment and particularly the aquatic systems, but also from atmospheric deposition, and erosion of minerals from geological environmental sources, but it remains that the human activities considered as the major sources of heavy metals to enter the environment through mining activities, industrial wastewater discharge to the environment without advance proper treatment and other anthropogenic sources (Tarvainen, 1997).

Heavy metals toxicity is variance between the metals themselves, some of these heavy metals considered to be very toxic event at very low concentrations such as Cadmium (Cd) and Lead (Pb). Other heavy metals considered to be essential for human body health, metals such as Zink (Zn) and Cupper (Cu) are essential for human body health and required at certain concentrations and these metals are natural constituents in the aquatic systems and only become toxic when their required concentration for human body demand has been exceeded (Khallaf, 1998).

Heavy metals are different in their nature from other element, they are non-biodegradable by their nature same as other inorganic pollutants (Tulonen, 2006). Heavy metals are mobile and has a very high bioaccumulation rete by their nature, they can enter the food chain and then accumulate through the food chain and their toxic effects can have produced away from their main sources, so that, heavy metals control and monitoring is essential due to the difficult in controlling their movement and accumulation when they enter the environment (Tulonen, 2006). The accumulation of heavy metals in the human body though the food chain can occur through the contamination from the medium that these vegetables or other good grow in, such as contaminated soils or waters for irrigation (Tulonen, 2006).

Study Area

The field work was conducted in the Central Jordan Valley area which located in Al-Far’a area, starting from at the North Eastern part of Nablus East district in the West Bank (latitude 32.27 N, longitude 35.31 E, altitude and 360 m above sea level and the study area is extended from the West to the East and about 30 km from the eastern part of Nablus, to the Jordan River, with an area of 331 km2 (EQA, 2004). The stream Wadi Al-Bathan and Wadi Al-Far’a is one of the tributaries of the Jordan River, and one of most important wetlands in the West Bank (EQA, 2004). The topography of the study area is a unique factor in the catchment at large and Wadi Al-Far'a in particular which ranges from 900 m above sea level in eastern mountains Nablus in the west to about 250 m below sea level near Al-Jiftlik village where Wadi Al-Fra'a meets the Jordan River (Figure 1.1). These factors have made a unique sort of biodiversity in this part of the West Bank contributing to create high and unique biodiversity ecosystems, with many plant species especially endemic, and considered one of the largest agricultural areas in the region of West Bank (EQA, 2004).

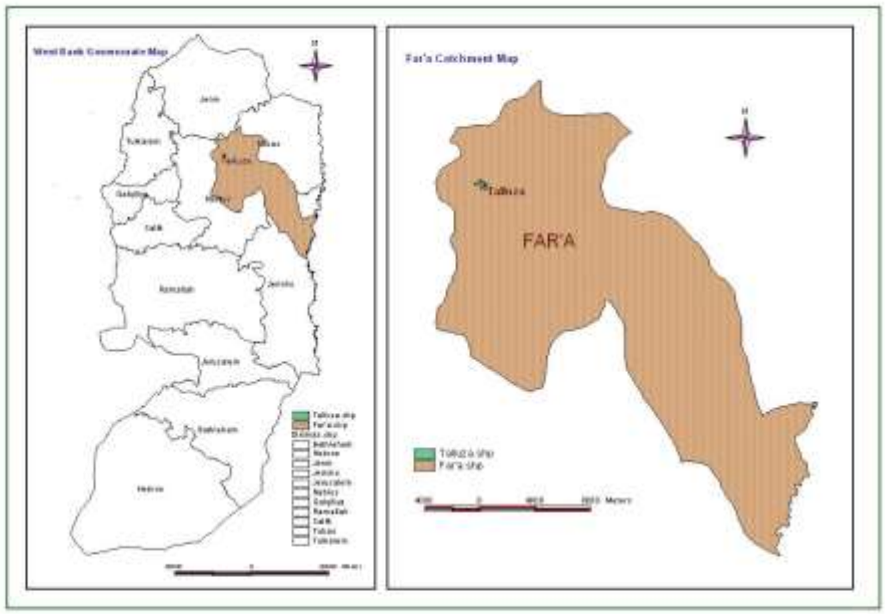

Figure 1. 1: Map of West Bank which showing the study area.

Source: EQA 2004

The study is extended from the eastern part of Nablus city and all the way down to the central Jordan Valley in Al-Jiftlik village. The topography of the study area is created with a high slope level from high mountains to village in the valley below the see level, it is hilly type of topography with a slope around 20% (EQA, 2004).

The soil types of the study area is Rendzina soils, and the texture of the soil is clay at a variable depth, but not deeper than 60 cm and with a rock coverage in general of around 30% of the total study area (EQA, 2004).

The study area has a micro-climate of semi-arid to hyper-arid Mediterranean climate, the study area micro-climate characterised by dry and hot summer, and wet mild winter, with a mean temperature of 14 C minimum and 23 C maximum (EQA, 2004). The annual precipitation in the study area is around 540 mm, which failing mostly in the winter season which starting by November and ends by April (EQA, 2004).

2.1 Agricultural sector – Vegetables

Fruit and vegetables are rich sources of vitamins, and folic acid, and the vitamin A precursor β-carotene. They are also important for the human health, in daily use, humans tend to consume vegetables because they are a major source of antioxidants and are remarkably healthy and have many advantages for human health A diet rich in vegetables and fruits may provide protection against cardiovascular disease, many common cancers, and other chronic diseases (Serdula, 1996).

The Solanaceae, or nightshades is a family of economic importance for flowering plants. The beds range from annual and permanent herbs to chromium, Liana, mashline, shrubs, and trees, and include a number of important agricultural crops, medicinal plants, spices, herbs and ornamental plants. Roots and tubers are plants that produce starchy roots, tubers, rhinosomes, corks and stems. They are used in the main class for human food as such or in processed form, for animal feed and for making starch (Fischer, 2011).

Many epidemiological studies have support the correlation between the intake of regular quantities of vegetables and fruits and the effect of low risk of chronic diseases. There are many biologically reasons show that the consumption of fruit and vegetables might reduce or prevent the commencement of chronic diseases. fruits and vegetables considered as a rich sources of a variety of nutrients, including vitamins, dietary fibers, and many other biologically active compounds. These phytochemicals can provide complementary mechanisms of action, including the modification of detoxification enzymes, reduction of platelet accumulation, formation of cholesterol and hormone synthesis, and lowering of blood pressure.

Vegetables in the West Bank are vary in all governorates. In fact, there are wholesale markets for the sale of agricultural products between the governorates of the West Bank. Through these wholesale markets, agricultural products are supplied by farmers and end up with the consumer

(ARIJ., 2012). These markets also offer a variety of vegetables, fruits and crops. Among those plants are eggplant, potatoes, onions, and zucchini.

2.1.1 Eggplant

Eggplant, the kind of vegetables that is from Solanum Melongena family, it also known as aubergine (HealthyEating, 2012). The eggplant considered as an important solanaceous vegetable crop in many diets in countries all over the world (HealthyEating, 2012). The eggplant is a plant which is a native Indian. This plant considered to be a major source of minerals and vitamins and with its total nutritional value, it can be of a beneficial comparison with tomatoes (HealthyEating, 2012). The biggest countries in the eggplant production are India, Indonesia, Bulgaria, and Japan, and other countries (HealthyEating, 2012).

Farmers in the West Bank are rely on the eggplants as a main crop, and considered as a seasonal crop that usually being cultivated in the winter season for most of the West Bank cities including the cities located in the central Jordan Valley. Farmers consider this crop as an economically feasible due to the high demand on it in the local Palestinian markets.

Figure 1. 2: Eggplant

Credit: Johnny seeds, 2017

Eggplant grows to 98 different species and belongs to three categories: Solanum melongena, Solanum, Aethiopicum and Macanum macrocarpon with 58, 27 and 16 species respectively. The form of eggplant from large zucchini to small gravel and weighs from 15 to 1500 grams. Eggplant contains protein, fats, carbohydrates, minerals, vitamins and water. They reduce the risk of cancer, cardiovascular disease, premenopausal syndrome, menopause, prenatal anemia and cholesterol. They also absorb harmful chemicals, enable weight loss and manage diabetes. Moreover, the leaves, stem, fruit and roots of eggplants are used for food, fuel, rituals, decoration, and to cure diseases.

2.1.2 Potatoes

The Potato which is named Solanum tuberosum as well is a native from South America and in some other literature, it is probably from central Andes of Peru (Richard, 2009). The Potatoes is farmed and grown by the indigenous farmers in many communities all over the world for more than 4000 years. The Potatoes has been transformed to Europe in the 16th century. The Potatoes has been later distributed all over the world including Asia (Richard, 2009).

Potatoes are one of the most important nutrients that meet the nutritional requirements of the human being. All over the world, potatoes come in terms of production after wheat, corn and rice. In some countries it serves as a staple food because of its excellent nutrition contains.

In a worldwide, farmers tend to cultivate potatoes because of its advantages over other crops, such as, potential for high productivity, and being extremely profitable and easily marketed, and also due to its price where it is relatively stable (Warsito, 2006).

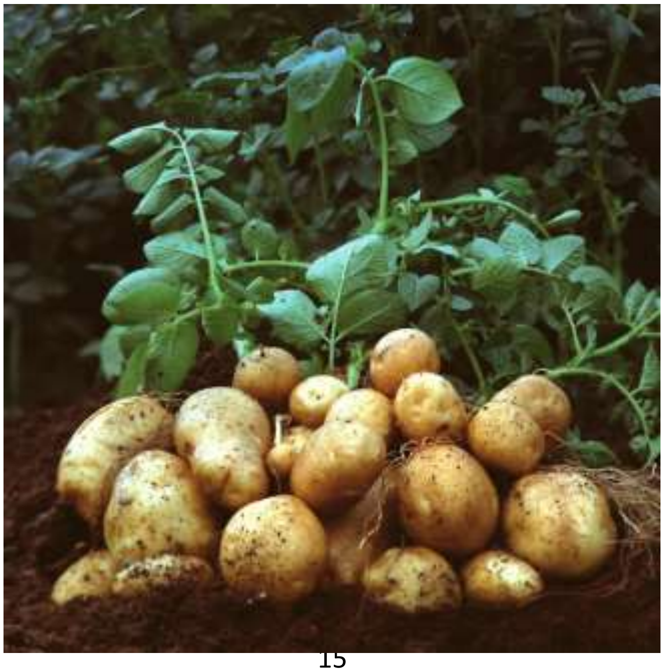

Figure 1. 3: Potato plant

Credit: Griffins garden center

The Potatoes is a root type plants, it is consisting of the following parts: Roots and tubers as the important part of this kind of vegetables as it is the vegetable fruit, leaves which is the part that can be seen from the plant, and the tubers (Warsito, 2006). For each of the mentioned before part of this vegetables has a function; the leaves are the part where plant gets the supply of nutrients. The steam is the supporting part in the plant and have vessels cells inside. And the roots which is to absorb the nutrients from the soil, and the tubers which considered as the storage part in this vegetables (Warsito, 2006).

2.1.3 Onion

The Onion which also known as Allium cepa L. scientifically, it has been recognized as most of the most important food vegetables but also as a medical plant since ancient times (Aklilu, 2015). The onion is one of the most cultivated crops wildly it is in the second place after tomatoes, making this crops as one of the most culturally consumed at worldwide (Aklilu, 2015). The onion is the most important vegetable for human daily food demand, it is known as the "Queen of the kitchen" due it its unique taste and it is used in many of international dishes (Aklilu, 2015). Onion has other importance than being one of the most consumed vegetables, it is also known as natural medicinal vegetable (Sunil, 2017).

Onion is one of the biggest cultivated crops all over the world, it is extensively grown widely with a world production of 74,250,809 tones/year (Warsito, 2006). There are many countries that depends on Onion production as one their main agricultural economy, China and India are among the largest countries of the Onion production, followed by the United States of America, Egypt, Iran, Turkey, Pakistan (Warsito, 2006).

Figure 1. 4: Onion plant

Credit: West Coast Seeds

Onion farming is either semi-annual or permeant crop, this kind of vegetables belong to the family of Amaryllidaceae (Sunil, 2017). The onion is a root type plant it has a adventitious fibrous roots and tubers leaves (Sunil, 2017). The length of the onion stems is between 100 – 200 cm during the second year of the onion plant life (Sunil, 2017). The main food storage is in the tubers and the roots of the onion plant, but also the leaves considered as an extension of external food storage in this kind of plant (Sunil, 2017). The inflorescence is umbel-like and develops from a ring-like apical meristem (Sunil, 2017). The onion plant has an umbel which is the aggregation of flowers developed at a various of stages in the plant life, and it usually contains 200–600 small individual flowers that create the biggest umbel at the top (Sunil, 2017).

2.1.4 Zucchini

Zucchini, also known as the courgette, is a type of summer pumpkin that belongs to the Pumpkin family. Summer Zucchini is part of a humane diet starting from 5.500 years BC. Originating from Central and South America. Summer pumpkins were introduced to Europe in the 16th century. A kind of summer zucchini known as Zucchini was created during the 19th century in Italy. The zucchini germinates in a warm, dry climate, on well-infected moist soil. It is one of the most popular and most consumed vegetables today. China is the world's greatest Zucchini factory.

The Zucchini is one of the most popular vegetables for human diet, it is unique of its high water content with more than 96 percent of the total body of the fruit (Ayotte, 2015). Zucchini is an important healthy vegetable with a very low calories rate in its squashes, in which there are only around 13 calories in half a cup of zucchini, and can be increased to 19 calories when cooked

(Ayotte, 2015). Nutritionally, zucchini is one of the healthiest food for human body, it is valuable antioxidant and it is a major source of vitamins such as vitamin A, and C and a good source of potassium and it is very low in its calories rate which makes the zucchini perfect choice for dieters (Ayotte, 2015).

Figure 1. 5: Lebanese Zucchini

Photo Credit: (Growers, 2017)

Zucchini is an excellent source of many important nutrients one of these are potassium, and it is considered as an important intra-cellular electrical electrolyte (Ayotte, 2015). Potassium is important for the human body health; in which it helps to act as a heart coloured and also plays a major role in reducing the blood pressure and regulating the heart rate resisting the effects of sodium compression (Ayotte, 2015). Zucchini and fresh fruits provides rich source of vitamins to the human body which it provides around 200 IU per 100 g of vitamin A (Ayotte, 2015). Another important vitamin that is provided through these kind of fruits is the vitamin C, which helps to keep the health of the human body and act as antioxidant vitamin (Ayotte, 2015).

In Palestine, this kind of vegetables is known as “Koosa” and this term comes from Arabic, this kind of vegetables consider one of the cash crops and it is widely cultivated in many cities in Palestine, including the study area. The fruits of Zucchini is usually harvested when it reaches a length of 15 cm (Growers, 2017). There are many kinds of zucchini, but the middle-eastern type of the zucchini is known by being stocky, pale green, and tapering ends with a think dark green stem and with a very similar shape to the cucumber (Growers, 2017).

2.2 The Industrial wastewater in the study area

In the study area particularly in the eastern part of the city of Nablus, there are around 115 industrial facilities. Most of these facilities are located in the industrial zone. Due to the decline in the economic situation, 25 industrial facilities were closed (Nablus Municipality, 2006). The main types of industries in the industrial zone are classified into eight types, including stone cutting, quarries, concrete, tiles, concrete blocks, plastics, paper, fodder, minerals, furniture, chemical industries, food industries and slaughterhouses. Table 2.1 illustrates the types of industries and the number of establishments for each type in the eastern industrial area of Nablus city.

Most of the facilities that are located in the eastern part of Nablus city produce wastewater in a conditions similar to domestic wastewater while other industries produce wastewater of specific quality that necessitates special attention and pre-treatment (Nablus Municipality, 2006). Only stone cutting factories have on-site treatment that includes settling basins used for settling and reusing as cooling water. Table 2.1 shows the annual generated wastewater quantities from industrial facilities in the eastern industrial zone.

Table 2. 1**:** Type of Industries, Wastewater Generation and Composition in the East Industrial Zone of Nablus City (Baker, 2007)

Item	**Industry type**	**Total**	**Water consumption m3/month**	**Wastewater generation m3/month**	**Wastewater collection method**	**On-site treatment**
1	Stone cutting	17	905	634	Cesspit/septic tank	Primary sedimentation
2	Quarries and concrete		180	Few quantities for domestic uses	Wadi	No

3	Plastic, paper and forage Plastic and	3	12	12	Network	No
4	Paper and printing	2	375	187	Network	No
5	Shoes and rubber	1	3	3	Network	No
6	Metal and furniture	12	86	76	Network	No
7	Textile	2	9,300	9,300	Network	No
8	Tannery	1	430	430	Network	No
9	Cosmetics	2	69	69	Network	No
10	Paints Ind.	1	105	11	Network	No
11	Chemical detergents	5	265	29	Network	No
12	Insecticide and veterinary medicines	3	67	Unknown	Network	No
13	Tahina industry	7	1,295	768	Network	No
14	Dairy products	1	3,000	3,000	Network	No

2.3 The Agricultural soils types of the study area

Palestine is a small geographical area, however, its soils are remarkably diverse in their properties (Dudeen, 2001). The variation of micro-climate, the origin of these soil from their parent materials, and also the topographic features has made this diversity in the soil types in Palestine (Dudeen, 2001). Many studies has been focused on the soils of Palestine, since the beginning of last century, there are many studies has been subjected to the soils of Palestine (Dudeen, 2001). The major purpose of these studies is to classify, identify and even map the soils (Dudeen, 2001).

The first soil survey was conducted in Palestine was in 1927 by (Strahorn, 1929) from the American Bureau of Soils. During this study, they surveyed almost 4.9 million dunums of the lowlands of Palestine (Strahorn, 1929). They used the American system of soil series as a primary unit for soil classification and for mapping purposes (Strahorn, 1929). During this study, twenty-six soil series were defined and given the geographical names (Reifenberg & Whittles, 1938).

One of the important studies of the soil of Palestine is the study that has been conducted by (Reifenberg & Whittles, 1938) in which they studied the detail the chemical properties of the most soil types in Palestine and also compared the result of the study of the composition of the soil to those subjacent rocks (Reifenberg & Whittles, 1938). During this study, the soils were classified according to specific climatic areas in Palestine (Reifenberg & Whittles, 1938). The micro-climate and climate was considered as a dominant factor when combination of the soil results with the parent materials of these soils (Reifenberg & Whittles, 1938). And the soils were thus grouped into four major climatic zones which also vary according to the rainfall conditions (Reifenberg & Whittles, 1938).

In Palestine, the soils were grouped into four major climate zones; the arid zone which includes desert soil, lisan marl soils, and the loess areas (Reifenberg & Whittles, 1938). The semi-arid region in Palestine includes the soil of the Mediterranean steppe and sand dunes (Reifenberg & Whittles, 1938). The semi-humid areas in Palestine includes kurkar soils which is the sandstone cemented with calcium carbonate, and sandy red soil and nazzaz soils that is red sandy soils, which contain a built-in, impermeable panlayer (Reifenberg & Whittles, 1938). In the humid areas of Palestine, the soils of terra Rosa and red soil includes volcanic rocks and mountain marl soils (Reifenberg & Whittles, 1938). It is worth mentioning that not all of these soils are in the West Bank and Gaza Strip (Reifenberg & Whittles, 1938).

2.3.1 Brown Rendzina soil

The Rendzina soils is one of the major soils in Palestine, it has been typically developing from solid or unconsolidated rocky material that is rich with carbonate and sulphate (Reifenberg & Whittles, 1938). Limestone is the most common in the Rendzina soils but also includes dolomite, gypsum, marble, chalk and marlstone (Reifenberg & Whittles, 1938). The development of the

Rendzina soils is a major result from physical weathering which breakdown the parent rocky materials, and other of chemical weathering (Reifenberg & Whittles, 1938).

The Rendzina soils is a red dark colour which is the effect of clay and humus content that also create the Rendzina soil crumb structure (Michael, 2014). The pH typically for Rendzina soils is between 5 and 8, and it is base saturation is high comparing to other types of soils (Michael, 2014). The potassium content in the Rendzina soil is often low but this soil type is rich calcium and magnesium and usually abundant in this soil type (Michael, 2014). Due to this fact of low potassium content and high calcium and magnesium content in the Rendzina soil this soil type is usually of a nutrient imbalance (Michael, 2014).

Figure 1. 6: Rendzina soil profile

Source: Rendzina flachgruendig Heufeld Schwaebische-Alb

The Rendzina soils is usually poorly suitable for agricultural use (Michael, 2014). And thus, mechanical tillage is required to hindered by this soil type shallowness (Michael, 2014). For the Rendzina soils, the small soil volume limits their capacity to store and supply water (Michael, 2014). Due to the fact that this type of soils occurs usually on slopes, this will increase the risk of erosion is high to occur (Michael, 2014). But by other natural conditions to the locations where these soils found, there is much natural vegetation to be found in these areas (Michael, 2014).

2.3.2 Terra Rossa soil

The terra Rosa soil shown in figure (1.7) is found in many places in Palestine, the term terra Rosa comes from the Italian name of this soil for red soil (Antonio, 2012). Terra Rosa soil exist in many other places in the world, but these soils in particular is common in the areas of the Mediterranean climates, which characterised by rainy and cool to warm dry season (Antonio, 2012).

The terra Rosa soils in well found in the Palestinian areas, and typically in the mountains in the West Bank (Reifenberg & Whittles, 1938). The terra Rosa soils is a naturally formed in the Mediterranean climate regions and the product of this soils is hard limestone (Reifenberg & Whittles, 1938). The soil reaction of the terra Rosa soil is generally neutral to moderately alkaline and thus this soil type has a high content of soluble salts (Reifenberg & Whittles, 1938).

The red colour of the terra Rosa soils comes from the very high content of the iron in these soils and due to the low organic matter which both are responsible for its red colour (Reifenberg & Whittles, 1938). The main texture of the terra Rosa soil is loamy texture (Reifenberg & Whittles, 1938).

Figure 1. 7: Terra Rosa soil profile

Source: Soil System Sciences

Preferential formation of hematite over goethite can result of the red colour of the terra Rosa soils (Randall, 2005). The terra Rosa soil type typically occurs as an intermittent layer that are different in their thicknesses, and can be ranged from a few centimetres to several meters in thickness (Randall, 2005). In the karst regions same as in the study area, the intermittent layer of terra Rosa usually cover the limestone and dolomite bedrocks (Randall, 2005). A situation of underlying limestone and dolomite can be resulted from the internal drainage of neutral pH conditions of the terra Rosa soil in the karstic nature (Randall, 2005).

2.3.3 Alluvial soil

Alluvial soil which has been deposited by rivers is considered the most fertile, as it generally consists of minute particles of soil of various kinds mixed with salts and other minerals, and containing animal and vegetable matters in a state of complete decay shown in figure (1.8). It is now well known that those soils are most fertile which contain the greatest number of different ingredients; and as alluvial soil must have been gathered by the rivers which deposit it from many different lands, and as its particles must have been in a state of minute subdivision to be held in solution by the water, they must, of course, have been intimately mixed, and this is probably the cause of the great fertility of soils of this description. It must be observed, however, that it is only sluggish rivers which deposit rich alluvial soil, and that rapid currents are exceedingly injurious to the lands they overflow. The effect produced naturally by rivers is sometimes imitated by irrigation (Gama-Castro, 2000).

Figure 1. 8: Alluvial soil profile

Source: Civil engineers – Soils types 2018

Alluvial soils is one of the highly fertile soils, it is very rich in minerals and nutrients (Gama-Castro, 2000). The Alluvial soil is considered as a very good soil for the agricultural production due to the very high content of minerals and nutrients in these soils (Gama-Castro, 2000). These soils are often contain sand, silt, and gravels (Gama-Castro, 2000). The Alluvial soils has a chemical content that is dependent on where the soils is formed and located (Reifenberg & Whittles, 1938). The weathering processes plays a major role in the formation of the Alluvial soils, also the topography of the land that can influence the runoff into natural water systems and rivers that eventually from the Alluvial soils (Gama-Castro, 2000). The Alluvial soils is of a unique chemical and physical properties which makes it prefect for the plant growth and the agricultural production (Gama-Castro, 2000).

Chapter Three

Literature Review

3.1 Introduction

This chapter presents an approach to the concept of the study. The discussion presents reviews on wastewater, which includes an overview of the definition of wastewater as well as its various impacts, followed by approaches for the perspective of reuse and preservation of the environment. Furthermore, this chapter provides a range of previous studies and their results for the same concept. These studies will contribute to a general understanding of the research problem and to the adoption of relevant methods to answer the research questions.

3.2 Urban Wastewater Treatment

The Council of the European Communities (CEC, 1991) defines the urban wastewater as domestic wastewater or that water resulted from mixing domestic with industrial wastewater (and / or) storm water runoff.

In particular, the two expressions “Wastewater” and “Sewage” are perplexing due to 'run-off' entity. The first one (Wastewater) is used in USA; while the second ‘Sewage’ is more common in the UK, but the two expressions are used ultimately as synonyms. Furthermore, the difference between run-off sewage and sanitary sewage is that the latter consists of domestic and industrial wastewater (CEC, 1991).

An Urban Wastewater System (UWwS) is composed mainly of three components; the Sewer Network, the Wastewater Treatment Plant (WwTP) and the Water Receiving System (e.g. Rivers or lakes) as well. The UWwS usually has links with other urban water components such as rural streams, groundwater, drinking water production and supply as well as agricultural runoff (CEC, 1991).

The use of wastewater has the potential both to be used as a good fertilizer, since its considered a source of organic matters and plant nutrients which considered as positive externality, as well as groundwater resources polluter with potentially harmful substances including soluble salts and heavy metals like Cu^{+2}, Fe^{+2}, Pb^{+2}, Zn^{+2}, Mn^{+2}, Cd^{+2} and others which would create negative externality.

Using of these heavy metals is undesirable; despite its harmful effects like contamination by heavy metal of soil, crops and different environmental and health negative issues, many farmers using irrigation by wastewater for many reasons like: increasing crop yield, effective way of effluent disposal, low cost source of water, organic matter and nutrient source as well as other reasons (Masood, 2005).

To this extent, the deterioration in water quality is resulted by industrial waste or domestic wastewater, microorganisms in addition to a high concentration of toxic chemical (Yasser, 2010). Other studies reveal that heavy metals resulted from human activities such as industrial activities, automobiles, batteries, tires and wastewater disposal (Miroslav, 2009).

Using wastewater for irrigation contaminates the soil and crops and resulted in plants toxicity and decay of soil (Masood, 2005). One of the most serious polluters that is affecting the fresh water resources is the disposal of domestic and industrial wastewater, it's also affecting human health and agricultural productivity. This problem aggravates in urban and industrial areas, where rapid water quality deterioration may result in different waterborne diseases (Almas, 2013).

The fresh water scarcity has resulted in using wastewater for agriculture and related activities in many countries in the arid and semi-arid region. Irrigation by Sewage effluents goes back to 2500 years ago in Iran (Gadhia, 2014). Currently this practice is common in different parts of the world.

(Das, 2003) found that the natural treatment process of industrial effluent and municipal wastewater could be an innovative process to meet the growing needs of water. The plants' uptake nutrients (nitrate, phosphate, etc.) while soil adsorb the toxic inorganic/organic substances and microbes, this makes it harmless to some extent. However, soil and vegetation have a limit to absorb these contaminants, thus, waste should be given a primary treatment before its disposal. Septic Tanks are widely distributed creating a potential source of ground water pollution in urban settlements.

Enough safe distance should be maintained between drinking water sources and treatment units, to avoid recontamination by accidental discharge. To decide this distance, both soil types and existing hydrogeological conditions should be taken into consideration (Das, 2003). Despite Actions promoting wastewater reuse are common, there is a clear shortage of human health and the environment protection frameworks in most developing countries (Hanjra, 2011).

3.3 Global Studies

There are relevant studies have been conducted to tackle similar issue in different places around the world. Below are some scientific papers that helped me to better understanding of my research, and have supported my hypothesis regarding the impact of using the raw wastewater for agricultural irrigation purposes.

(Sharma, 2016) in their study of the health risks associated with the intake of contaminated vegetables with heavy metals had determined the levels of Cu, Zn, Fe, Pb and Cd in various fruits (tomato, cherry, grape, Lady Finger, Green Chilli Bottle Gourd) (Sharma, 2016). And also they studied vegetables that grown in north-west of Amritsar which are (Onion, garlic, Radish, Turnip) located in Tung-Dhab drain region (Sharma, 2016). They used the Atomic Absorption Spectrophotometer to determine the levels of the selected heavy metals to be studied for their content in these vegetables and fruits (Sharma, 2016). In their study, they have found that vegetables grown in areas close to wastewater flow are not safe for human consumption (Sharma, 2016). They have assessed the health risk associated with the intake of contaminated vegetables with heavy metals in the human body by calculating the hazard quotient and the results of the study revealed that the hazard quotient for leafy and tuberous vegetables was higher than the safe limits in all the sites irrespective of mode of irrigation (Sharma, 2016). The studied vegetables were different in their ability of heavy metals accumulation in the plant body, spinach was at the most hazardous among all studied vegetables as the hazard quotient for cobalt and copper was highest in spinach (Sharma, 2016). They have studied the levels of heavy metals uptake by plants and they have classified the studied heavy metals to their levels of accumulation in these plants as the following; Iron>Cobalt>Copper>Cadmium>Lead (Sharma, 2016). At was concluded by this study that some of the very carcinogenic heavy metals have been found in vegetables at most of the studied sites, such as Cadmium which has been found high in most of the studied vegetables and above the safe limit for human consumption (Sharma, 2016). The highest levels of cadmium content in the studied vegetables was in these farms located close to wastewater drain but irrigated with groundwater, the highest cadmium and copper levels was (1.20mg/kg) and copper (81.33mg/kg) respectively was reported in these sites (Sharma, 2016).

(Achakzai, 2011) In their study of the accumulation of heavy metals by lettuce (Lactuca sativa L.) irrigated with different levels of wastewater of Quetta City have studied the possibility of heavy metals accumulation in the soil as a result of the irrigation with untreated wastewater and the health risks associated with the consumption of these contaminated vegetables grown in these soils (Achakzai, 2011). The study was conducted in Chiltan and Quetta city, Pakistan, in which the study was designed to investigate the heavy metals content in the soils and vegetables in the study area by lettuce (Lactuca sativa L.) (Achakzai, 2011). The heavy metals that was studied by their study was as follows; Cu, Fe, Mn, Zn, Pb, Ni and Cd (Achakzai, 2011). The study has focused on leafy vegetables irrigated with five different wastewaters (Achakzai, 2011). The author of this study used the methodology of using Atomic Absorption Spectroscopy for the analysis of the heavy metals content in the studied plants (Achakzai, 2011). The results of the study indicate that localities, treatments and their interactions, except Cu and Pb is generally exhibited highly significant that resulted in influence on the accumulation of heavy metals (Achakzai, 2011). They have concluded in their study that irrigation using raw wastewater can result in potential health risks for humans who consumes these contaminated leafy vegetables with heavy metals (Achakzai, 2011). The use of raw wastewater for irrigation around the pre-urban areas of Quetta has highly resulted in soil and vegetables contamination mainly due to the contamination of Pb and Cd metals which both considered to be very highly toxic even at low concentrations (Achakzai, 2011). Therefore, they have recommended in their study that domestic and industrial wastewaters in this study area must be treated and properly discharged and or re-used for agricultural irrigation in a proper way so this can reduce the present and future health risks (Achakzai, 2011).

(Adeel Mahmood R. N., 2014) In their study have studied the soil pollution with heavy metals that is related to the discharge of raw wastewater in the form on untreated urban and industrial wastewaters to natural system which is considered as a major environmental threat to the integrity of environment and human well-being (Adeel Mahmood R. N., 2014). The goal of the study is to determine the human health risks associated with the intake of contaminated vegetables with heavy metals and its effects on the human body when entering it through the food chain which is resulted through the irrigation of raw wastewater (Adeel Mahmood R. N., 2014). The research team have analysed the heavy metals content in the irrigated waters, the soils, and vegetables, they have analysed the following heavy metals; Cr, Co, Ni, Cu, Pb, Cd, Mn, and Zn (Adeel Mahmood R. N., 2014). They have also studied the transformation factor of these element from the water or soils system to the plants, and the daily intake of vegetables per person, and the daily intake of metals per person (Adeel Mahmood R. N., 2014). The results of this study has indicated that Cr, Pb, and Cd levels in the studied vegetables cultivated under wastewater irrigation conditions has exceeded the permissible limits (European Union, 2002) (Adeel Mahmood R. N., 2014). As for the transformation factor of each element of the selected heavy metals was lower for all metals except for Co (Adeel Mahmood R. N., 2014).

(Xingmei, 2013) In their study conducted in China, they have done an assessment of the human health risks associated with the human intake of contaminated vegetables with heavy metals (Xingmei, 2013). The study focused on the analysis of heavy metals content in the vegetables and the soils in order to indicate the source of the heavy metals content in these vegetables and soils (Xingmei, 2013). The study area where they have conducted their study is suffering from increasing heavy metal damages from various pollution sources including agricultural activities, mining, trrafic, and Chinese local private family-sized industry (Xingmei, 2013). In this study 268 vegetable samples were collected, which included celery, rape, carrots, cabbages, asparagus lettuces, tomatoes, cowpeas, and cayenne pepper and soils samples in where these plant grown in three economically developed areas in Zhejiang Province, China (Xingmei, 2013). The research team have studied the heavy metals content in the soil samples and the vegetables sample, heavy metals of Pb, Cd, Cr, Hg and As have been studied for their conent in the selected soils and vegetables (Xingmei, 2013). The results of the study showes that heavy metal contaminations in the studied vegetables and corresponding soils were significant (Xingmei, 2013). It was conculded by the research team that pollution levels with heavy metlas content in the vegatlbes and soils were varied with metals and vegetable types (Xingmei, 2013). The study of the health risk assesment reulted in indicating the the diet is a dominated to the exposure roots, so heavy metlas in the soil samoles by their bioaccumllation might cause a seriuos health risks through the food chain transfer (Xingmei, 2013). In a view of the risks associated with the intake of these contaminated vegetables, the study of the health risk assesment has indicated that a total non-cancer and cancer risk results indistace that the vegetables gown in the studied areas is unsuitabel for human demand and the cultivation in these areas is unsutalbe for these kind of crops (Xingmei, 2013).

(Parvez, 2013) have measured : (the different (Physico-chemical) properties (i.e. pH), alkalinity, electrical conductivity (EC), total hardness (TH), Ca+2, Mg+2, Na+, K+, Cl-, NO3- , SO4-2, HCO3-, sodium absorption ratio SAR, total dissolved salts (TDS)) in the groundwater, wastewater irrigated and soil samples.

They found that wastewater affected the groundwater quality by increasing its EC, TDS and TH. Additionally, they found higher concentrations of heavy metals (i.e. Fe and Pb) in groundwater than the required standards of drinking water, due to the location of their study area near sewage water (Parvez, 2013).

In soil samples, except Cu and Cd, most of the parameters were within safe limits. The wastewater samples had elevated values of EC, TH, HCO3-, but the concentrations of all heavy metals were within safe limits (Parvez, 2013).

The study clarified that untreated wastewater polluted the groundwater, but not the soil, since soil particles are negatively charged so they can hold chemical and viruses - positively charged, thereby; soil particles provide a surface for the wastewater to pass over, and accordingly the physico-chemical percentages of soil remained in safe limits (Parvez, 2013).

(Chesnin, 1996) proved in his study that wastewater contains varying amounts of the Heavy elements for example; the installation of nitrogen ranges between (10.7-74.6 mg / l), while phosphorus proportion was less than (0.1-8.1 mg / l), and magnesium amount ranges between (18-116mg / l), in these values there is a high percentage of the Nitrogen concentration (NO3-N), the increase of Nitrogen above permissible limits can lead to groundwater contamination.

(Warner N. C., 2013) In their study that they conducted in Western Pennsylvania on the effects of shale gas wastewater disposal on water quality found that the levels of chloride and bromide concentration in the wastewater has been reflected on the composition of 'Marcellus Shale' produced waters (Warner N. C., 2013). They found that the combination of these elements with the oxygen, radium, strontium, and hydrogen isotopic compositions would affect the quality of the 'Marcellus Shale' waters by affecting its composition (Warner N. C., 2013).

In this study, the research team found that the discharge of the effluent would greatly increase the concentrations of bromide and chloride above the background levels for this region (Warner N. C., 2013). They found that the levels of the stream sediments at the discharge point was greater than the upstream sediments with around 200 times difference between the two points (Warner N. C., 2013). The study has showcased that the levels of the radioactive are also affected, the waste disposal has increased the radioactive levels above the maximum levels for this region which would create a potential of environmental health risks of radium bioaccumulation (Warner N. C., 2013). The study concluded that radium and barium were extraordinary of around 90 percent reduced in the treated effluent in a comparison of its concentrations in the produced waters (Warner N. C., 2013).

(Beata, 2013) In thiers study aimed to determine the degree of contamination of groundwater and the quality of drinking water, in three pig farms employing liquid manure cleaning systems, in lagoons without hydro isolation for storing wastewaters.

Ten piezometers were installed in the three pig farms to monitor the quality of shallow groundwater and its level, whereas samples from the local wells were used to test the quality of drinking water (Beata, 2013).

The significant correlation ($P < 0.001$) between the rainfall amount and the level of water in the piezometers, indicates the possibility of the pollutant's permeation from the earth's surface to the groundwater (Beata, 2013).

They measured the three components; (the parameters of wastewater, solid manure, as well as lagoon sediment) show that efficient water treatment occurred in the lagoons under natural conditions, where the overall contamination in the lagoons has been reduced. In more details; organic matter content in the lagoons was reduced by 85–90%, suspended matter by 94–96%, dry matter by 56–69%, total P by 31–50%, Cu by 69–85%, total N by 39–55%, and Zn by 83–89% (Beata, 2013).

Moreover, the results show that the risk of pollution of surface water and groundwater reduced, due to the fact that most of the metals precipitated in the bottom of lagoon (Beata, 2013). The results showed large variations in the groundwater parameters between different locations of the samples. The content of total N in the reference piezometers ranged between (0.14 and 22.4 mg/L), while the same content proportion was up to (90.4 mg/L) in the piezometers near the contamination source (Beata, 2013).

(Birame, 2012) In their study that focused on studying the heavy metals in Nyabugogo swamp by studying the heavy metals pollution that cased as a result of the industrial wastewater that is discharged as untreated to these natural swamps (Birame, 2012). The study area is the neutral swamp located in the city of Kigali in Rwanda, and it is worth mentioning that these natural swamps receive many sources of wastewater and most particularly the industrial wastewater (Birame, 2012).

The research team has investigated the content of the following heavy metals which are Cd, Cr, Cu, Pb and Zn in all the environmental aspects of the morass (Birame, 2012). The results of this research project have indicated that levels of Cr, Cu, and Zn were within the safe limit of the WHO of the drinking water safe limit (Birame, 2012). While the study has indicated that Cd and Pb were above the safe limit of the WHO guideline for drinking waters, and except Cd, all studied metals were below the safe limit of the WHO for irrigations waters (Birame, 2012).

3.4 Regional Studies

(Abu-Madi, 2004) In this research book of "Incentive Systems for Wastewater Treatment and Reuse in Irrigated Agriculture in The Mena Region: Evidence from Jordan and Tunisia" which aimed to analyze the technological, regulatory, institutional, financial, and socio-cultural incentives and disincentives, which influence the use of wastewater treatment and reuse for agricultural irrigation in the Middle East and North Africa region, based on the experiences of Jordan and Tunisia (Abu-Madi, 2004).

Very low rates of wastewater reuse have been observed in most Middle East and North Africa countries (Abu Madi, 2004). Despite of water scarcity, taken into consideration the urgent need for additional water resources, increasing acknowledgment of treated wastewater as a valuable non-conventional resource, and developing new technologies for wastewater collection and treatment (Abu Madi, 2004).

As a result, the countries of the Middle East and North Africa region which recognize treated wastewater as a non-conventional water resource, and wastewater that still discharged into the sea or water courses without treatment (Abu Madi, 2004).

(Mustafa, 2006) In their study have addressed the environmental impact of wastewater on the two rivers (Tangero and Kulaiasan), as well as its impact on groundwater, the sediments of drainage wadis and agricultural soils. The study found that the two rivers (Tangero and Kulaiasan) and groundwater in the study area is exposed to different sources of pollution like sulfate and nitrate and nitrite and ammonia and ammonium and rare heavy elements (Cd, Cu, Ni, Pb, & Zn) (Mustafa, 2006).

The increase in the physicochemical factors and biochemical demand of oxygen (BOD), and the chemical demand oxygen demand (COD), and the presence of fecal coliform, indicates that surface water and some groundwater models contaminated by wastewater. Agricultural soils in the study area are contaminated soils with rare heavy metals (Cd, Cu, Ni, Pb & Zn), when compared to the international and local standards. The wastewater of the city of Sulaimaniya presents a contamination source for each of the two rivers (Tangero and Kulaiasan), groundwater, the sediments of drainage wadis and agricultural soils as well (Mustafa, 2006).

Using water quality coefficient for agricultural purposes show that surface water and groundwater characterized by good quality for agriculture, with some risks for specific types of crops. Wastewater, it is not desirable for surface water and groundwater, and it cannot have used directly for industries, unless it passes through secondary and tertiary treatment processes (Mustafa, 2006).

(Al-Hammad, 2014), In their research study have performed a sanitary survey of the largest wastewater treatment plant in Riyadh city - Saudi Arabia, to examine its effluent quality (Al-

Hammad, 2014). By which 12 wastewater samples from the WWTP have been examined by biological and physico-chemical parameters using standard methods (Al-Hammad, 2014).

The physico-chemical analysis indicated that the surveyed municipal wastewater treatment plant contained some parameters which exceed the maximum permissible wastewater limits according to Saudi Standards such as: turbidity, biochemical oxygen demand, total suspended solids, chemical oxygen demand and residual chlorine (Al-Hammad, 2014). However, heavy metal concentrations were found within the recommended standards in all samples (Al-Hammad, 2014).

The biological analysis indicated that fifty percent of all wastewater samples were contaminated with faecal coliforms. In general total and faecal coliform results exceeds the permissible limits which reflects poor sanitation operations, but 'Escherichia coli' were detected in 8.3 % of the samples. Finally, and in order to preserve the environment and public health, the study recommended regular monitoring of microbial and physico-chemical parameters for the quality of treated wastewater which is used for agricultural irrigation (Al-Hammad, 2014).

3.5 National Studies

Wastewater that is generated in the West Bank and Gaza strip is usually discharged to the environment either untreated or treated, but mostly untreated (Lipchin, 2017). A report that has been published the Arava Institute’s Center for Transboundary Water Management summarising that around 60 mcm/year of untreated wastewater is discharged to the environment, which creates around 83% of the total Palestinian sewage (Lipchin, 2017). In the Israeli settlements in the West Bank, the total amount of untreated wastewater that is discharged to the environment is around 2.5 mcm/year of a percentage of 12% of their wastewater productions (Lipchin, 2017).

The geopolitical situation between Palestine and Isreal has to lead to creating a large disparity in wastewater management between both Israel and Palestine, the complex political situation, occupation of West Bank, the closure on Gaza Strip, financing and capacity (Lipchin, 2017). The accupation of West Bank in Palestine and the expansion of the Israeli settelement has effected the development in the water and wasetwater management in West Bank, as there are many plans for the implementation of centralized wastewater treatment facilities to service Palestinian towns and cities get mired in disagreements on whether or not to connect Israeli settlements to such infrastructure and an arduous process of permitting and approvals, according to the Joint Water Committee that was set up under the Oslo II accords to manage such projects (Lipchin, 2017). However, many Palestinian communities in the West Bank are off-grid, meaning they do not have access to a sewer network and without a network, they cannot connect to centralized wastewater treatment facilities due to the land division of the West Bank that does not allow Palestinian to develop infrastructure in areas recognized as C areas (Lipchin, 2017). The result is that sewage is disposed of into cesspits or directly into the environment (Lipchin, 2017).

(Auda, 2011) In their study of the concentrations of heavy metals in the soils and accumulation in edible parts of several crop plants that was conducted in Gaza, Palestine, have studied the contamination of Pb, Zn, Cd and Fe that is resulted in the vegetables of spinach, cucumber, wheat, carrot, strawberry, squash, onion, cabbage, faba bean and potato (Auda, 2011). These vegetables were grown in three selected site in Gaza strip in Palestine, the study indicated that concentration of heavy metals was in the normal ranges in the soils samples, except for lead concentrations which in some of the studied samples where higher than other soils samples, in most particularly in the site of Al-Monttar and Gaza city center (Auda, 2011). The study indicated that the accumulation of heavy metals in the plant samples was within the normal ranges, but again except for lead concentrations which were high in some plant samples and exceeding the safe limits (Auda, 2011). Cadmium has a very low accumulation in the plant samples but it was noticed that the cadmium concentrations in the soil samples were at equal levels, while its concentration in the plant was very low and even not detected in some plant samples (Auda, 2011). The research team also studied the measurement of the physiological attributes of the spinach plant revealed that the plant growth might be affected in the case of heavy metals accumulation, in this case, with the increasing of the cadmium concentration in the plant of spinach, because of the ability of cadmium to affect the root length of the plant, shoot length, and fresh and dry weights of the shoots that have been decreased in the case of this research (Auda, 2011). With the increasing of cadmium concentration in the plants, it was noticed that the plant pigments such as chlorophyll a, chlorophyll b and total carotenoids have been significantly decreased (Auda, 2011).

(Al-Khatib, 2019) In their study of the health risks associated with the heavy metals intake through water that have been conducted in Yatta, Palestine, they studied the possible health risks associated with the intake of heavy metals through contaminated harvested rainwater in Palestine (Al-Khatib, 2019). The aim of this research project is to study the potential of negative health effect that might be related to the drinking of contaminated harvested rainwater (Al-Khatib, 2019). The research team have collected around 74 harvested rainwater samples in the period of the months of January and February of 2016 from the study area to analyze its heavy metals content (Al-Khatib, 2019). The heavy metals that have been studied in this research project are Ca, Mg, Al, Fe, K, Na, Ag, Li, Co, Ba, Bi, Sr, Ga, V, Rb, and Mo (Al-Khatib, 2019). The results of this research project indicate that all results of the studied water samples were within the national and international standereds of heavy metals content in drinking waters, except for Al, and K which they were above the allowable limit for these meatals in the drinking waters (Al-Khatib, 2019). The study was carried also to investigate the potential negative health risks associated with the drinking of these waters on the health of the adults and children in this study area (Al-Khatib, 2019). The values of the HRI in this study was below 1 which indicating a good status, except for Li which might be indicating potential health risk for children (Al-Khatib, 2019). The final results of this study have indicated the local residents have a higher chance of developing cancer in their lifetime, especially children, with respect to the carcinogenic risk (Al-Khatib, 2019). The result of the study has concluded that in this study area, geogenic and anthropogenic activities are considered as the major source of the contamination by heavy metals in this water resource (Al-Khatib, 2019).

(Nejem, 2009) In their study that was conducted in Gaza, Palestine has studied the heavy metals concentration in Um Al Nasser village in Gaza, and also they studied the transformation factors of these heavy metals including Cu, Zn, Ag, Pb, Hg, and Cd metals content in studied fruit and leaves of plants grown in polluted soil of Um Al Nasser village in Gaza, Palestine (Nejem, 2009). The analysis of heavy metals content of the fruit and leaves of plants has been carried through using the atomic absorption spectroscopy (Nejem, 2009). The study has indicated contamination caused by the polluted soil which has to lead to contamination of plant by heavy metals and in some cases exceed the allowable safe limit for these metals in fruits and vegetables (Nejem, 2009). The results of the study area showed that the levels of concentrations of zinc, copper, lead, mercury, and silver were in the safe limit and in some plants under the safe limit (Nejem, 2009). It was noticed that the cadmium concentrations were very low and even not detected (Nejem, 2009). The study has focused on studying the transformation factor of heavy metals from soil to plant, the results of the transformation factor were different in all studied vegetable samples and also among the heavy metal as themselves (Nejem, 2009). A very high levels of mercury, silver, and lead was detected in most of the samples from the study area (Nejem, 2009). It was noticed that a very high levels of zink and copper were detected from two kind os plant samples from the study area (Nejem, 2009). In a conclusion of this study, the results indicating a serious environmental contamination with heavy metals in the study area, there are an urgent need to the polluted environment regulate and monitor the environmental conditions in the study area to reduce any possibility of health risks to the residents in this community living within the vicinity of the polluted area (Nejem, 2009).

(Al Daraowsheh, 2014) In their resreach study that focued on the Spatial Quality of domistic Wastewater Flowing in Wadi Al-Zomar and Infiltrated Through wadi bed which they aimed to investigate the degree of pollutants in the infiltrated water and their effects on groundwater quality in Wadi Al Zomar Catchment – Tulkarem (Al Daraowsheh, 2014). The research project has focused on self-purification that can occur in the study area and also the potential of pollutants to infiltration from untreated wastewater through the soil at different sections in the wadi (Al Daraowsheh, 2014).

The quality of wastewater that is discharged into the study area has been evaluated during two seasons, in terms of (COD, BOD, NH4, PO4, NO3, Fecal Coliforms and Heavy Metals), Physical Parameters have also been tested, represented by (TSS, TDS, DO, pH, EC and Turbidity) (Al Daraowsheh, 2014).

The study found that the degree of purification in dry season for COD, BOD, PO4, NH4 and Fecal Coliforms were (50%, 12%,50%, 34% and 84%) respectively, compared to the results of the wet season; where the percentages of reduction were (53%, 48%, 50%, 48% and 90%), respectively. These differences between dry and wet seasons refer to temperature variation and dilution (Al Daraowsheh, 2014).

Furthermore, and in terms of dilution effect; the concentrations of pollutants found to be higher in the dry season than in the wet season, where the percentages of the reduction for COD and BOD were (50%), (20%), respectively (Al Daraowsheh, 2014).

Moreover, during the dry season the infiltrated wastewater results showed a reduction in the measured pollutants; COD (35-51) %, BOD (31-61) %, NH4-N (9-28) %, Fecal Coliforms (87-100) % (Al Daraowsheh, 2014). While the Heavy Metals in the infiltrated wastewater decreased for (Zn) and (Fe) by (48-73) % in both seasons, however, the (Mn) concentration increased from (1-fold) up to (6-folds) in the surface wastewater (Al Daraowsheh, 2014).

(Daghrah., 2005) Has studied the potential of Pollution in natural stream of Wadi Al-Qilt and the Water Quality in this wadi, this research study has focused on the water quality of Wadi Al-Qilt drainage basin, for the purpose of the project obejtive, the research team have located five sampling stations along the Wadi's path (Daghrah., 2005). These stations were located in the period between November (2004) and July (2005), where chemical, physical, biological and hydrobiological studies have been analyzed (Daghrah., 2005).

Results detected major trends in most of measured parameters; where higher concentrations of lead and cadmium have been found in three samples (Daghrah., 2005). However, five samples have been polluted by fecal coliform, which indicates the presence of contamination in the springs sources. Additionally, results showed that three samples were contaminated with aluminum, lead and cadmium (Daghrah., 2005).

Finally, the study found that the dilution process that is resulted from spring's discharge that ends up in the wadi's which are forming Wadi Al Qilt, is the reason behind decreasing the concentration of parameters when water is flowed in the open transportation canal (Daghrah., 2005).

(Amous, 2014) In their research project have studied the fluxes of nitrogen and heavy metals from cesspits in Beit Dajan village in the central Jordan Valley, the research has evaluated the contamination in Beit Dajan and Beit Fourik villages that are located in Nablus governorate, in terms of total nitrogen and heavy metals from cesspits (Amous, 2014).

The average concentration of heavy metals in the cesspit septage were: (Cu 0.24 mg/l), (Ni 0.03 mg/l), (Pb 0.01 mg/l), (Mn 0.47 mg/l), (Fe 12.56 mg/l), (Cr 0.04 mg/l), and (Zn 1.23 mg/l) (Amous, 2014).

After being moved through soil; the concentrations of heavy metals in the infiltrated septage have been reduced. By which Copper (Cu), Nickel (Ni) and Chromium (Cr) have not been found in the infiltrates, other metals have been reduced dramatically such as manganese (Mn), iron (Fe) and zinc (Zn) (Amous, 2014).

Chapter Four

Materials and Methods

4.1 Study Area and Sampling Locations

The study area is located in the northeastern parts of the West Bank. Its western part is Nablus City while its eastern boundary is adjacent to the Jordan River as shown in Figure (3.1). Know as Faria Catchment, which is extends over Nablus, Tubas and Jericho governorates with a total area of 320 km2 , which accounts for 6% of the of West Bank area. Faria Catchment is almost contained within the Eastern Aquifer Basin as shown in figure (4.1).

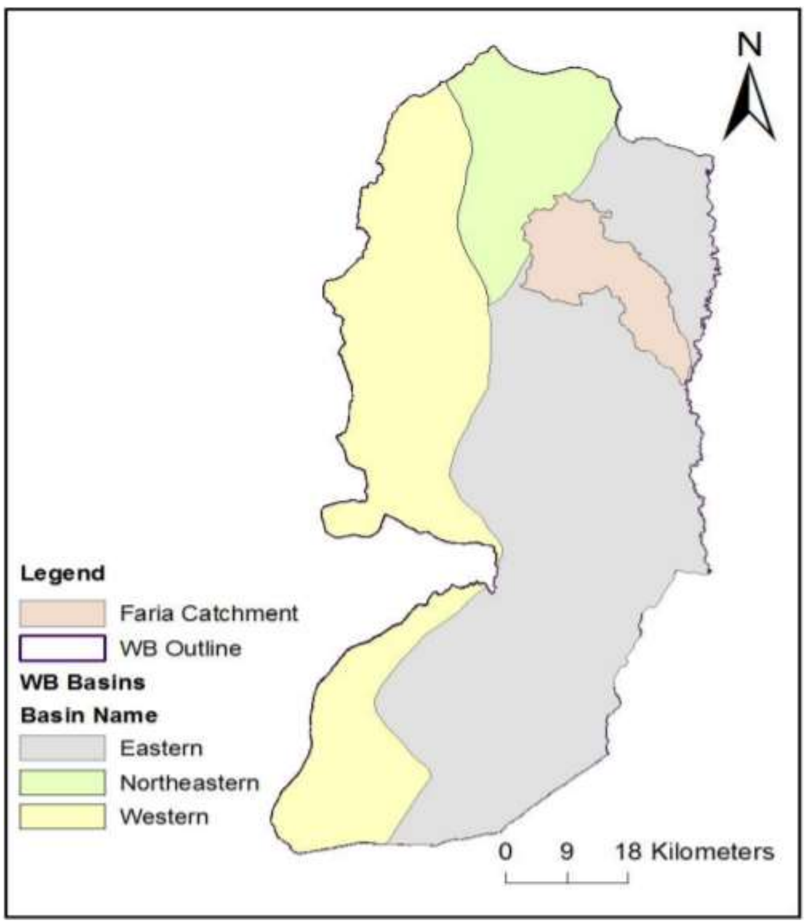

Figure 4. 1: Groundwater mountain aquifers in the West Bank

The main sources of water in Faria Catchment are rainfall, springs and groundwater, and one of the most famous watershed in the study area is Wadi Al-Bathan which is the focus on this research project. The main water use is for domestic and agricultural purposes. Faria Catchment accounts for 20% of the West Bank water resources and it provides more than 26% of total West Bank food basket (Birzeit University, 2003). Wadi Faria (surface runoff) does not dry completely in the summer because of the springs and wastewater effluent form the Eastern part of Nablus City (Abu Ghosh, 2006,). Within the catchment area, the runoff decreases from west to east as the slope becomes relatively gentile eastwards as shwon in figure (4.2) down the main stream where rainfall rates reduce also.

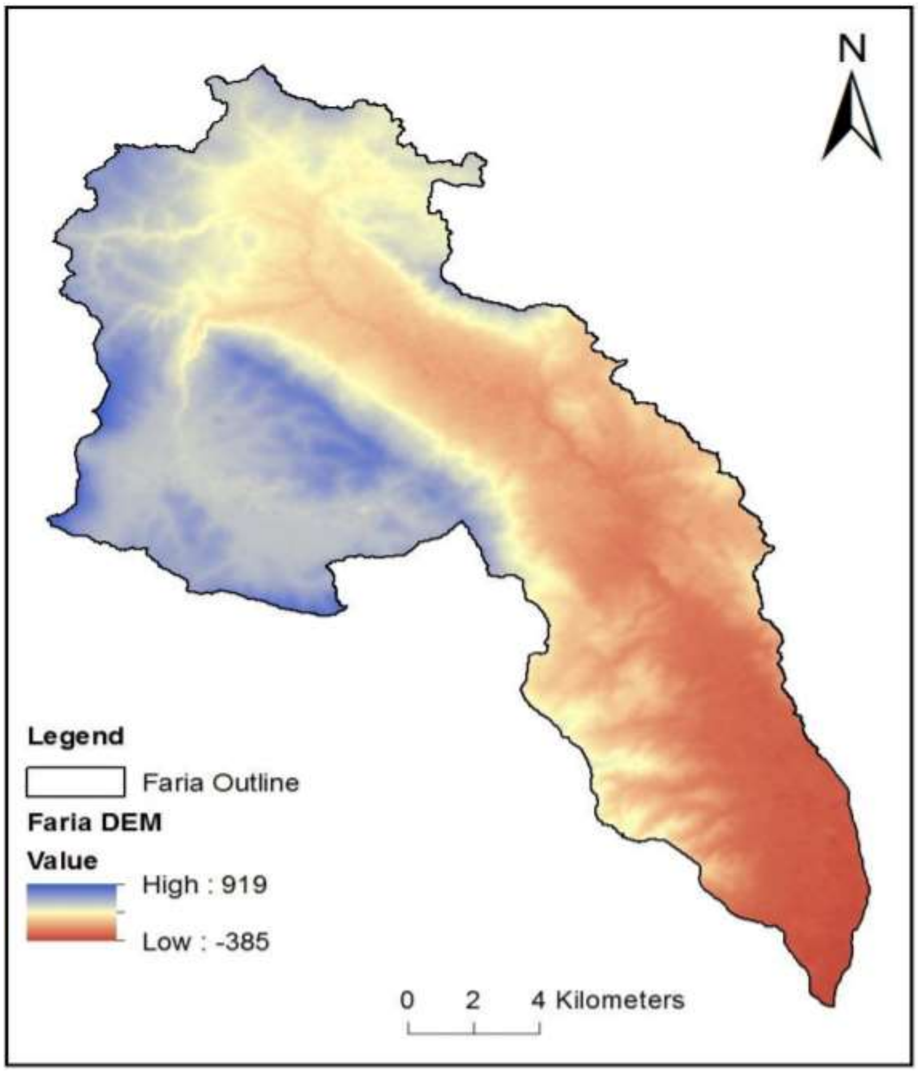

Figure 4. 2: Digital elevation model of Al-Far'a catchment area

For the purpose of this research project, three main communities have been identified in this catchment area for the samples collection. Within the catchment of Al-Far'a, and Wadi Al-Bathan stream, the villages of Aqrabaniyah, An Nassariyeh, and Al-Jeftlik has been chosen for samples collection as shown in figure (4.3).

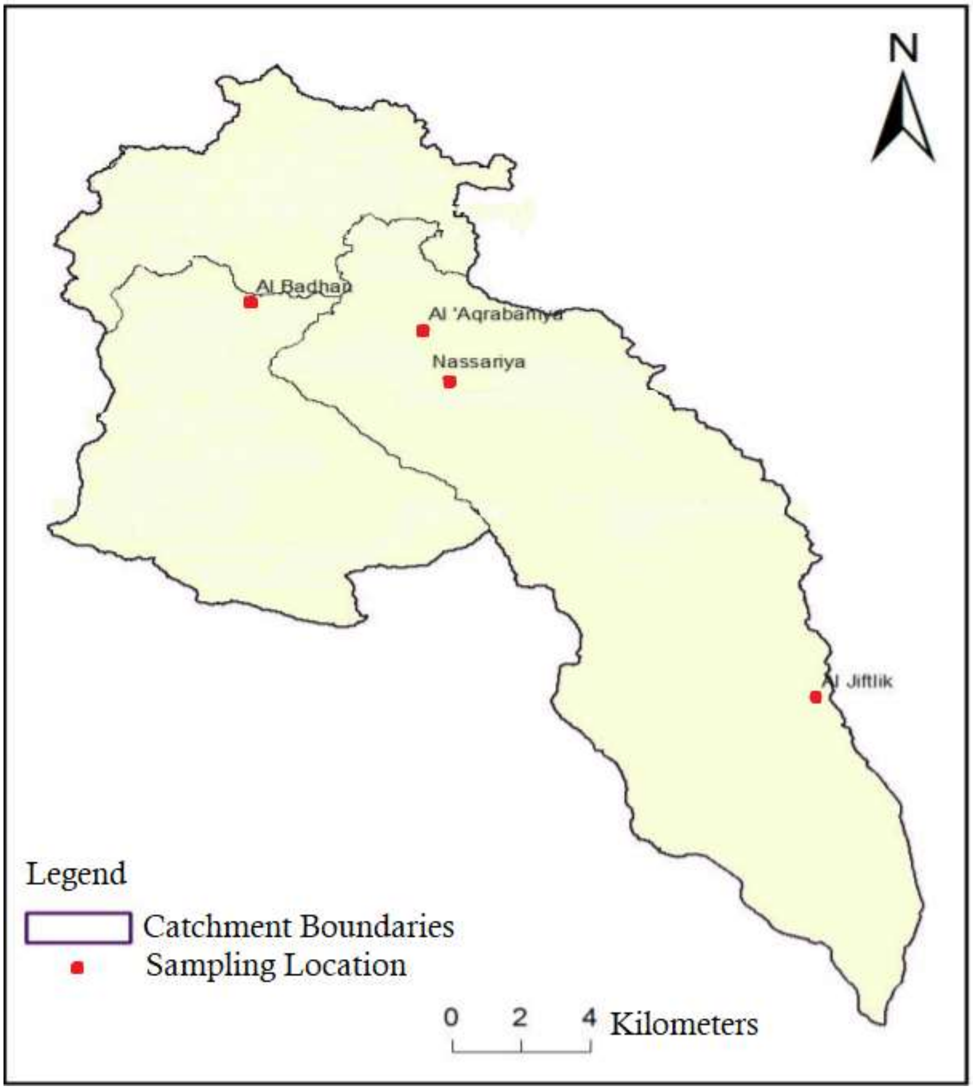

Figure 4. 3: Sampling locations with the catchment of Al-Far'a, West Bank

4.2 Samples collection

More than 50 samples of vegetables, soils, and water were collected during 2018 and around 30 vegetable samples were collected only during one period of time which is the high farming season (Winter Season) and grown in different farms within the study area. Eighteen samples were chosen for analysis. Four types of vegetables were chosen from different farms for the same vegetable. These vegetables were eggplant, potatoes, onions, and zucchini. All collected samples were stored in clean plastic bags and brought to the laboratory for analysis.

Water and wastewater samples were collected from the study area within two periods of time, the first period of time was during the farming season (Winter Season) and the second one was during the low farming season which is the (Summer Season) from each site for further analysis; the same water used for irrigating these vegetables, as there are some fields that are irrigated with raw wastewater or with mixed wastewater. Water and wastewater samples was stored in clean plastic bottles washed with distilled water. On site, the water bottle was washed with the same irrigating water then was filled with water.

Soil samples were collected from the study area within two sampling period, the first one was during the farming season (Winter Season), and the other sampling period was during the low farming season (Summer Season) where almost there are zero ago-activity while the farmers use these months for the next agricultural season as a preparation season.

4.3 Preparation and Treatment of Samples

The collected vegetables samples were washed at the lap using distilled water for the purpose of removing the attached dust particles on the samples. Then, the vegetables samples were cut down into smaller pieces. For the purpose of increasing the accuracy level, random vegetables pieces were selected and taken and dried in the over with a temperature of a 100 °C. The samples then will be ready for the acid digestion after draying them in the oven.

For the process of acid digestion, the Microwave Digestion System (MARS) showed in figure (4.4) was used for the digestion process due to its high speed, precision, and high sensitivity. The method of digestion was given by the machine itself. Each samples of the vegetables samples were weighted of 0.5 grams, then 50 ml of 65% pure nitric acid was added to each sample to create a mixture. Then the mixture was digested until the transparent solution was achieved. After the cooling down of the digested vegetables samples, the samples were filtered using CA sterile syringe filters which has a diameter of 30 mm and the pore size of µm.

Figure 4. 4: Microwave Digestion System (MARS)

The level of determination of heavy metals content in the vegetables samples was reached by using Inductively Couples Plasma Mass Spectrometry (ICP-MS) showed in figure (4.5). Which the Inductively Couples Plasma Mass Spectrometry is an analytical technique that is used for elemental determinations.

As for the soil samples analysis, 50 grams of the soil samples was weighted, to each sample, 250 ml of milli-Q water was added. The milli-Q water is a very ultrapure water that is used in such analysis as defined by the ISO 3696. The analysis of the soil samples includes processes of purification that consist of many stages of filtration and deionization in order to reach a high level of purity that is characterized in term of resistivity 18.2 MΩ·cm at 25°C. The ready soil samples then were kept for 14 days so this time period will allow what surround the soil particles can be tested and will then increase the accuracy rate for this test. In order to reach a high level of accuracy in the soil samples test, this process is applied to reach the highest level of analysis also to the surroundings of the particles. 2 ml of the sample were taken for analysis.

Water samples were tested for its content by the addition of 65% pure nitric acid. 2 ml of the sample were taken for analysis.

Figure 4. 5: Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

4.4 Statistical Analysis

For the statistical analysis, the results of the heavy metals analysis were assessed using Microsoft Excel 2016. The interpretation of the results and data was done by the appropriate mathematical equations in order to understand the conditions in the study area and the issue of the heavy metals content in these vegetables sample. In order to communicate these numbers and results of the mathematical calculations, various of graphs and figures were built in order to understand the levels of heavy metals contamination in these vegetables and to correlate the vegetables results to its corrospendances of the water and soil samples and to compare these results to its national, regional, and international standers of heavy metals content in vegetables.

The selected heavy metals for this study were chosen due to their availability and values in the results and for the main objective of this research project.

As the ICP-MS provides the concentration in parts per billion (ppb), there are a need to demonstrate a path of mathematical calculations that includes conversion between the units of the concentrations of the chosen heavy metals. And in order to build a relation of the study results and its corrospendances international standers of the WHO, the soil and vegetables results have been converted into mg/kg, while water results have been converted into parts per million (ppm).

Chapter Five

Results and discussion

5.1 Introduction

The main objective for this chapter is to determine the presence of heavy metals in vegetables samples from the study area that its sources might be from the water and soil composition in the semi-arid region, where the tested waters and soils are located. The water and soil testes has been conducted to identify the main effects of an anthropogenic factor which is the direct discharged of raw wastewater to Wadi Al-Bathan area that if surface-flowing a distance of around 32 km from Nablus East toward Al-Jiftlik in the Jordan Valley, and this waters infiltrates thorough soil and rocks layers downward to the underground water aquifer affecting groundwater quality, which is represented by agricultural water quality in this study.

Analysis of heavy metals content for each water sources and agricultural land can indicate its properties and qualities for many purposes such as agricultural uses. Thus, water and soil quality variations of heavy metals content can be explained and interpreted based on the circumstances and activities that surround the study area.

Heavy metals have a high resistance for degradation by its nature, and by this, it has been classified as a persistent metal. Each element has certain effects on public health, these effects are dependent on its doses, bio-availability, and chemical composition (Arnason, 2003). The occurrence of heavy elements in the irrigation water can be attributed to natural sources dissolution in aquifers and soil or to anthropogenic activities such as industrial sewage and heavy industries wastes etc., nevertheless, these elements are naturally existed in low concentrations (Arnason, 2003).

More than 50 samples of fruits of vegetables of Zucchini, Potatoes, Eggplant, and Onions from the study area have been collected and tested for its heavy metals content as shown in Table (5.1). Based on the WHO (2007) guidelines for heavy metals concentrations limits for food and vegetables which are listed in the attached Table (5.2).

Sample Name		Sample Fresh Weight (g)	Ba	Mn	Fe	Co	Ni	Pb	Cr	V	Cd
Zucchini	zucchini	0.505	0.54 ± 0.03	1.01 ± 0.01	42.08 ± 1.58	0.01 ± 0.00	0.66 ± 0.08	0.05 ± 0.01	6.71 ± 0.30	0.02 ± 0.00	0.00 ± 0.00
	zucchini	0.503	0.89 ± 0.05	N/D	17.37 ± 0.04	0.00 ± 0.00	0.06 ± 0.01	0.06 ± 0.04	N/D	0.00 ± 0.00	0.00 ± 0.00
	zucchini	0.506	0.45 ± 0.10	0.92 ± 0.08	50.60 ± 2.90	0.03 ± 0.00	0.82 ± 0.03	0.03 ± 0.01	18.46 ± 2.64	0.04 ± 0.01	0.00 ± 0.00
	zucchini	0.503	0.17 ± 0.01	1.46 ± 0.02	141.80 ± 4.93	0.01 ± 0.00	1.40 ± 0.07	0.05 ± 0.04	24.90 ± 0.99	0.09 ± 0.01	0.00 ± 0.00
	zucchini	0.505	0.42 ± 0.00	1.00 ± 0.01	109.45 ± 1.15	N/D	N/D	0.05 ± N/A	N/D	0.07 ± 0.00	N/D
	zucchini	0.506	0.06 ± 0.00	2.08 ± 0.01	121.49 ± 1.80	0.03 ± 0.00	0.10 ± 0.01	0.05 ± 0.02	29.78 ± 1.35	0.10 ± 0.00	0.01 ± 0.00
Potatoes	potatoes	0.502	0.35 ± 0.01	2.72 ± 0.66	154.10 ± 0.71	0.04 ± 0.00	2.38 ± 0.19	0.06 ± 0.01	36.89 ± 2.50	0.23 ± 0.00	0.01 ± 0.00
	potatoes	0.503	1.80 ± 0.01	1.25 ± 0.02	119.89 ± 0.93	0.01 ± 0.00	2.44 ± 0.05	0.06 ± 0.08	29.43 ± 3.17	0.09 ± 0.00	0.00 ± 0.00
	potatoes	0.503	1.61 ± 0.01	1.92 ± 0.01	116.54 ± 1.78	0.03 ± 0.00	2.64 ± 0.10	0.06 ± 0.03	29.79 ± 1.57	0.09 ± 0.00	0.00 ± 0.00
	potatoes	0.505	1.45 ± 0.03	1.32 ± 0.01	110.78 ± 0.50	0.03 ± 0.00	2.82 ± 0.07	0.05 ± 0.01	29.74 ± 1.24	0.07 ± 0.00	0.02 ± 0.00
Eggplant	eggplant	0.502	0.53 ± 0.00	0.33 ± 0.00	116.82 ± 1.12	0.02 ± 0.00	0.01 ± 0.00	0.05 ± 1.26	N/D	0.09 ± 0.00	0.00 ± 0.00
	eggplant	0.502	0.44 ± 0.00	0.85 ± 0.01	133.50 ± 5.92	0.02 ± 0.00	0.05 ± 0.00	0.04 ± N/A	8.06 ± 0.75	0.12 ± 0.00	N/D
	eggplant	0.504	0.14 ± 0.03	0.60 ± N/A	1.20 ± 3.49	0.04 ± 0.00	0.67 ± 0.02	0.05 ± N/A	N/D	N/D	N/D
	eggplant	0.502	0.09 ± 0.01	0.17 ± N/A	31.59 ± 0.69	0.03 ± 0.00	0.47 ± 0.01	0.09 ± 0.03	N/D	0.10 ± 0.00	0.01 ± 0.00
Onions	onions	0.503	0.54 ± 0.03	1.01 ± 0.17	407.33 ± 3.87	0.01 ± 0.00	0.66 ± 0.13	0.05 ± 0.02	30.94 ± 6.81	0.40 ± 0.02	0.00 ± 0.00
	onions	0.505	0.89 ± 0.00	1.19 ± 0.01	123.23 ± 1.16	0.00 ± 0.00	0.06 ± 0.10	0.06 ± 0.10	28.84 ± 0.24	0.13 ± 0.00	0.00 ± 0.00
	onions	0.505	0.45 ± 0.22	0.92 ± N/A	5.66 ± 0.49	0.03 ± 0.00	0.82 ± 0.33	0.03 ± 0.10	28.90 ± 0.71	N/D	0.00 ± 0.00
	onions	0.506	0.17 ± 0.05	1.46 ± N/A	13.98 ± 0.63	0.01 ± 0.00	1.40 ± 0.11	0.05 ± 0.01	28.05 ± 0.75	N/D	0.00 ± 0.00

Table 5. 1: Heavy Metals Concentration (mg/kg) in studied vegetables from the study area.

Table 5. 2: Average concentration of Heavy Metals (mg/kg) in studied vegetables from the study area in comparison to the WHO guidelines 2007.

Sample Names	**Ba**	**Mn**	**Co**	**Fe**	**Ni**	**Pb**	**Cr**	**V**
Zucchini	0.42	1.28	0.01	80.46	0.51	0.05	19.96	0.05
Potatoes	1.30	1.80	0.03	125.33	2.57	0.06	31.46	0.12
Eggplant	0.30	0.49	0.02	70.78	0.30	0.06	8.06	0.08
Onions	1.39	1.96	0.11	137.55	2.69	0.09	29.18	0.20
WHO/FAO safe limit	**1**	**500**	**50**	**425**	**67**	**0.1**	**1.3**	**0.1**

5.2 Vegetable Results

Vegetables were grouped into 2 types (fruit, and roots vegetables) for statistical analysis, as trace metals are known to be accumulated to different degrees in different plant tissues (Douay F, 2013). Roots vegetables were grouped separately from fruit vegetables because preliminary results showed a greater tendency for studies heavy metals to accumulate in roots vegetables than in fruit vegetables such as onion.

A summary of the results of the fruits analyses for Ba, Mn, Co, Ni and Pb is provided in Table (5.2) were all metals concentration in all tested vegetables has been converted to (mg/kg) concentration and compared to the recommended WHO guidelines for heavy metals concentration in food and vegetables. Because this study did not measure vegetable moisture contents, vegetable metals concentrations were converted to (mg/kg) and the average of all results for each metal/crop were taken. concentrations using a published mean moisture content (US EPA. National Center for Environmental Assessment, 1997).

Barium

The average concentration of barium in the studied vegetables varied by type of the vegetables as shown in Tables (5.1), (5.2) and Figure (5.1).

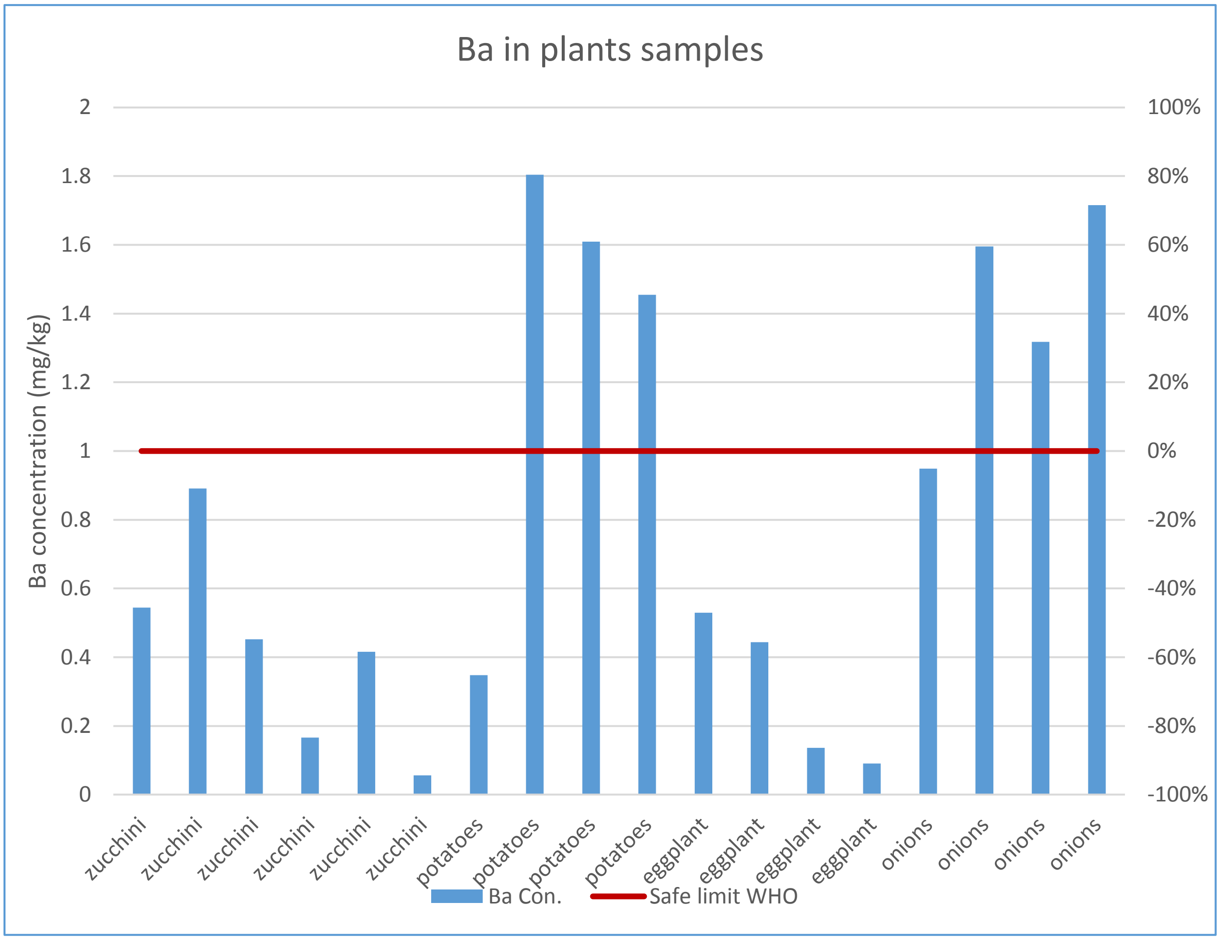

Figure 5. 1 Barium concertation in vegetables samples from the study area

Human activities including industrials activities are diverse, from a huge drilling to small medical research, both considered as a main source of barium to the environment (Hanor, 2000). The human activities can increase the barium concentration in the environment and can influence biogeochemical cycle of barium (Hanor, 2000). Barium can release to the environment through the activities of drilling, medical research, and paint activities (Hanor, 2000). In the industry sector, there are many barium minerals which considered important, such as the Barite that is widely used as a chemical in the manufacturing of glass, paint, plastics and other industrials uses (Hanor, 2000).

For human body, most of the exposure to toxic barium can occur through the pathways of ingestion or inhalation (Gould, 1973). There are many health effects for the human body that are associated with the intake of barium either through ingestion or inhalation which can cause cardiac, renal failure, or respiratory paralysis (Gould, 1973). Barium has been recognized as carcinogenic for human since 1940s and can cause a serious health effects to the human body (Shankle, 1988).

between Ba concentrations in vegetables water Ba concentrations.

As indicated from the results of the analysis, roots type of the vegetables samples has the highest Barium concentrations root type vegetables > fruit type vegetables as shown in figure (5.1). The vegetables type is clearly appearing to be an important predictor of vegetable barium concentrations. Both for the fruits and roots types of the vegetables, there was no significant relationship of the vegetable type and its correspondences soil in the regard to the barium content either in the vegetables samples nor in the soil samples. And as indicated from the water samples results shown in figure (5.2), there was a very weak tendency for crops grown in higher barium waters to accumulate more barium in these vegetables.

Given the results of vegetables, water and soil samples and by the wide range of barium concentrations with each crops of the root and fruit types that makes it difficult to building a relation of the barium content in the vegetables samples to its concentration in the soil and water samples.

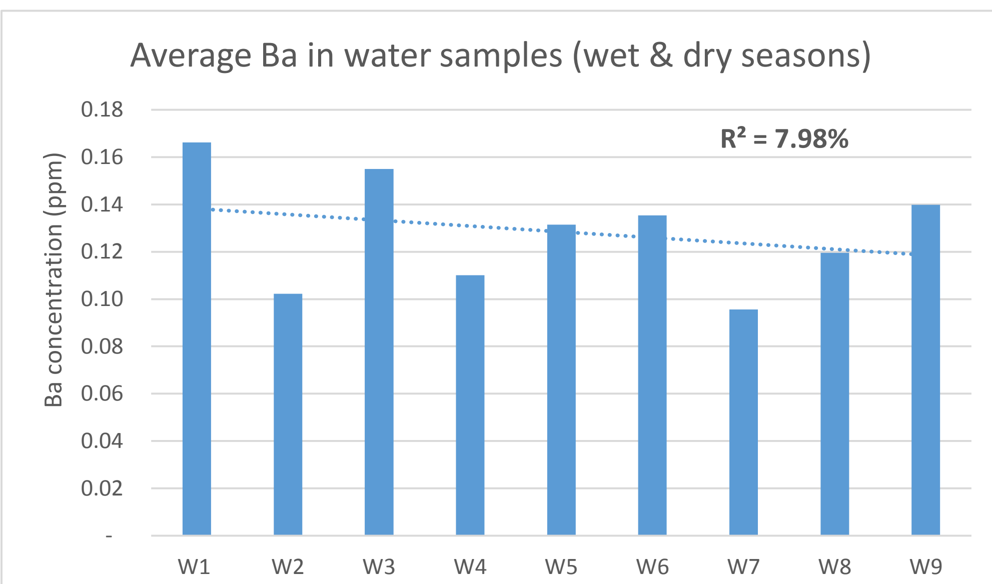

Figure 5. 2 Average Barium concentration in water samples in wet and dry seasons

Although the barium concentration in the root type of the vegetables were much higher than these in the fruit type of vegetables and also higher than the barium content in the soil and water samples, and that makes it hard to understand the relation of physical contamination of barium as it is without any clear explanation of these parameter together and for the water samples in particular as it shown in figure (5.2).

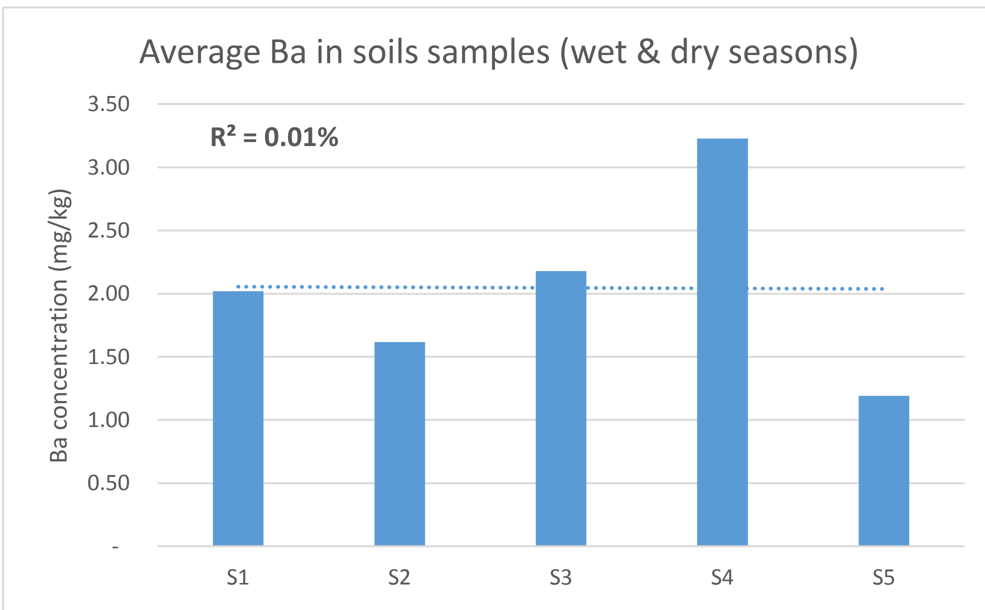

Figure 5. 3 Average Barium concentration in soil samples in wet and dry seasons

Despite the evidence for relatively higher uptake rate of root type vegetables of barium, but in our case, the soil total barium failed to predict crop barium content, see Figure (5.3) probably because the solubility of barium in soils is low and dependent on a number of soil properties (Lamb DT, 2013). Our study suggested that barium contamination might be a source of irrigation of by either raw wastewater or contaminated waters with Ba concentrations, and the fact that barium is soluble in water in higher rate and the plant has the ability to uptake Ba from water via the roots in higher rate than the fruits as it is shown in Figure (5.1).

Manganese

The levels of Mn was ranged (between 2 mg/kg and 3 mg/kg) observed in most of the studied vegetables a low uptake of Mn, way below the toxic levels (500 mg/kg) see Figure (5.4), by these plants, although these levels may not necessarily be toxic to humans. Results of soil analysis show detected levels of Mn, around 08 - 1.0 mg/kg, which are comparable with the low concentrations found in all studied vegetables.

Mn usually accumulates on top soils as a result of its fixation by organic matter (McGrath SP, 1994). It may thus be expected that during the dry season, the relatively high decomposition rate of organic matter is likely to release Mn into the soil for possible uptake by plants (McGrath SP, 1994).

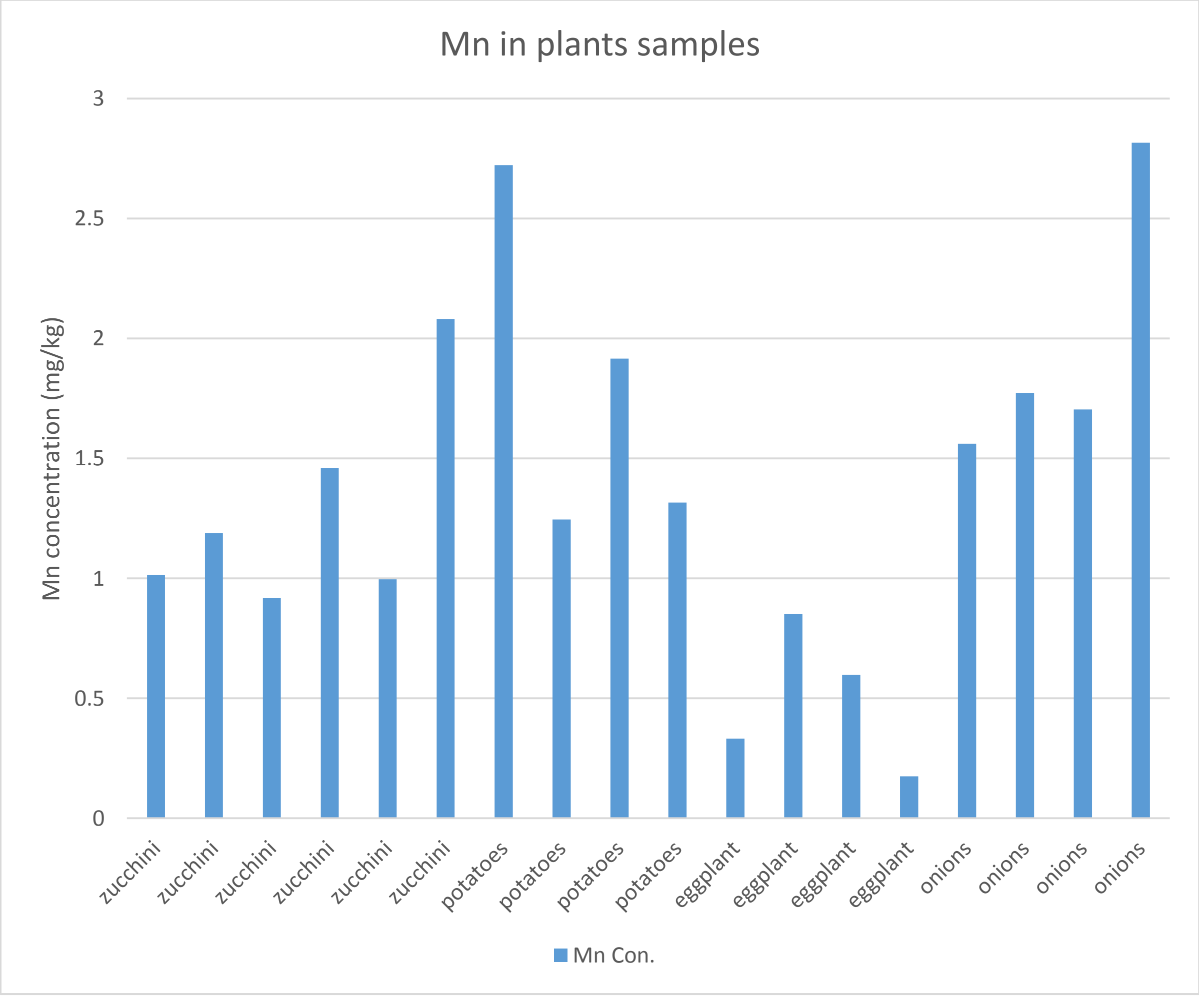

Figure 5. 4 Manganese concertation in vegetables samples from the study area

The Mn level in the tested soil samples were very low and within the WHO permissible limits (12 mg/kg) see Figure (5.5). But even higher concentration of manganese metal in soil does not mean that it will be bioavailable to plants and especially with the application of Fe to the agricultural lands which might decrease the Mn mobility in the soil and thus the Mn uptake by plant as shown in Figure (5.4). A very clear relation can be seen from the data of the Mn and Fe concentration in the studied vegetables, the very low Mn uptake by plant is mainly due to the natural abundance of Fe in the soil of the study area or by the application of Fe to the agricultural lands, which we suggest that will reduce the ability of plant to uptake Mn due to high mobility of Fe in the soil and the suggestion of similar uptake processes by roots of Mn and Fe.

In a recent greenhouse study that was conducted by (Ronaghi, 2008), and the aim of this research project is to evaluate the influence of soil properties with the application of Fe to the soil (Ronaghi, 2008). It was concluded by this research study that in some cases, the application of Fe to the soil might case what is called the nutritional disorder of the soil (Ronaghi, 2008). This effect can be result of the nature of Fe of the antagonistic effect of Fe with other micronutrients and with Mn in particular (Ronaghi, 2008). Therefore, the study has conducted that in some cases of Fe application to the soil, this can result with Mn deficiency and will increase the Fe uptake by plant (Ronaghi, 2008).

Average Mn concentration in the analyzed soil samples remains with very low concentrations between (0.1 – 0.6 mg/kg) which also can’t be correlated to the analyzed plant samples due to the absence of any relations that suggest the contribution of Mn uptake from the soil to the plant, although the soil types in the study area are from Terra Rosa and calcareous soil which can be rich of Fe and Mn, but also the fact that Mn is not bio-available and mobile in the soil under certain conditions, such as pH and soil EC (Loonker, 2011).

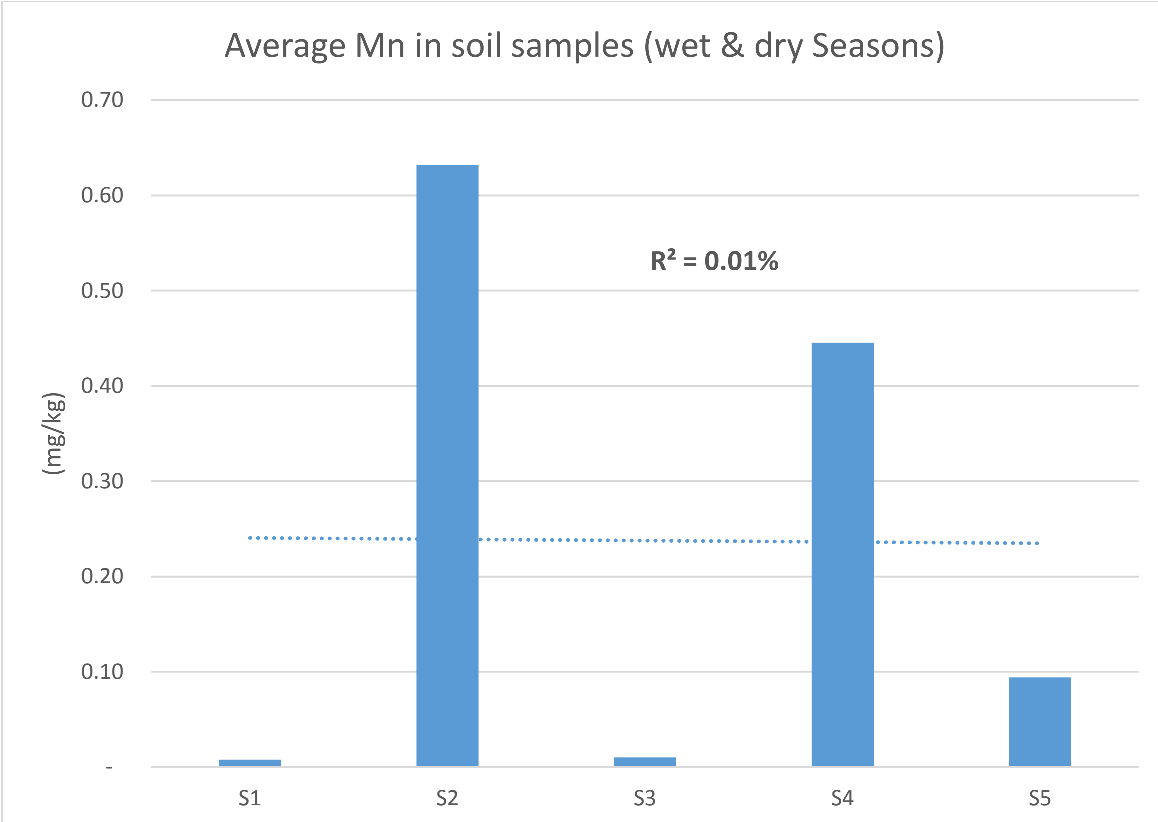

Figure 5. 5 Manganese concentration in soil samples in wet and dry season

The results showed the concentrations of manganese in the water samples to be 0.06 ppm to 0.1 ppm, see Figure (5.6). These concentrations in the samples didn't exceeded the recommended maximum concentration (RMC) for irrigation (0.2 ppm). Manganese (ferromanganese) is used principally in steel production along with cast iron and super-alloys to improve hardness, stiffness, and strength (HSDB, 1998). This makes manganese a component in iron alloys since it is used to improve iron stiffness, hardness and strength. Manganese concentrations in the water samples must therefore increase with increase in iron concentration, but since manganese concentration remained at a very low levels, that suggest that Mn natural removal took place during the discharge of the raw wastewater to the natural stream that is full of raw wastewater with average pH at 8.3 allowing Mn to naturally removed from entering the irrigation waters.

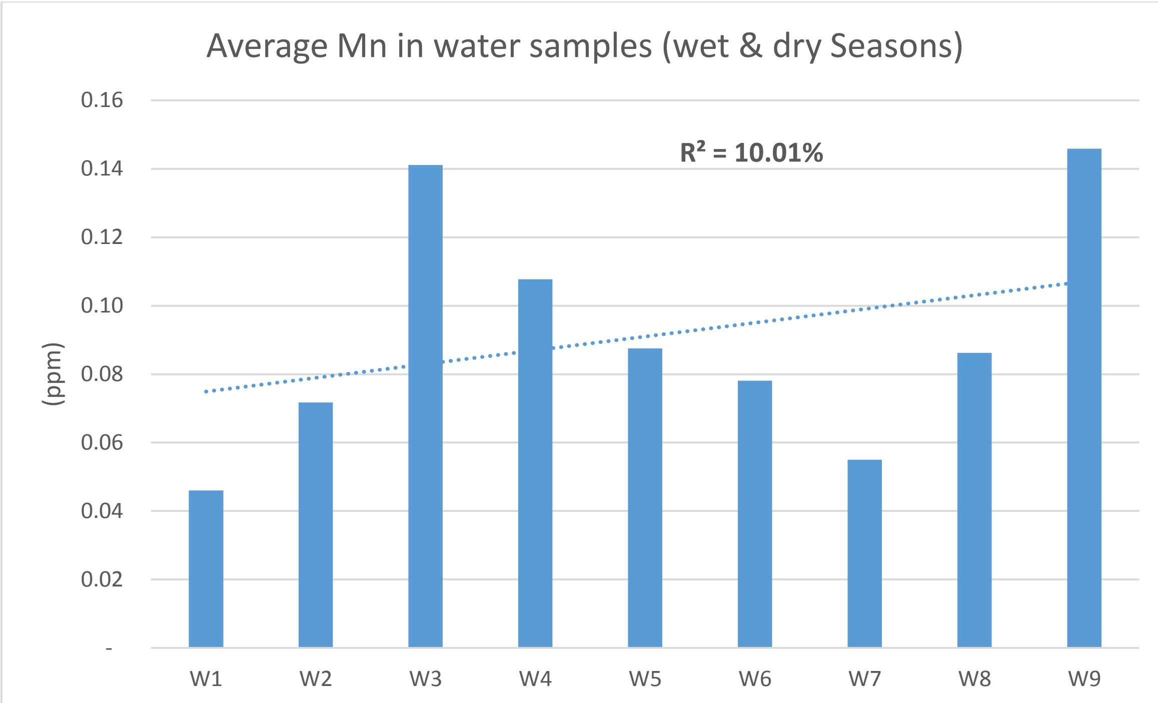

Figure 5. 6 Manganese concentration in water samples in wet and dry season

Manganese levels in soil and water samples remain very low and within the WHO recommended limits, also it is very hard to establish a correlation of the contribution of the wastewater or mixed water to the levels of Mn in soil and plant samples. The plant uptake of Mn might have been affected by the Fe application to the agricultural land, or the natural abundant of Fe in the Terra Rosa soils making the uptake by plant less occurring comparing to the Fe levels. There was no clear relation in the levels of accumulated Mn in the soil samples from the study area in the two periods of the sampling, the Mn levels remain very similar and no big change took place between the two sampling periods.

Iron

The amount of iron is different in soils of various origins and used differently. Its natural, average content in soil is 0,6% (Kabata-Pendias A., 1999). It may undergo significant changes due to the high anchor movement of iron in soil profiles. There is less iron in limestone and dolomite. Iron, like other heavy metals, has a long life in the natural environment (Kabata-Pendias A., 1999).

Economic activities, including industrial activities, leads to a continuous supply of heavy metals to the environment in the form of various compounds. Continuous emissions of dust and mineral vapors, as well as sewage discharge and waste deposition, are increasing the concentration of heavy metals in the environment.

Iron in the soil has different functions depending on the correspondence of the element. In general, the presence of iron has a positive effect on the soil structure, it plays an important role in soil formation processes, and it affects the chemistry of other elements in the soil (Grusak, 1998).

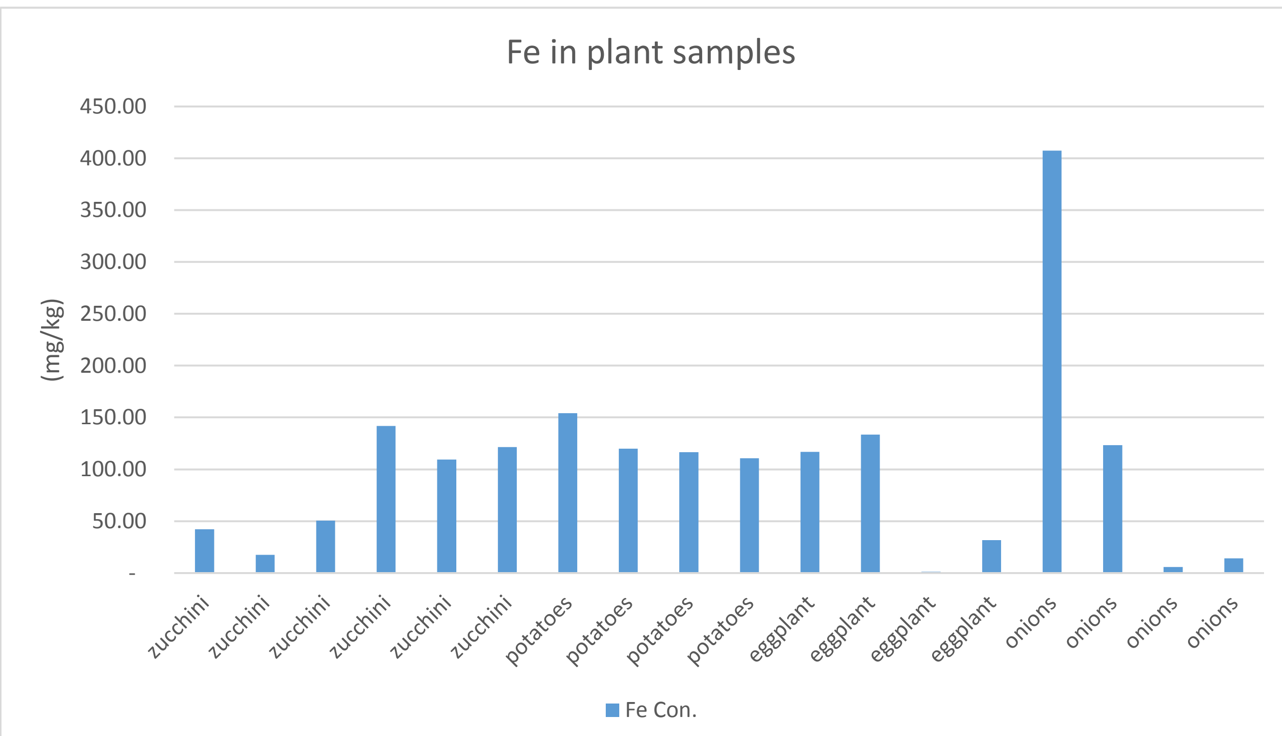

Figure 5. 7 Iron concertation in vegetables samples from the study area

Iron oxides found in the soil depends on the moisture content, pH and oxygen content of the soil. In wet such as agricultural lands, iron oxide is usually present in the case of wet ferric oxide. In various soils and especially at low pH, iron oxides can precipitate on clay surfaces. These coatings, once formed, are stable at higher pH(s). The coatings are gel-like in appearance, may flow when wet, shrink and become porous when heated, and cement primary particles into aggregates. (Dragun, 1988.).

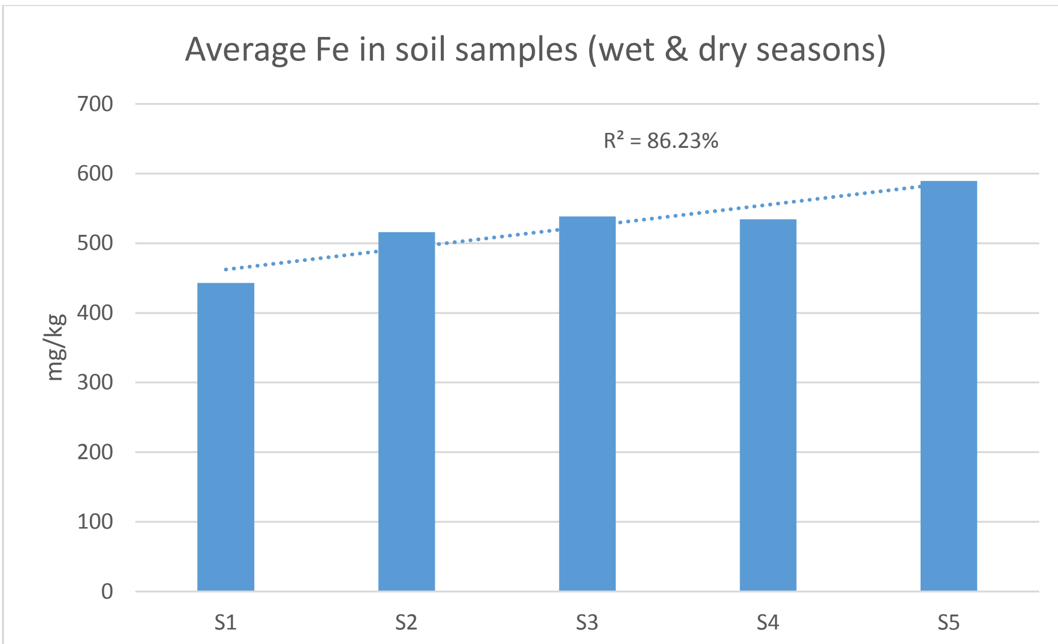

Figure 5. 8 Iron concentration in soil samples in wet and dry season

As shown in Figure (5.8), Iron looks to be higher in the soils samples of S5>S4>S3>S2>S1 respectively, each soil sample is differing in location and altitude and climate conditions. These differences might affect the accumulation status of Iron in these different soil types. In the Central Jordan Valley area, more organic matter applications seem to occur by the agricultural activities along the year, as he reported in his study (Dragun, 1988.), said that formation of iron oxides is a function of organic matter and bacteria. Bacteria may mediate the conversion between the principal iron valence states.

Iron is a commonly occurring metallic element, comprising 4.6% of igneous rocks and 4.4% of sedimentary rocks (Morel, 1993). Soil types and parent rocks are very important factor for the availability of Iron and Iron – oxides in the soil, the study are soil types are differing from alluvial soils in the area of Central Jordan Valley and terra Rosa soils at the higher areas such as Nablus east areas, which both of soils are rich in Iron and can contribute to the availability of Iron in the soils and to the plants.

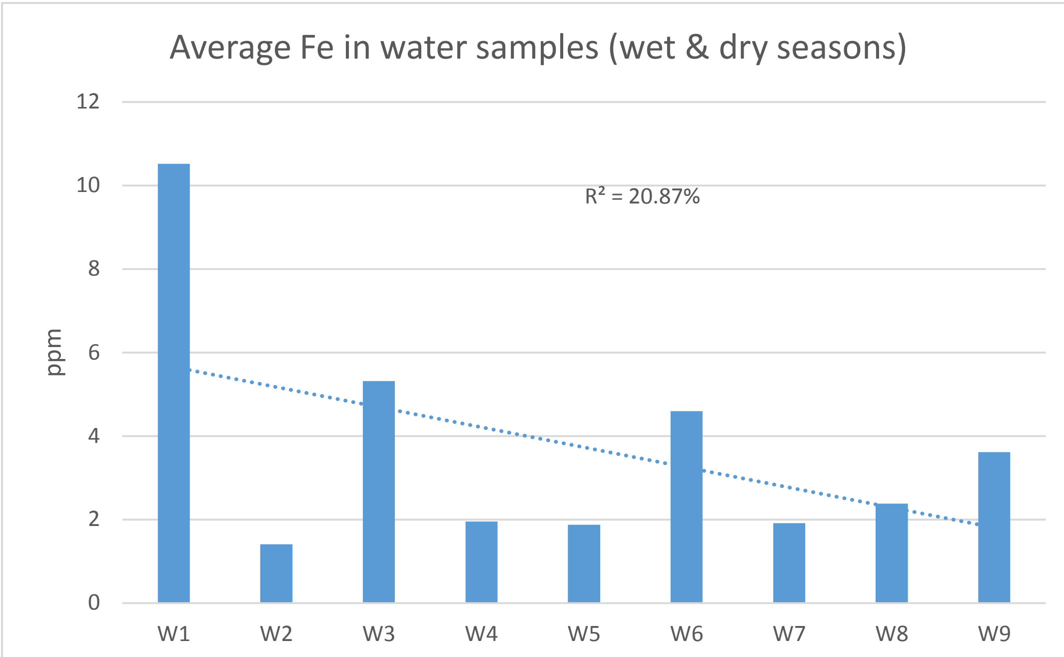

Figure 5. 9 Iron concentration in water samples in wet and dry season

Iron dissolves in water under normal conditions. Many iron compounds share this property. Naturally occurring iron oxide, iron hydroxide, and carbonyl iron are water insoluble. Water solubility of some iron compounds increases in low pH values. Iron occurs naturally in water in soluble form as the ferrous iron (bivalent iron in dissolved form $Fe2+$ or $Fe(OH)+$) or complexed form like the ferric iron (trivalent iron: $Fe3+$ or precipitated as $Fe(OH)3$). The occurrence of iron in water can also have an industrial origin; mining, iron and steel industry, and metals corrosion.

In aerated water, the redox potential of the water is high and it allows an oxidation of the ferrous iron in ferric iron which precipitates then in iron hydroxide, $Fe(OH)3$, thus allowing a natural removal of dissolved iron.

At our case, Iron seems to be less available by the water for irrigation, in fact, farmers in the study area are dependent on the stream water and well water for agricultural irrigation, Iron is removed under aeration conditions as a physical – chemical conditions, and with pH > 6. The fact that farmers are using open canals, see figure (..) to carry the water between their farms and usually harvest these waters in open ponds, see figure (..) which that would reduce the availability of Iron in the water of agricultural irrigation as shown in the Figure (5.9) where the highest Iron concentration in the water samples is 10.5 (ppm), while the location of this water sample is close to the discharge of the wastewater to the stream, and the Iron concentration is decreasing by the physical – chemical conditions occurring when water is moving in the stream towards the eastern part to the central Jordan Valley areas.

Cobalt

Cobalt is a naturally occurring element. Small amounts of cobalt are necessary for good health. It's a natural earth element in the form of pure gray steel to a shiny black steel metal. It is also present as cobalt II and cobalt usually occurs with other metals such as copper, nickel, manganese and arsenic. There are small amounts in most rocks, soil, surface water, groundwater, plants and animals.

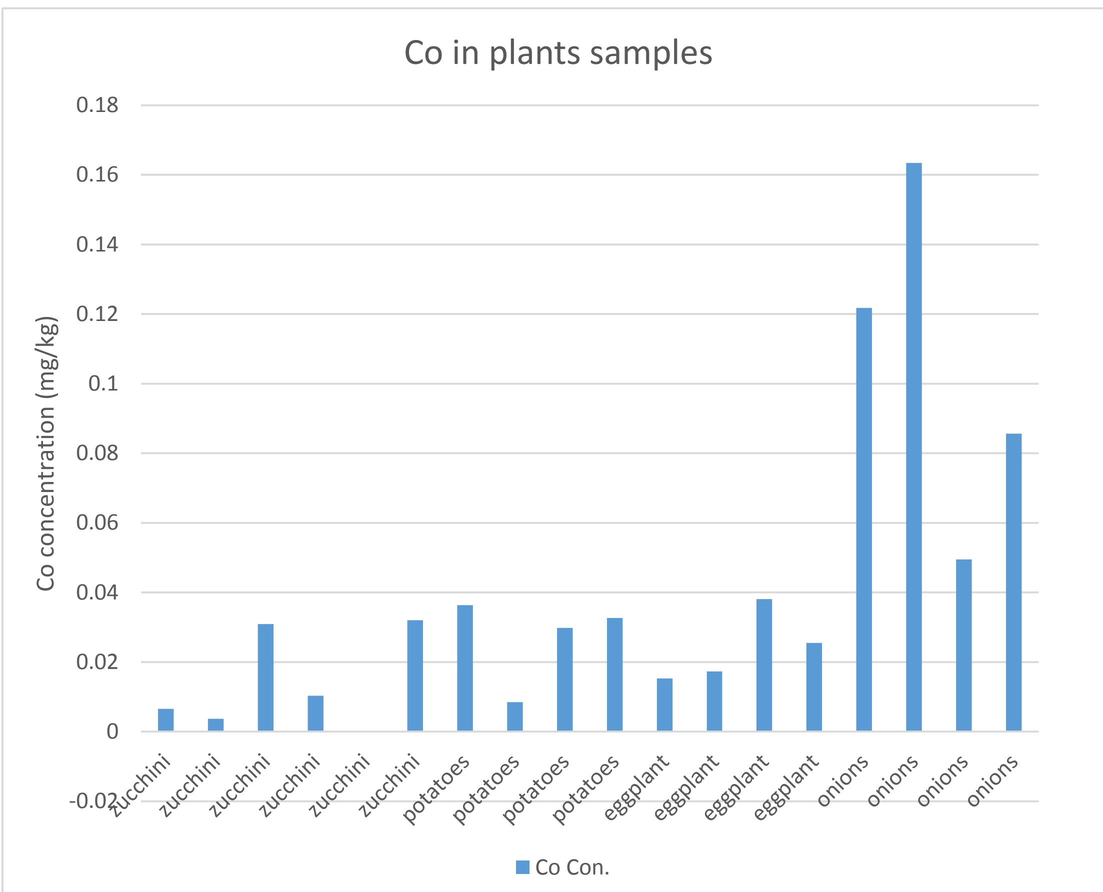

Figure 5. 10 Cobalt concertation in vegetables samples from the study area

Cobalt is an important element for animals. The compounds of Cobalt play a major role in the formation of hemoglobin, and in several regions in the earth, sheep and cows may become anemic die to eating vegetation grown in Cobalt-deficient soils.

Cobalt distribution different between soil horizons and organic matter content. Cobalt seems to be fixed by humans. In the chernozems and vertisols, cobalt distribution is uniform for the whole profile, in podzols, cobalt accumulates in the illuvial B horizon, while the eluvial A horizon is generally poor with cobalt.

Cobalt mainly sorbed by clay minerals and its distribution in the profile also follows that of clay. Fine-texture soils are richer in cobalt than coarse-texture soils (Hosohara, 1964). The available cobalt content depends on the redox potentials of the soils. The effluence of soil pH on cobalt compounds and aids their elimination by leaching. Alkaline pH soils are relatively rich in available cobalt.

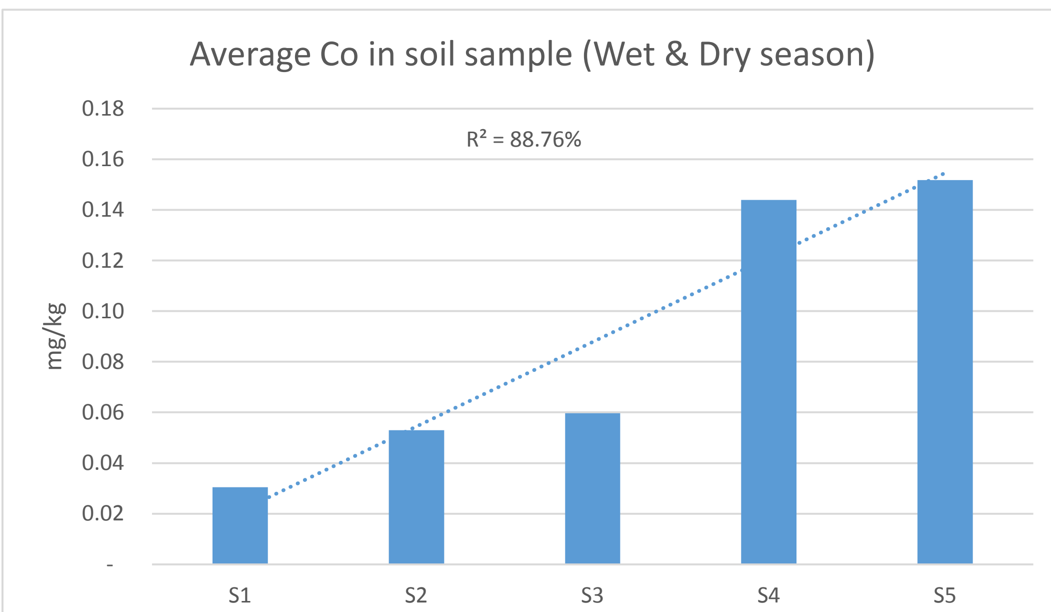

Figure 5. 11 Cobalt concentration in soil samples in wet and dry season

According to (Racikovitch, 1961) soils containing less than 5 ppm of total cobalt are deficient and cannot supply plants with the quantities of cobalt essential to animals and for human food. By comparing the analyzed data for the studied plants, it’s clear that cobalt uptake by plant is very low, as the results shown in figure (5.10), which the highest concentration of cobalt content for plant is (0.16 mg/kg) while the rest are below (0.04 mg/kg) and this status of cobalt content in plant can be called a cobalt deficient status.

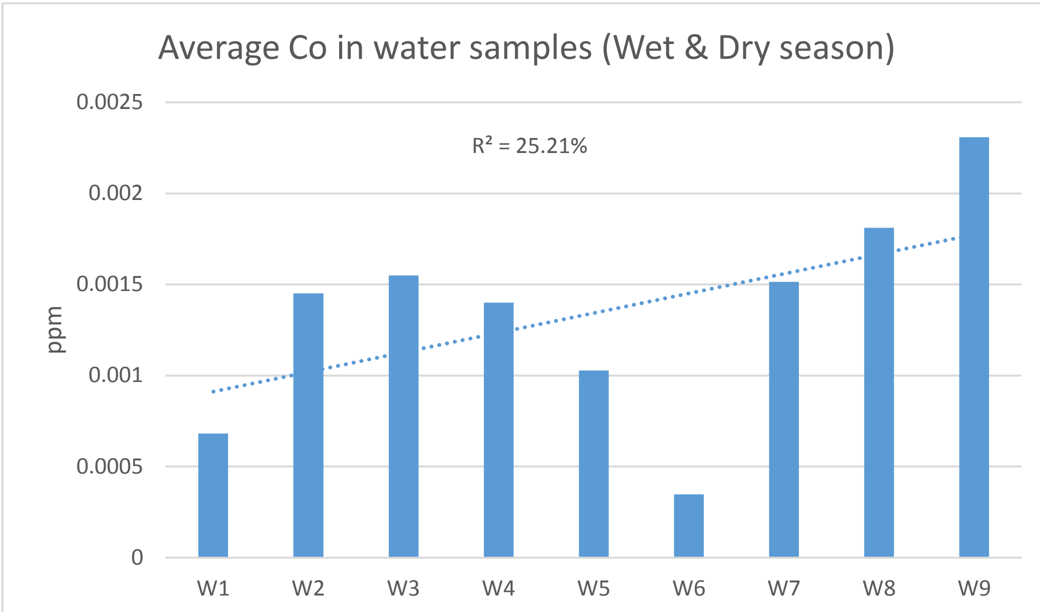

Figure 5. 12 Cobalt concentration in water samples in wet and dry season

The results indicate that Co is quantitatively a very high sorption on these soils, under all conditions, when the pH is around 7, Co sorption is very high in soil B horizon. Given that the soil solution pH of these soils is approximately 8, Co is expected to bind strongly on these soils. In addition, there is a substantial difference were observed between the two different types of soils, as shown in figure (5.11), the soils located in the farms in Nablus east area (Terra Rosa) are very less rich in available Cobalt, as the data of the plant uptake of cobalt also indicate a higher uptake in soil from farms located in central Jordan Valley area (Alluvial soils) as shown in figure (5.10). Cobalt appears to bind strongly on soils clay particles in soil B horizon, making it very less available for plant uptake. This has significant implications for the mobility of Co in these soils. It appears that mobility of Co would be severely retarded under most but extreme conditions. Such conditions might include acidic pH (approximately 6 or below) as it shows a very low cobalt concentration in the tested water samples.

Nickle

Nickel is an element metal, which occurs naturally in the environment at a very low levels. Nickel is an essential metal but at a small dose, when over doses, Nickel can cause various dangerous issues such as cancer for animals and human bodies. Nickel is an element that is widely used in textiles industries, the element most application is in steel and other metals products. The major source of anthropogenic Nickel that cause contamination to terrestrial and water system is metal plating industries, nickel mining and electroplating (Khodadoust, 2004).

Nickel can be found on water bodies, the metal can reach the water system by wastewater contamination, wastewater can be a major source of Nickel metal to other water system such as rivers and groundwater systems. Nickel can be adsord to sediments and soil particles at a large amount but it will become immobile as a results of its adsobtion. Nickel mobility can be affected by different physical and chemical conditions, in acidic soils, Nickel becomes more mobile and can leaches down to the groundwater system. Nickel if founded at a high level in the water bodies can affect the growth of microorganisms (Khodadoust, 2004).

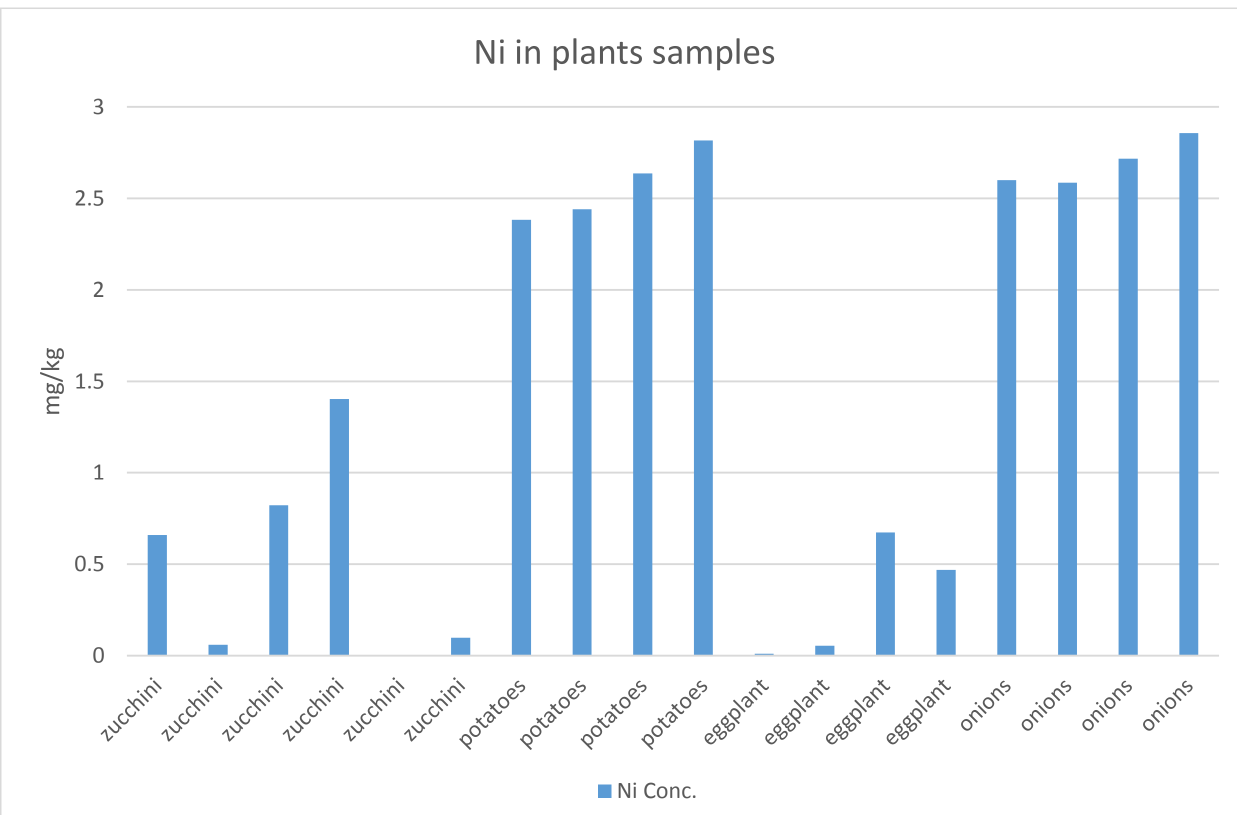

Figure 5. 13 Nickel concertation in vegetables samples from the study area

It is noticed that Nickel uptake by plant is reduced as shown in figure (5.13) where the highest uptake of Nickel is in the root vegetables such as Potatoes and Onions. Root type of vegetables tend to accumulate more Nickel comparing to the rest of studied vegetables as shown in figure (5.13).

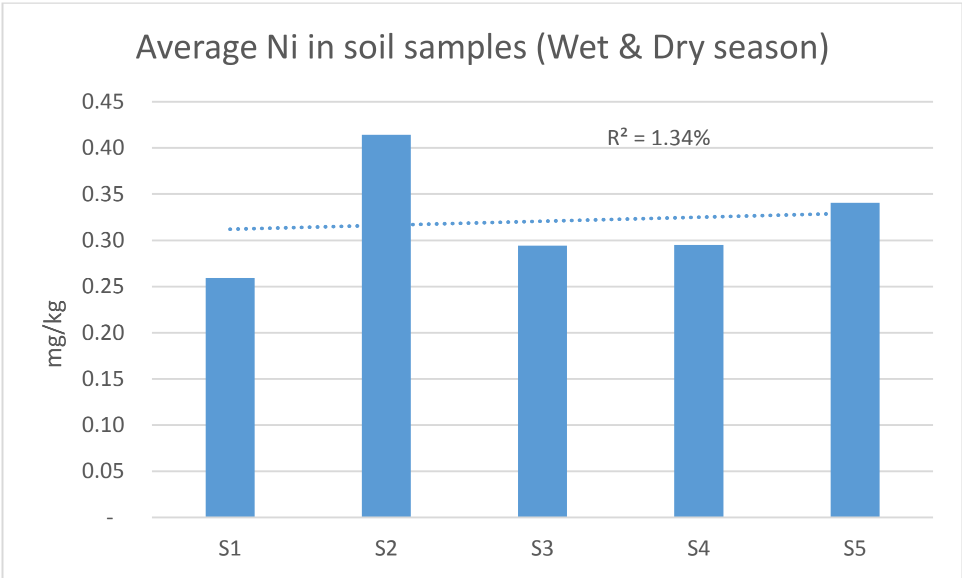

Figure 5. 14 Nickel concentration in soil samples in wet and dry season

(Kukier, 2001) have reported in their study that the use of wastewater from quarries and with lime effluent will reduce the uptake of Nickel by plant by making it less bioavailable for plant uptake. (Kukier, 2001) Also suggested that the addition of limestone either directly to the soil or with wastewater effluent would significantly increase Fe concentration as it is shown by our results in figure (5.7) in the shoots and diminished Ni phytotoxicity in these plants. The symptoms of stunting and extreme chlorosis observed in the plants grown on the low Ni, un-limed Loam soil could be a result of Ni toxicity and Ni toxicity-induced Fe deficiency.

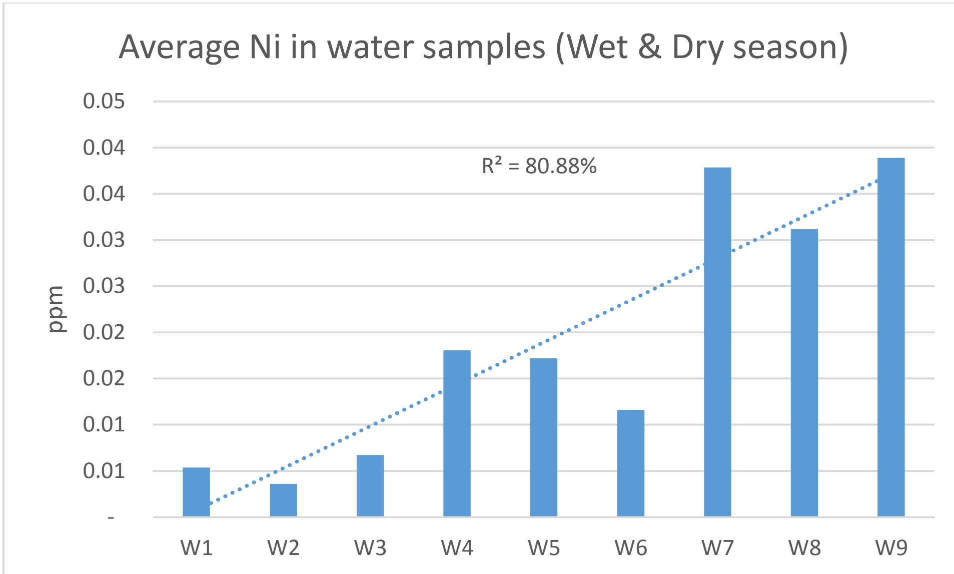

Figure 5. 15 Nickel concentration in water samples in wet and dry season

Lead

The Pb concentrations in the vegetables, summarized in Figure (5.13) were with few exceptions quite low compared to the other studied heavy metals. Overall, roots vegetables (Onions) contained the highest Pb concentrations; zucchini, potatoes and eggplants had the lower concentrations. Although the high percentage of results below the detection limit and below the recommended WHO guidelines for food and vegetables concentration of Pb makes statistical comparisons among the latter three categories less meaningful.

The range of measured Pb concentrations within each vegetable grouping was as high as in roots vegetables (in onions), and as low as in fruits vegetables (zucchini and eggplants); however, given the large proportion of samples with Pb below the detection limit, the actual ranges may have been greater. As noted below, this variation could not be explained by soil - water Pb levels.

There are no accepted health-based standards in the United States with which to compare the measured Pb in vegetables. EU standards, which vary by vegetable type and limit contaminant concentrations in foods that may be sold commercially (EC. Commission Regulation, 2006) were used as guidance values.

Only one of 18 fruit and root vegetables samples exceeded the 0.1 mg kg−1 fruit guidance value, but 17 of the studied roots and fruits vegetables crops didn't exceed the 0.1 mg kg−1 root guidance value, and 35% of the studied samples exceeded the value of 0.05 mg kg−1.

For fruits, and root crops, there was no significant relationship of crop Pb to soil - water Pb content; even for root crops, there was only a weak tendency for crops grown in higher Pb soils to be more Pb-contaminated. The analysis of data showed soil Pb to account for a few of the variability soil Pb content, as shown in Figures (5.17 and 5.18) which makes building a relation of Pb vegetables content to Pb soil - water content very hard due to the high variability of the results of Pb soil - water. Thus, the wide range of Pb concentration within each crop type was largely unexplained by the soil -water Pb concentration. There was also no significant and clear relationship between Pb concentrations in vegetables and the soil - water Pb content.

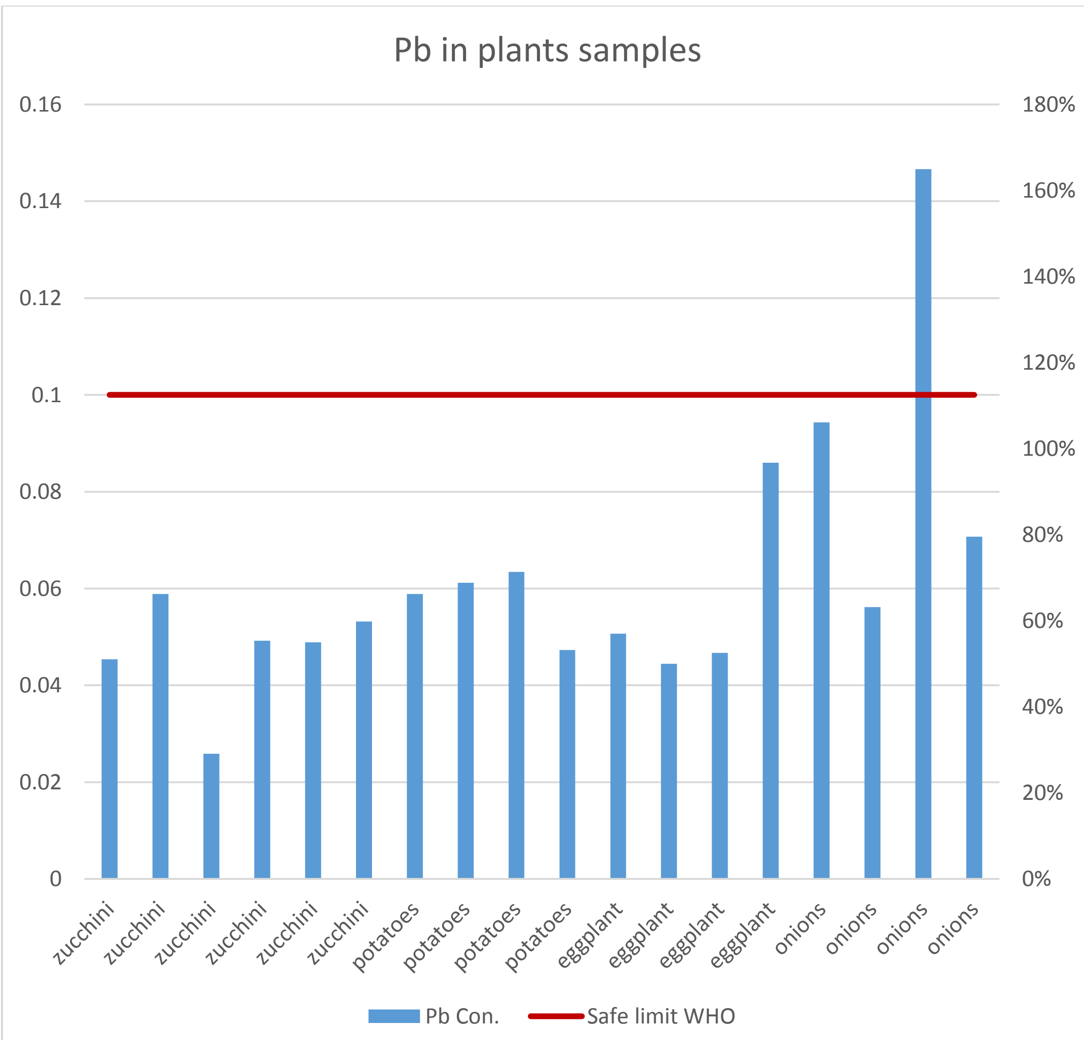

Figure 5. 16 Lead concertation in vegetables samples from the study area

Although it is a bit hard to explain the relation of the Pb soil – water concentration due to the high variation in the concentrations of the detected Pb mainly in the soil samples during the dry and wet season, recent research has shown that the local settings of urban farms affected heavy metal contamination of vegetable crops, with Pb concentrations being higher in fruits and roots vegetables grown in farms with higher traffic burdens (Säumel I, 2012), but also giving the fact that there is a point source of pollution in the study area which is the discharge of raw wastewater to a natural stream (Wadi Al-Bathan) which is very close to the irrigation water sources for these farms, this might be one of the sources of Pb in soil – water samples even in places where the sale of leaded gasoline has long been banned, as it has been in the U.S. since 1996 as in our region as well. This trend could indicate that particle dispersal and aerial redeposition over relatively short distances is contributing to vegetable contamination, and obscuring the effect of soil Pb concentration in the soil beds.

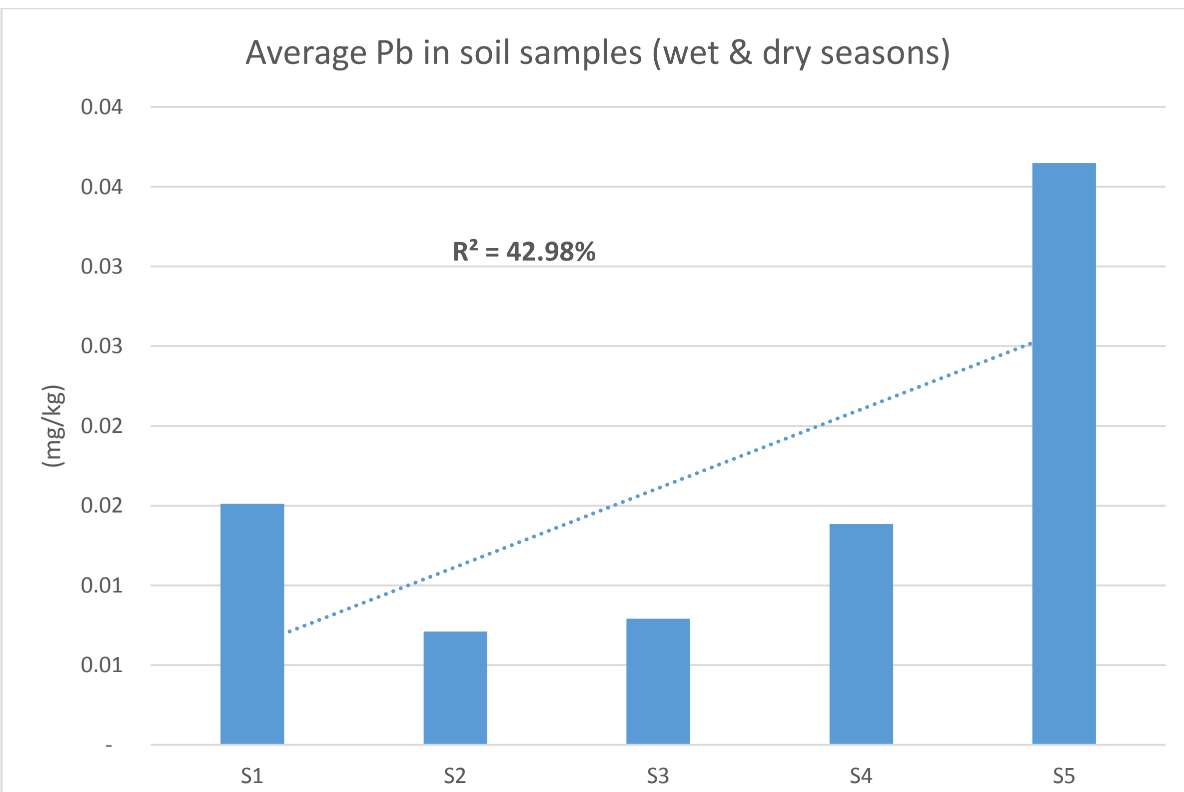

Figure 5. 17 Lead concentration in soil samples in wet and dry season

The poor ability of soil – water Pb to predict vegetables Pb is perhaps understood in view of the fact that vegetable Pb content can't be correlated to soil - water Pb content in our case study due to the very high variability in the results of the soil - water Pb content. Only the root crops (Onions) have a statistically significant (Onions > fruit vegetables) relationship of vegetable Pb.

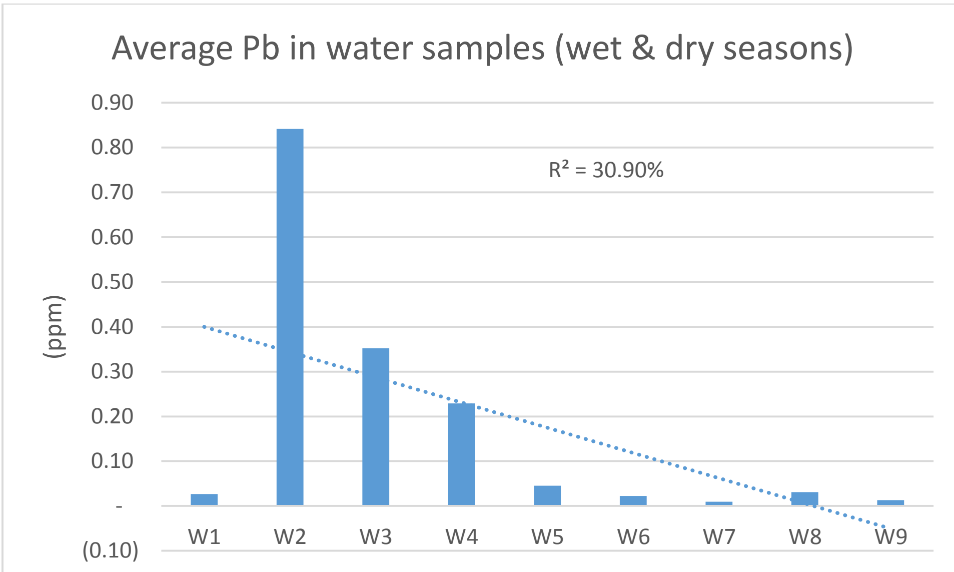

Figure 5. 18 Lead concentration in water samples in wet and dry season

The fact that vegetable Pb content is hard to be correlated to soil – water Pb concentrations is an indication that particulate contamination of vegetables from the soil or from aerosols is more important than plant uptake via roots in transferring Pb into the crop. This is supported by (Mosbaek H, 1989), who found that plant root (physiological) uptake of Pb from non-acid soils is low (0.02 – 0.10 mg/kg) with the exception of carrots (up to 0.3 mg/kg); most of the Pb they measured in plants (1–10 mg/kg in many crops) was from airborne contamination. Since urban aerosols as well as soil particles can have high Pb content (Smichowski P, 2004), the results found here do not exclude the possibility that atmospheric aerosols from local or non-local sources are contributing to the vegetable Pb contamination.

The variability of individual soil particle composition, the random nature of soil particle adherence and incorporation into plant tissues, and the possible contribution of non-local urban aerosols and the discharge of the wastewater to the nearby natural stream may have contributed to the very weak relationship between soil – water Pb and vegetable Pb concentrations.

Chromium

The concentration of Cr may be vary in soils types, depending on some factors that might affects its concentration such as the natural composition of rocks and sediments that compose it (Kimbrough, 1999). The levels of Cr in soil may increase mainly due to anthropogenic activities, as for example atmospheric deposition (Rosas, 1989). Dumping of chromium-bearing liquids and solid wastes as chromium byproducts is an increasing factor of Cr in the environment. Generally, Cr in soil can be a combination of both Cr (III) and (VI). As in aquatic environment, Cr in soil or sediment undergoes a variety of transformations, such as oxidation, reduction, sorption, and dissolution (Kimbrough, 1999). The oxidants present in the soil though some chemical reactions that can oxidize Cr (III) to Cr (VI). The forms of Cr (VI) are on the other hand reduced by iron, vanadium, sulphydes, and organic materials. While when the reducing capacity of the soil is overcome, Cr (VI) may persist in the soil or sediment for years, especially if the soils are sandy or present low levels of organic matter (Zasoski, 1992).

The way of Cr uptake by plants is a very complex elucidated. However, being a nonessential element, Cr does not have any specific mechanism for its uptake and is also dependent on Cr binding mechanism with other elements. Plant uptake of Cr is a complex process that is no energy expenditure is required by the plant to make the uptake of Cr directly. The uptake of Cr is thought to be an active process performed by carriers for the uptake of essential elements such as sulphate. Cr also competes with Fe, S, and P for carrier binding (Liu, 2011).

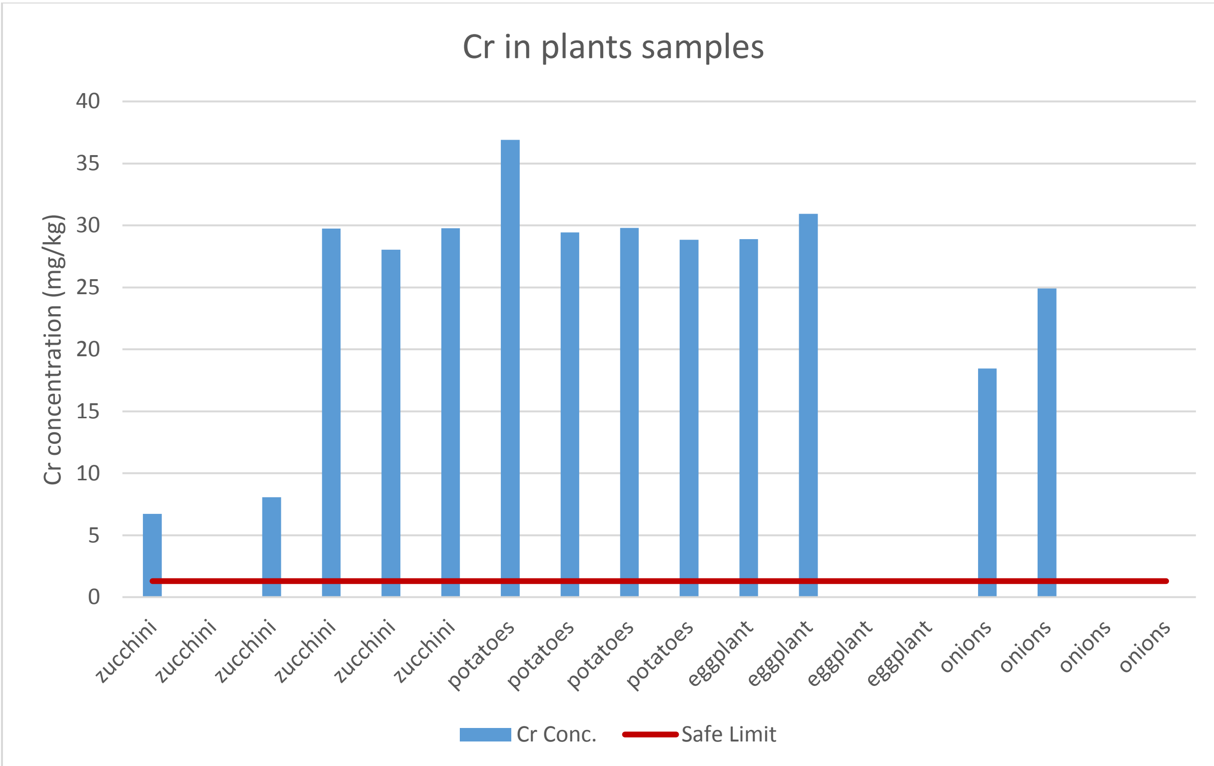

Figure 5. 19 Chromium concertation in vegetables samples from the study area

Cr(VI) is with a higher solubility and thus bioavailability which make Cr(VI) more toxic at lower concentrations than Cr(III), and thus tends to form stable complexes in the soil (López-Luna, 2009). Authors defend that Cr(VI) is reduced to Cr(III) on the root surface, others suggest that it dissolved Cr(VI) is taken up by plants without reduction (Mishra, 1995).

Cr accumulates mainly in roots and shoots in the body of a plant; however, roots accumulate the major part of Cr and thus, root plant are more expected to accumulate more Cr comparing to other types of plant that are not root type. In the results shown in figure (5.19) from the study area, there was an increase in concentration of Cr in different types of the plants. Accumulation of Cr in the different types of plants was in the following order Potatoes> Onions> Zucchini>Eggplant. Corroborating these results are the findings of several works, (Allaway, 1973) found that bean seeds accumulated about 0.1% Cr, while roots accumulated 98%. And by depending on the results that (Allaway, 1973) found, it support the results that has been found by our study, Cr tend to be accumulated more in the root type of plants in the study area, thus Potatoes tend to accumulate Cr the highest comparing to other types of plants.

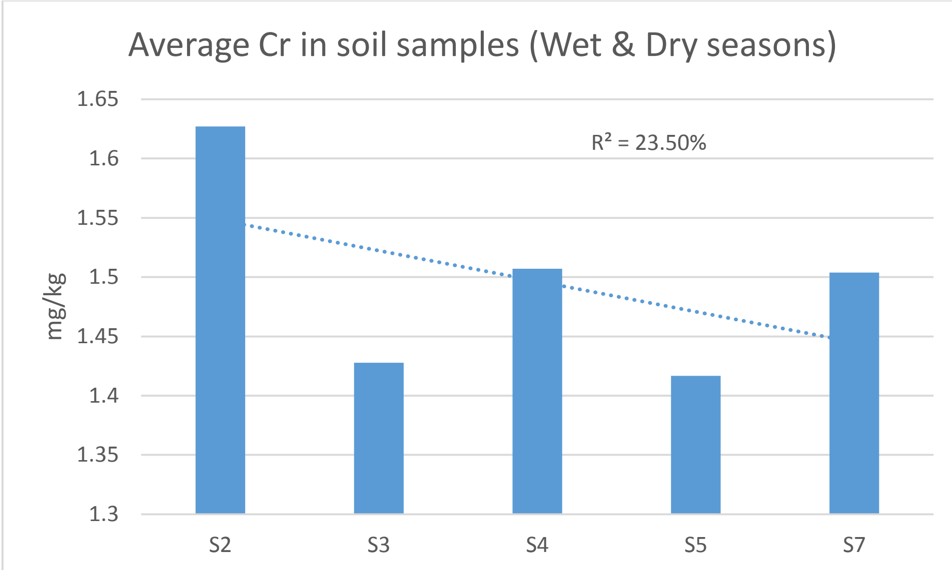

Figure 5. 20 Chromium concentration in soil samples in wet and dry season

The transport mechanisms of Cr are mainly dependent on the speciation of the metal, which determines its uptake and accumulation (Shanker, 2004). Moreover, Cr absorption and distribution mechanisms in vegetables are still not very clear due to the Cr nature. It has been reported that Cr is transported and accumulate in plants via carrier ions, such as sulfate or iron, and is not directly absorbed by plants (Hayat, 2012). It is also known that Cr can be absorbed both as Cr3+and Cr6+, but no specific mechanism for Cr absorption is postulated (Oliveira, 2012).

(Liu, 2011) in his study found that Cr uptake by root plant that is receive Fe is much higher due to the nature of Cr to bind to other metals and that Cr absorption by plant roots may be mediated in part through Fe3+ complex carriers. Iron uptake by root plant in this study was very high, figure (5.7) shows that root plant tend to accumulate more Fe comparing to other types of plant, potatoes was the highest in accumulating Fe as shown in figure (5.7), and this finding suggest that Cr nature of binding to other metals complex such as the Iron is true as it has been found by (Liu, 2011).

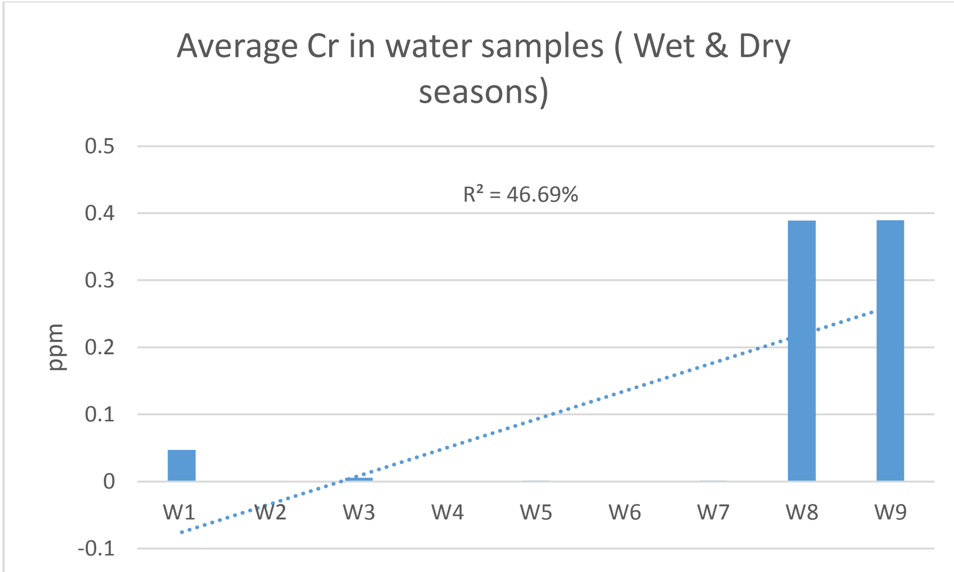

Figure 5. 21 Chromium concentration in water samples in wet and dry season

The amount of Cr available in soil and water bodies depends on source of Cr discharge and the surrounding environmental factors; for example, the intensity of industrial processes, proximity to the sources, the amount of chromium released, and meteorological factors. Cr from sources releasing the element is deposited and can migrate through particular environmental media such as soil or liquid medias, and these processes depends on the nature of Cr. The distance covered by a deposited metal in the environment depends on meteorological factors, topography, and vegetation (Nriagu, 1988).

Cr concentration is very low in the analyzed water samples from the study area as shown in figure (5.21), but only two of the samples showed a high concentration of Cr comparing to the rest of samples. Cr transport within the terrestrial and water systems is greatly affected by chemical speciation; chemical forms of chromium and their affinity to chemical and photochemical redox transformations (Kotaś, 2000). Chemical form of Cr and redox reactions can affect the mobility and bioavailability of Cr in terrestrial and water systems, Cr concentration remain higher in the studies soil samples comparing to its levels in the water samples figure (5.20, and 5.21) and that suggest that Cr tend to deposit from its source at in the water system at a higher concentrations in the terrestrial system (Bartlett, 1976).

The Cr transformation and transport mechanism seems to be hard to explain in our case study. Cr is a metals that is highly affected by its surrounding environmental conditions, such as pH, Cr tend to deposit as lower pH value. Previous researchers have demonstrated that Cr(VI) is stable in oxidizing environment with pH above 6.0. Under conditions of pH 3 to 6, compounds of Cr(VI) tend to reduce to more thermodynamically stable Cr(OH)3 (Masscheleyn, 1992). In natural system of the study area, the agricultural water system tends to have pH value at around 7.5 which allow a Cr to be stable and will deposit in the terrestrial environment which explain why Cr concentrations are lower in the water samples comparing to the soil samples.

Vanadium

Vanadium is among the most 20 abundant elements in the earth crust, it has mostly the same concentration range as copper and lead. Vanadium has many application, while its main application in human society is within the steel industry. The steel industry generates by-products such as vanadium from road fill materials, cement, and steel industries (Anke, 2005). There are still conflict of generalizing the essentiality of Vanadium for humans, although human body always contains traces of Vanadium, but there are still ethical and practical issues with the investigation of the impact of Vanadium on human deficiency. Thus Vanadium essentiality for human still has not been confirmed (Anke, 2005).

Vanadium is a high toxic element and the excessive Vanadium concentration may be carcinogenic. There are some cases where Vanadium releases accidentally to the environment and caused a high damage due its high toxicity, the recent spillage of bauxite residue "Red Mud" was in Hungary in 2010 (Ruyters, 2011). In 1980s, slag containing 3% Vanadium was inappropriately applied as a soil amendment in north Sweden which caused a death of 23 cattle due to the acute Vanadium toxicity (Frank, 1996).

In this study, Vanadium safe limit will be assumed to the lowest possible concentration that we believe that would not make any human deficiency, thus we will set (0.1 mg/kg) for Vanadium detected in plant samples of this study. As shown in figure (5.22) Vanadium concentrations was detected at the safe limit that we set for this study, the average concentration was 0.05, 0.12, 0.08 and, 0.20 (mg/kg) for Zucchini, Potatoes, Eggplant, and Onions respectively. The highest Vanadium concentration was detected for Onions with an average of (0.20 mg/kg), while the lowest Vanadium concentration was detected for Zucchini with an average of (0.05 mg/kg).

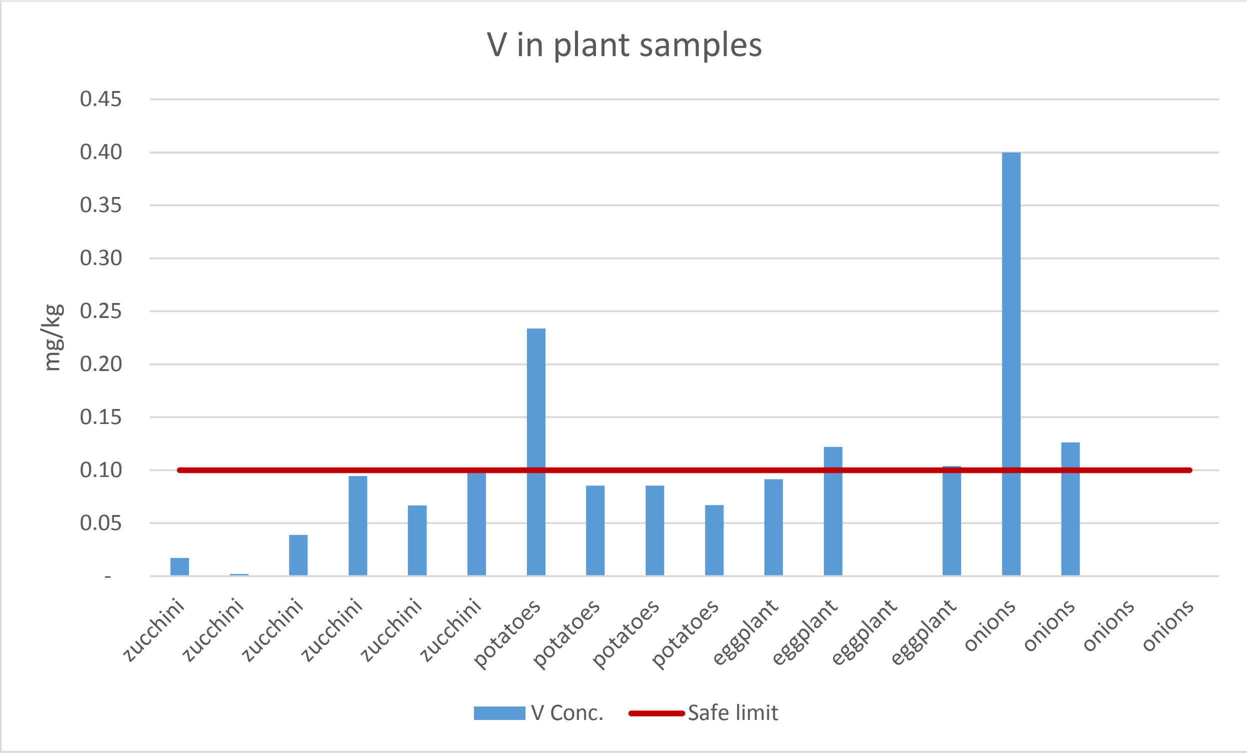

Figure 5. 22 Vanadium concertation in vegetables samples from the study area

Vanadium concentration in the studies soil samples were in the average between 0.20 – 0.50 mg/kg of soil samples from the agricultural lands in the study area as shown in figure (5.23). (Eissa, 2017) found in their study of the distribution and mobility of vanadium in some calcareous soils along northwestern coastal region of Egypt that Vanadium bounding rate to Fe-Mn oxides was ranged between 7% and 10.3% of total vanadium content. And it was noticed that the amounts of Vanadium that bound to organic matter was ranged between 1% and 5% of total available Vanadium content in the soil.

Figure (5.23) shows Vanadium concentrations from five agricultural lands from the study area, in general, vanadium concentration in plants was ranged between 0.10 – 0.40 mg/kg, and soil data showed a concentrations of Vanadium that are ranged between 0.20 – 0.50 mg/kg, which are very similar to the concertation of the Vanadium that accumulated in the plant samples. Thus plants in general have a soil bioaccumulation and transfer of Vanadium from soil to plant.

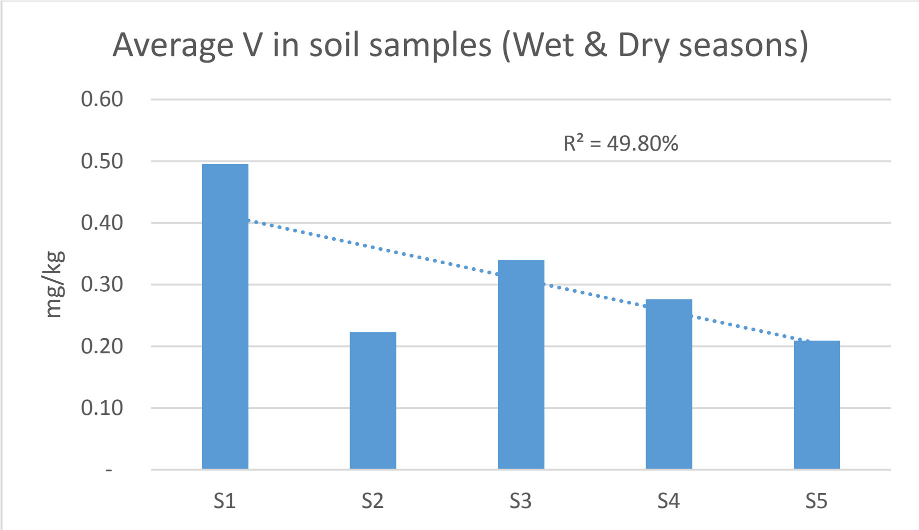

Figure 5. 23 Vanadium concentration in soil samples in wet and dry season

Vanadium sorption capacity of the soil from its sources is directly influenced the mobility of Vanadium in the soil system and then to plant availability. If the structural analogy between Vanadate and Phosphate ions exist then Vanadium most likely to react like phosphate in the soil which in some soils properties that influence Phosphate fixation will also then influence Vanadium sorption and availability in the soil system and to plant (Rehder, 1999).

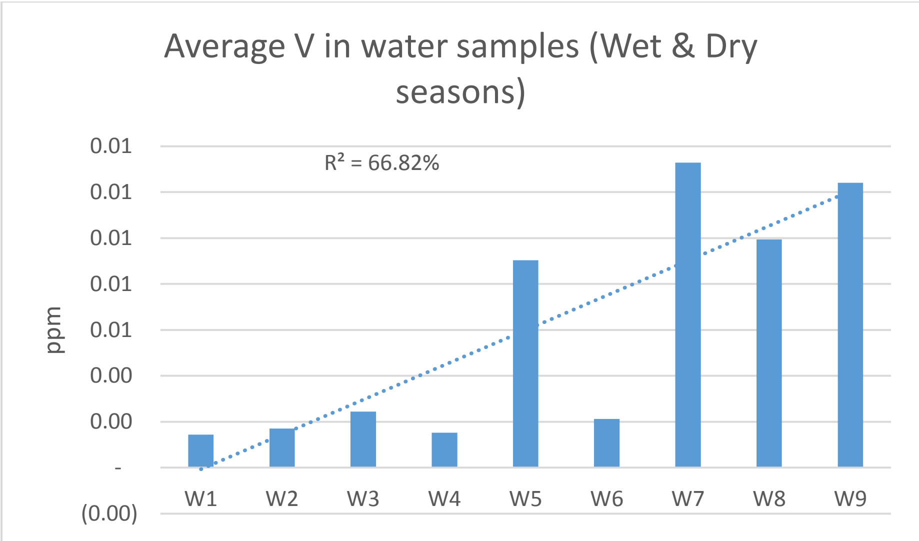

Figure 5. 24 Vanadium concentration in water samples in wet and dry season

Although Vanadium concentration of the water samples from the study area seems to be very low and in most of the studied samples the results were around 0.01 ppm as shown in figure (5.24). (Welch, 1973) found in their study that anion that produced the greatest accumulation of

Vanadium is Phosphate ($H2PO4$) by an inhibition level of up to 27% less than the control, thus we suggest in this study and by the results we have from the analysis on Vanadium concentrations in plant, soil, and water samples that Vanadium tend to accumulates from the wastewater source that it either reaches the agricultural lands directly or by mixing these waters with the water of irrigation and use it to irrigate the fields. Another hypotheses can be the fixation of Vanadium in the soil system by the addition of Superphosphate to the agricultural fields by the farmers, as suggested by (Welch, 1973) that the addition of phosphate to the soil will influence the fixation of Vanadium by 27% and depending on the soil type and other factors like the pH and EC of the soil.

Cadmium

Cadmium occurs naturally in many other metal ores such as zinc, lead and copper ores, in coal and other fossil fuels, and is released during volcanic action (WQA, 2019). These deposits can serve as sources to ground and surface waters, especially when in contact with low total dissolved solids (TDS) and acidic waters.

Cadmium found to be low in all studied samples of vegetables and in some samples it has been low to not be detected during analysis as it shown in figure (5.25). The average concentration of cadmium in all the studied vegetables is (0.001 mg/kg) for most of the vegetables samples, potatoes samples were the highest in accumulating the cadmium with highest levels of (0.01 mg/kg) which is still below the safe limit by the (WHO) which is (0.2 mg/kg).

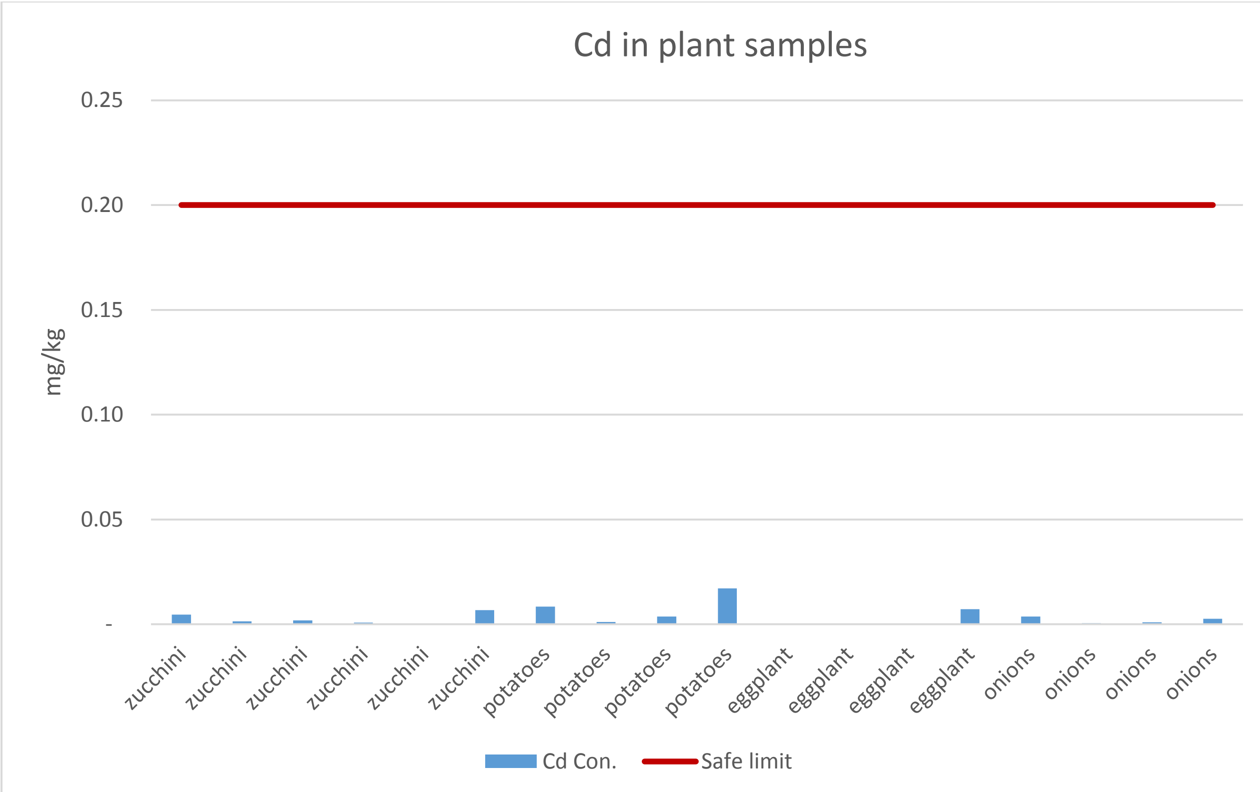

Figure 5. 25 Cadmium concentration in vegetables samples from the study area

Some heavy metals are considered highly toxic, even when present in humans at low concentrations such as cadmium. It is indicated to be carcinogenic and persistently cumulative poison (Lin, 2005). A long term exposure to cadmium in humans may lead to renal dysfunction; while high exposure levels could cause obstructive lung disease, cadmium pneumonitis, bone defects, osteomalacia, osteoporosis and spontaneous fractures, increased blood pressure and myocardic dysfunctions (Duruibe, 2007).

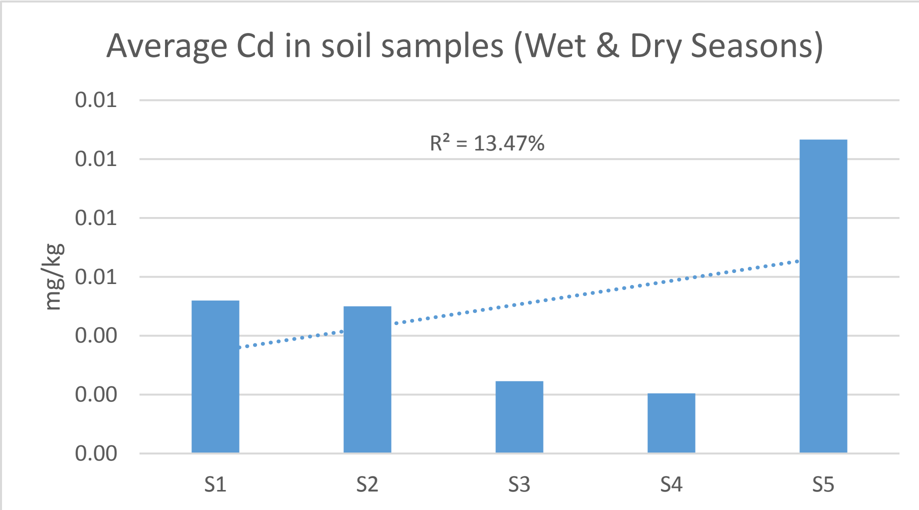

Figure 5. 26 Cadmium concentration in soil samples in wet and dry season

In all the studied soil samples, cadmium showed a very low concentrations levels as shown in figure (5.26) the average cadmium concentration in all the soil samples was (0.01 mg/kg). Cadmium can be found in most of the soils in the earth crust but it is a rare element that can be found naturally with a concentration not exceeding (0.1 mg/kg).

Cadmium can be released from new housing infrastructure. (Rule, 2006) Found in their study that Cadmium can release from infrastructure of new housing potentially from galvanized parts/pipes and steel fittings and pipes. However, the levels tend to decrease with aging and the frequency of such infrastructure type in households would need to be verified in order to assess the cadmium contribution from this source (Rule, 2006).

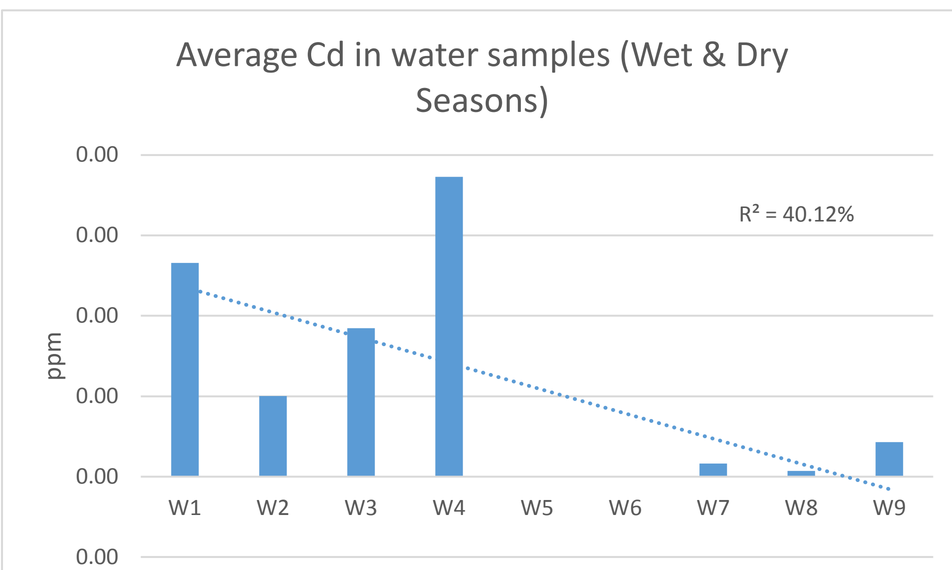

Figure 5. 27 Cadmium concentration in water samples in wet and dry season

All water samples showed a very low concentration of cadmium as it is shown in figure (5.27). The average cadmium concentration in water samples was (0.001 ppm) and in some samples it was below the detected level indicating a very low concentration of cadmium.

From domestic wastewater at the household level there is limited agreement on the major sources of cadmium. There is difficulty in determining the cadmium loads and sources from the domestic wastewater because of the low concentrations detected. (Jenkins, 1998) found in their study that cadmium concentrations have been detected in some cases in laundry, bathroom and kitchen greywater but again at close to detection limits.

5.3 Soil-Plant Transfer Coefficient

5.3.1 Introduction

Environmental contamination with heavy metals is widely distributed and can reach the food chain through different pathways and from different sources, air, water and soil considers the major sources of heavy metals contamination to the environment (Censi, 2006). Heavy metals is considered one of the biggest environmental concerns, due to its nature and being a very high toxic element event at low concentrations in some of heavy metals (Censi, 2006). Agricultural contamination with heavy metals can results from many sources of emissions and once these heavy metals enter the water or soil system it can became mobile and bioavailable for the pant uptake and this can highly affect safety of the food chain (Ho, 1988).

Heavy metal accumulation in plants depends upon plant species, soil properties, and the efficiency of different plants in absorbing metals is evaluated by either plant uptake or soil-to plant transfer factors of the metals (Rattan, 2005). The uptake of heavy metals in vegetables is likely to be higher and accumulation of these toxic metals in human body created growing concern in the recent years. At our case, there are very limited information about the issue of accumulation of heavy metals in vegetables of Wadi Al Bathan (Al Far’a catchment area) are available. But such information is vital for the production of quality vegetables as well as healthy food stuffs. Therefore, the aim of this section of the study project is to determine the concentrations of heavy metals in soil vegetables samples along Wadi Al Bathan (Al Far’a catchment area) Nablus East and Central Jordan Valley region, West Bank to assess the potential ecological risk posed by heavy metals and transfer factor of heavy metals in the soil-vegetables system.

5.3.2 Soil-Plant Transfer Coefficient

The transfer coefficient was calculated by dividing the concentration of heavy metals in vegetables by the total heavy metal concentration in the soil (Kachenko, 2006). The results of the average concentration of heavy metals in all vegetables samples are shown in Table (5.2) where the results of the average concentration are used as the reference to calculate the Transfer Coefficient (TC) from the soil to the plants. By dividing the data from Table (5.2) on its correspondences data from the soil we get the data of the TC for each plant type with regard to the concentration of the heavy metals in the soil and the TC for each set of data as presented in Table (5.3).

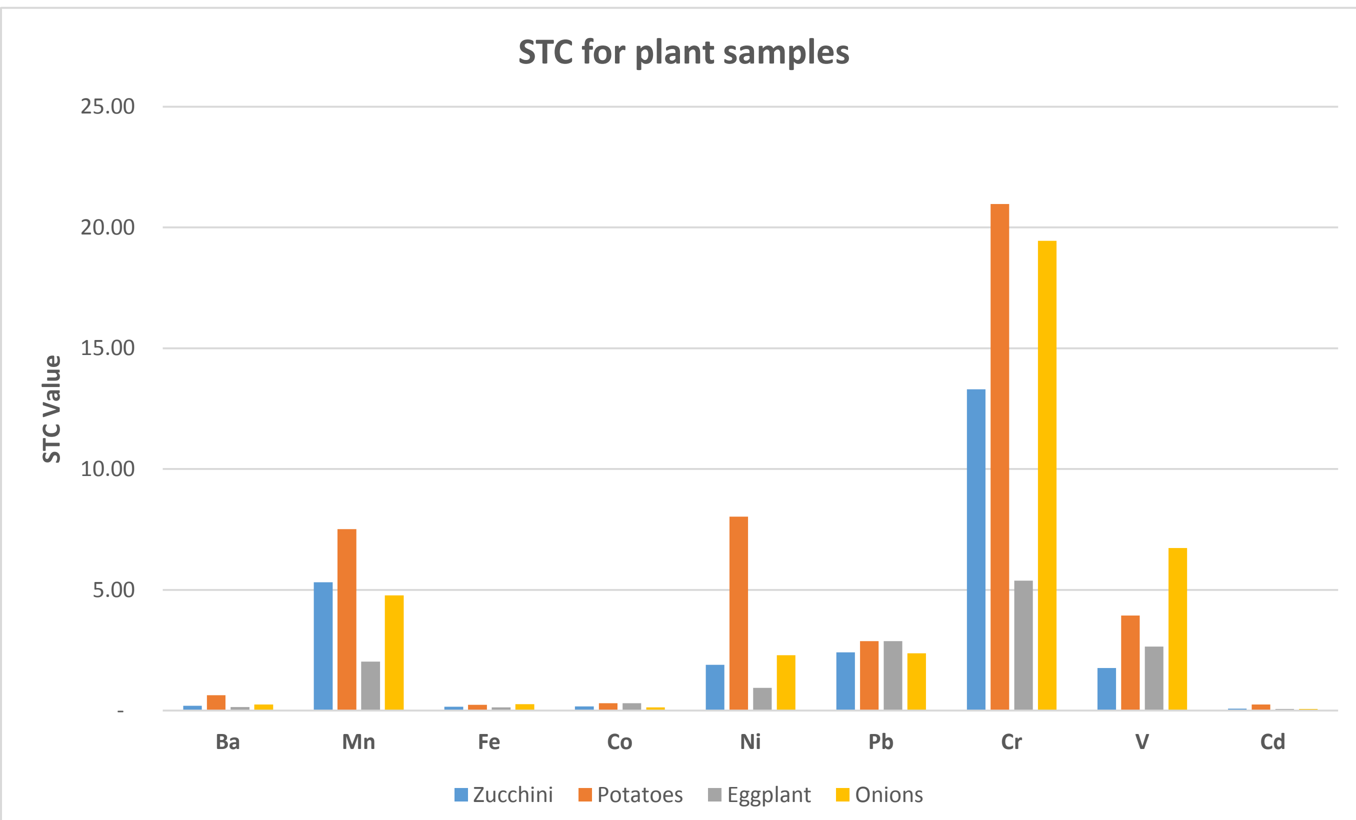

Figure 5. 28 Soil Transfer Coefficient of heavy metals from soil to plants

The soil Transfer Coefficient represents the potential capability of heavy metal transmission from soil to the edible parts of a vegetable. Low transfer factor reflects the strong sorption of metals to the colloids while higher transfer factor reflects relatively poor retention in the soil or greater efficiency of vegetables to absorb metals (Ogoko, 2014). As it shown in figure (5.28) the soil transfer coefficient is quite high for the root type of vegetables as for the potatoes and onions which they are having the highest level of transferring the heavy metals into the plant system, while much less of the soil transfer coefficient is indicated for the other type of vegetables such as for the eggplant by having the lowest level of transferring the heavy metals from the soil to the plants.

Table 5. 3: Average concentration of Heavy Metals (mg/kg) and the soil transfer coefficient (STC) from these metals to plants cultivated in these soils.

Sample Name	Ba average	Ba STC	Mn average	Mn STC	Fe average	Fe STC	Co average	Co STC	Ni average	Ni STC	Pb average	Pb STC	Cr average	Cr STC	V average	V STC	Cd average	Cd STC
Zucchini	0.42	0.21	1.28	5.32	80.47	0.15	0.02	0.18	0.61	1.90	0.05	2.42	19.96	13.31	0.05	1.76	0.00	0.08
Potatoes	1.30	0.64	1.80	7.51	125.33	0.24	0.03	0.31	2.57	8.03	0.06	2.88	31.46	20.98	0.12	3.93	0.01	0.25
Eggplant	0.30	0.15	0.49	2.03	70.78	0.14	0.03	0.31	0.30	0.94	0.06	2.88	8.06	5.37	0.08	2.64	0.00	0.06
Onions	0.51	0.25	1.15	4.77	137.55	0.26	0.01	0.14	0.74	2.30	0.05	2.38	29.18	19.46	0.20	6.73	0.00	0.06

Chapter Six

Conclusion and Recommendations

6.1 conclusion

From the present study, it can be concluded that some heavy metals (Ba, Pb, Cr, and V) concentrations in some studied vegetables and especially the root type vegetables obtained from Central Jordan Valley region including East Nablus were above the permissible limits set by FAO/WHO for human consumption. However, levels of (Mn, Ni, Fe, Cd, and Co) in all studied vegetables collected found below the maximum allowable limit. The results also indicated that the source of contamination was by using either raw wastewater or mixed with fresh water. Plants cultivated in agricultural lands which are located close to the wastewater stream has a high level of heavy metals concentrations which can indicate that it might be the main source of heavy metals contamination to these plants.

Roots vegetables had the highest heavy metals concentrations (roots vegetables > fruit vegetables), Barium accumulated in roots vegetables higher than fruits vegetables but wide range of Ba concentration within each crop type was largely unexplained by the soil and water Ba concentration. There was also no significant relationship between Ba concentrations in vegetables water Ba concentrations. The manganese levels in the tested vegetable samples were very low and within the WHO permissible limits. Soil data showed a very low concentrations of Manganese but even higher concentration of manganese metal in soil does not mean that it will be bioavailable to plants and especially with the application of Fe to the agricultural lands which might decrease the Manganese mobility in the soil and thus the Manganese uptake by plant. Iron seems to be less available by the water for irrigation, but higher concentrations in soil and plant. In fact, farmers in the study area are dependent on the stream water and well water for agricultural irrigation, Iron is removed under aeration conditions as a physical – chemical conditions, and with pH > 6 which explain the status of the low Iron concentration in the water for irrigation. Iron might be added to the soil by the application of some Iron complexes such as

Ferric EDTA. The highest concentration of cobalt content for plant is (0.16 mg/kg) while the rest of the tested plants are below (0.04 mg/kg) and this status of cobalt content in plant can be called a cobalt deficient status according to (Racikovitch, 1961). The results indicate that Cobalt is quantitatively a very high sorption on the soils of the study area, under all conditions, when the pH is around 7, Cobalt sorption is very high in soil B horizon. Given that the soil solution pH of these soils is approximately 8, Cobalt is expected to bind strongly on these soils. Cobalt appears to bind strongly on soils clay particles in soil B horizon, making it very less available for plant uptake. It was noticed that Nickel uptake by plant is reduced. Where the highest uptake of Nickel is in the root vegetables such as Potatoes and Onions. Root type of vegetables tend to accumulate more Nickel comparing to the rest of studied vegetables. (Kukier, 2001) reported in their study that the use of wastewater from quarries with lime effluent will reduce the uptake of Nickel by plant by making it less bioavailable for plant uptake. It has been reported from many other previous studies that there are some quarries are discharging their raw wastewater to Wadi Abashan natural stream which by then reach the agricultural lands. For fruits, and root crops, there was no significant relationship of crop lead to soil - water lead content; even for root crops, there was only a weak tendency for crops grown in higher lead soils to be more Pb-contaminated. The poor ability of soil – water lead to predict vegetables lead is perhaps understood in view of the fact that vegetable lead content can't be correlated to soil - water lead content in our case study due to the very high variability in the results of the soil - water lead content. Only the root crops (Onions) have a statistically significant (Onions > fruit vegetables) relationship of vegetable lead. A clear increase in concentration of Chromium in different types of the plants. Accumulation of Chromium in the different types of plants was in the following order Potatoes> Onions> Zucchini>Eggplant. In our case study there is a clear trend of Chromium to be accumulated more in the root type of plants in the study area, thus Potatoes tend to accumulate Cr the highest comparing to other types of plants as it has been reported by (Allaway, 1973). The Chromium transformation and transport mechanism seems to be hard to explain in our case study. Chromium is a metals that is highly affected by its surrounding environmental conditions, such as pH, Chromium tend to deposit as lower pH value. Chromium levels in the studied soil samples remain higher than the water samples but in natural systems such as our study area, the agricultural water system tends to have pH value at around 7 which allow a Chromium to be stable and will deposit in the terrestrial environment which explain the status of Chromium concentrations that are lower in the water samples comparing to the soil samples. Vanadium concentrations was detected at the safe limit that we set for this study, the average concentration was 0.05, 0.12, 0.08 and, 0.20 (mg/kg) for Zucchini, Potatoes, Eggplant, and Onions respectively. The highest Vanadium concentration was detected for Onions with an average of (0.20 mg/kg), while the lowest Vanadium concentration was detected for Zucchini with an average of (0.05 mg/kg). Vanadium concentration of the water samples from the study area seems to be very low and in most of the studied samples the results were around 0.01 ppm while soil data showed a concentrations of Vanadium that are ranged between 0.20 – 0.50 mg/kg, which are very similar to the concertation of the Vanadium that accumulated in the plant samples. Thus plants in general have a soil bioaccumulation and transfer of Vanadium from soil to plant. (Welch, 1973) found that accumulation of Vanadium is Phosphate (H_2PO_4) by an inhibition level of up to 27% less than the control, thus we suggest in this study and by the results we have from the analysis on Vanadium concentrations in plant, soil, and water samples that Vanadium tend to accumulates from the wastewater source that it either reaches the agricultural lands directly or by mixing these waters with the water of irrigation and use it to irrigate the fields. Another hypothesis can be the fixation of Vanadium in the soil system by the addition of Superphosphate to the agricultural fields by the farmers as it has been found by (Welch, 1973).

Despite the relation between water, soil and vegetables, sometimes, the data of soil – water heavy metals content can be hard to be correlated to plant – heavy metals content which suggest that there are some other non-point sources of pollution to this study area and make it clear evidence that contamination results from the direct irrigation of raw or mixed wastewater and other non-point sources of pollution. The results reveal that the discharge of raw wastewater to natural stream has a high negative impacts on the environment and other sectors such as the agricultural sector. Some local farmers apply unaccepted farming and irrigation methods in violation to the instruction from the Palestinian responsible authorities such as the ministry of Agriculture that is highly prohibit the use of untreated wastewater for vegetables irrigation. Yet, long term consumption of heavy metals may cause several health hazards in human. Thus, regular monitoring of heavy metals content on vegetables is crucial to avoid accumulation of such metals in the human food chain.

6.2 Recommendations

Based on the findings of this research project, which were collected over one-year data gathering and analysis, the following recommendations are proposed within suggested interventions that could reduce the environmental and economic risk of the discharge raw wastewater to natural streams and agricultural lands:

1- Construction a proper wastewater treatment plant in Nablus East area in order to lessen the negative effects of the wastewater discharge to Wadi Albathan natural stream, which can help in applying a sustainable development strategy for wastewater management and reuse in Palestine.

2- The local municipalities and authorities in Nabuls East area urgently need to apply policies to stop the discharge of raw wastewater to Wadi Albathan natural stream.

3- The local textile industries need to have a primary on-site treatment unit at each factory especially that deals with chemicals to avoid discharge of heavy metals to natural water systems.

4- The Ministry of Agriculture and Palestinian Water Authority must work to ensure proper agro-business management in term of water and food qualities in the central Jordan Valley area and to be impermeable through the development of specialized monitoring programs.

5- Raising awareness between farmers on the high negative impact of the use of mixed or untreated wastewater for agricultural irrigation.

6- Other studies of this approach should be conducted for monitoring heavy metals in vegetables in this location and others in Palestine.

Bibliography

Abu-Madi, M. O. (2004). *Incentive Systems for Wastewater Treatment and Reuse in Irrigated Agriculture in the MENA Region, Evidence from Jordan and Tunisia.* Rotterdam, The Netherlands: A.A. Balkema.

Achakzai, A. &. (2011). Accumulation of heavy metals by lettuce (Lactuca sativa L.) irrigated with different levels of wastewater of Quetta City. *Pakistan Journal of Botany* , 2953-2960.

Ackah, M. A.-N. (2013). Uptake of heavy metals by some edible vegetables irrigated using wastewater: a preliminary study in Accra, Ghana. Environmental Monitoring and Assessment. *USA*, 6.

Adeel Mahmood, R. N. (2014). Human health risk assessment of heavy metals via consumption of contaminated vegetables collected from different irrigation sources in Lahore, Pakistan. *Arabian Journal of Chemistry*, 91-99.

Adeel Mahmood, R. N. (2014). Human health risk assessment of heavy metals via consumption of contaminated vegetables collected from different irrigation sources in Lahore, Pakistan. *Arabian Journal of Chemistry*, 91.

Aklilu, N. Y. (2015). Onion production for income generation in small scale irrigation users' agro-pastoral households of Ethiopia. *Food and Agriculture Organization FAO*.

Al Daraowsheh, A. (2014). Spatial quality of municipal wastewater flowing in wadi Al-Zomar and infiltrated through wadi bed. *Institute of Environmental and Water Studies, Birzeit University, Palestine*.

Al-Hammad, B. A.-S. (2014). Quality of wastewater reuse in agricultural irrigation and its impact on public health. *Biology Department, College of Science and Humanity Studies, Salman bin Abdulaziz University, Al-Kharj, Saudi Arabia.*

Al-Khatib, I. A.-Q. (2019). Health Risk Associated with Some Trace and Some Heavy Metals Content of Harvested Rainwater in Yatta Area, Palestine. *Water Quality and Ecosystems*.

Allaway, E. W. (1973). Chromium in plants: distribution in tissues, organelles, and extracts and availability of bean leaf Cr to animals. *Journal of Agricultural and Food Chemistry*, 982–986.

Almas, H. M. (2013). Assessment of Wastewater Quality of Drains for Irrigation. *Journal of Environmental Protection*, 9.

Ammann, A. A., & Chem, A. B. (2002). Speciation of heavy metals in environmental water by ion chromatography coupled to ICP-MS. *Springer-Verlag*, 8.

Amous, B. (2014). Nitrogen and heavy metal fluxes from cesspits in Palestine Beit Dajan and Beit Fourik as a case study. *Institute of Environmental and Water Studies, Birzeit University, Palestine*.

Anke, M. I.-G. (2005). Recent progress on essentiality of the ultratrace element vanadium in the nutrition of animal and man. *Biomedical Research on Trace Elements*, 208-214.

Antonio Jordán (2012). *Mediterranean soils, terra rossa, The soil under our boots.* Spain: University of Sevilla.

ARIJ. (2012). Al Jiftlik Village Profile. *ARIJ*, 22.

ARIJ. (2012). Al Jiftlik Village Profile. *The Applied Research Institute – Jerusalem*.

Arnason, G. &. (2003). A 40+Year Record of Cd, Hg, Pb, and U Deposition in Sediments of Patroon Reservoir, Albany Country, NY, USA. *Environmental Pollution,*, Vol. 123, No. 3, pp. 383-391.

Arora M, K. B. (2008). Heavy metal accumulation in vegetables irrigated with water from different sources. *foodchem*, 11.

Arora, M. K. (2008). Heavy Metal Accumulation in Vegetables Irrigated With Water From Different Sources. *Food Chemistry*, 811-815.

Auda, M. &.-Z. (2011). Accumulation of heavy metals in crop plants from Gaza Strip, Palestine and study of the physiological parameters of spinach plants. *Journal of the Association of Arab Universities for Basic and Applied Sciences*, 21-27 .

Ayotte, E. (2015). *Zucchini from A to Z.* USA: University of Alaska, Extension Faculty, Health, Home and Family Development.

Baker, M. S. (2007). Wastewater Characteristics and the Impact of its Use in Irrigation on Soil: The Case of Faria Catchment . *An-Najah National University Faculty of Graduate Studies* , 82.

Bartlett, R. J. (1976). Behavior of chromium in soils: oxidation. *Journal of Environmental Quality*, 31–35.

Beata, F. D. (2013). Impact of wastewater from pig farm lagoons on the quality of local groundwater. *University of Novi Sad Faculty of Sciences,*.

Birame, C. (2012). Development of a low-cost alternative for metal removal from textile wastewater. *Wageningen University and the Academic Board of the UNESCO-IHE Institute for Water Education.*

Birzeit University, C. C. (2003). The use of untreated wastewater in irrigation is an on going practice . *Callvin Collage Partnership*, 16.

Boamponsem, G. A. (2012). Heavy metals accumulation in cabbage, lettuce and carrot irrigated with wastewater from Nagodi mining site in Ghana. *Int J Sci Technol Res*, 11.

Calace, N. P. (2002). Heavy metal uptake by barley growing in polluted soils, relationship with heavy metal speciation in soil. *Commun. Soil Sci. Plant Anal*, 103 – 115.

CEC, C. o. (1991). *Council of the European communities directive concerning urban wastewater treatment.* Official Journal of European Communities.

Censi, P. S. (2006). Heavy metals in coastal water systems. A case study from the Northwestern Gulf of Thailand. *Chemosphere*, 64: 1167-1176.

Chesnin, L. (1996). Irrigation with sewage of effluent. Cooperative extension service. *Institute of agriculture and natural resources-University of Nebraska-Lincoln-USA.*, 19.

Chu, D. (2018). Effects of heavy metals on soil microbial community. *Earth and Environmental Science*, 1755-1315.

Coscione AR, B. R. (2009). Barium extraction potential by mustard, sunflower and castor bean. *Sci Agric*.

Daghrah. (2005). Water Quality Study of Wadi Al Qilt-West Bank-Palestine. *Asian Journal of Earth Sciences*, 28-38.

Daghrah., G. (2005). Pollution and Water Quality Assessment of Wadi Al Qilt. *Institute of Environmental and Water Studies, Birzeit University, Palestine*.

Das, R. S. (2003). Impact of Wastewater Discharge on Soil and Ground Water - A case study. *journal of scientific and industrial research*, 207-211.

Dorne, J. K. (2011). Human risk assessment of heavy metals: principles and applications. *Royal Society of Chemistry,*, 60.

Douay F, P. A. (2013). Assessment of potential health risk for inhabitants living near a former lead smelter. Part 1: metal concentrations in soils, agricultural crops, and homegrown vegetables. *Environ Monit Assess*, 185(5):3665-80.

Dragun, J. (1988.). The Soil Chemistry of Hazardous Materials. *Hazardous Materials Control Research Institute. Silver Spring, MD*.

Dudeen, B. (2001). *The Soils of Palestine (The West Bank and Gaza Strip) Current Status and Future Perspectives* . 203-225: CIHEAM Options Méditerranéennes.

Duruibe, J. O. (2007). Heavy metal pollution and human biotoxic effects. *International Journal of Physical Sciences*, 112-118.

EC. Commission Regulation. (2006). setting maximum levels for certain contaminants in foodstuffs. *Off J Eur Union L*.

Eissa, D. A.-S. (2017). Distribution and Mobility of Vanadium in Cultivated Calcareous Soils and Some Food Chain Crops. *Desert Research Center, El-Matariya*, 385 - 392.

El-Turk, M. F. (2014). *Assessment of Heavy Metals Pollution of Wadi Gaza, Eastern.* Gaza, Palestine : Islamic University - Gaza.

EPA, U. (2015). Human health risk assessment: risk-based concentration table. *US EPA.*

EQA. (2004). Al-Fara'a Baseline Report. Palestine. *Environment Quality Authority EQA* .

Farzana, B. M. (2009). Heavy metals uptake by vegetables growing in sewage irrigated soil: relationship with heavy metal fractionation in soil. *Chemical Speciation & Bioavailability*, 199-209.

Fischer, G. P. (2011). Postharvest Biology and Technology of Tropical and Subtropical Fruits. *Food Science, Technology and Nutrition*, 374-396.

Frank, A. M. (1996). Vanadium poisoning of cattle with basic slag. Concentrations in tissues from poisoned animals and from a reference, slaughter-house material. *Science of The Total Envionment* , 73-92.

Gadhia, M. A. (2014). Effect Of Treated Wastewater On Growth Of Vegetable Crops. *Urban Water Journal*, 309-320.

Gama-Castro, J. E. Solleiro-Rebolledo, Elizabeth Vallejo-Gómez, E (2000). Weathered pumice in¯uence on selected alluvial soil properties in west Nayarit, Mexico. *Soil & Tillage Research ELSEVIER*, 165.

Gatto, N. M. (2010). Occupational exposure to hexavalent chromium and cancers of the gastrointestinal tract: a meta-analysis. *Cancer epidemiology*, 388–399 .

Gould, D. B. (1973). Bariumsulfide poisoning: Some factors contributing to survival. *Archives of Internal Medicine*.

Growers, Q. (2017). *Lebanese Zucchini.* AUSTRALIA: Quantum Growers .

Grusak, M. E. (1998). Iron transport and storage within the seed coat and embryo of developing seeds of pea. *Seed Sci. Res.*, 8, 367-375.

Hanjra, M. B. (2011). Wastewater irrigation and environmental health: Implications for water governance and public policy. *International journal of hygiene and environmental health*.

Hanor, J. S. (2000). Barite-Celestine Geochemistry and Environments of Formation. *Department of Geology and Geophysics*.

Hayat, S. e. (2012). Physiological changes induced by chromium stress in plants: anoverview. . *Protoplasma* , 599–611.

HealthyEating. (2012). *Health Benefits of Vegetables: Vitamins, Nutrients Eggplant: Solanum melongena L., NeuroImage.* USA: HealthyEating.

Ho, I. a. (1988). Elevated levels of lead and other metals in roadside soil and grass and their use to monitor aerial metal depositions in Hong Kong. *Environmental Pollution* , 49: 37-51.

Hosohara, H. R. (1964). The geochemistry of tin. *Elsevier*, 1039-1053.

HSDB, H. S. (1998). Bethesda, MD, National Institutes of Health,. *National Library of Medicine*.

Isa, B. K. (2017). Exposure Study and Health Risk Assessment of Heavy Metals in Soils around Tanneries in Challawa Industrial Estate, Kano, Nigeria. *INTERNATIONAL JOURNAL OF CHEMICAL*, 108-117.

Issam A. Al-Khatib, G. A.-Q. (2019). Health Risk Associated with Some Trace and Some Heavy Metals Content of Harvested Rainwater in Yatta Area, Palestine. *Water MDPI* , 16.

Iyengar, G. V. (2000). Global outlook on nutrition and the environment: meeting the challenges of the next millennium. *Department of Health Sciences and Applications, International Atomic Energy Agency*, 331-46.

Jenkins, D. (1998). The effect of reformulation of household powder laundry detergents on their contribution to heavy metals in wastewater. *Water Environment Research*, 980-983.

Jiries, A. K. (2002). Pesticide and Heavy Metals Residue in Wastewater, Soil and Plants in Wastewater Disposal Site Near Al-Lajoun Valley, Karak / Jordan. *Water Air and Soil Pollution*, 97-107.

Kabata-Pendias A., P. H. (1999). Biogeochemia pierwiastków śladowych, Warszawa, Wydawnictwo Naukowe . *PWN*, 329-336.

Kabata-Pendias, A. F. (1995). Agricultural Problems Related to Excessive Trace Metal Contents of Soils. *Environmental Science Springer, Berlin, Heidelberg*.

Kachenko, A. a. (2006). Heavy metals contamination in vegetables grown in urban and metal smelter contaminated sites in Australia. *Water Air Soil Pollution* , 169: 101-123.

Kanungsukkasem U, N. N. (2009). Fruit and vegetable consumption in rural adults population in INDEPTH HDSS sites in Asia. *Glob Health Action*, 35-43.

Kapri, A. Z. (2010). SPION-accelerated biodegradation of low-density polyethylene by indigenous microbial consortium . *Inter. Biodeterio. Biode.* , 238-244.

Khallaf, E. G. (1998). Assessment of heavy metals pollution and their effects on Oreochromis niloticus in aquatic drainage canals. *J. Egypt. Ger. Soc. Zool.*, 39-74.

Khodadoust, A. P. (2004). Removal of nickel and phenanthrene from kaolin soil using different extractants. *Environmental Engineering Science*, 691–704.

Kimbrough, D. E. (1999). A critical assessment of chromium in the environment. *Critical Reviews in Environmental Science and Technology*, 1–46.

Kotaś, J. S. (2000). Chromium occurrence in the environment and methods of its speciation. *Environ Pollut*, 263-83.

Kukier, U. C. (2001). Amelioration of nickel phytotoxicity in muck. *J Environ Qual*, 1949–60.

Lamb DT, M. V. (2013). Bioavailability of barium to plants and invertebrates in soils contaminated by barite. *Environ Sci Technol*.

Lin, X. B. (2005). Heavy metlas in wastewater: the effect of electrolyte composition on the precipitation of cadmium (II) using lime and magnesia. *Water, Air, and Soil Pollution*, 131-152.

Lipchin, C. (2017). Water and wastewater management cannot and need not wait for a political settlement, and the public, must demand from our governments to act now. *The Jerusalem Post* .

Liu, J. e. (2011). Characteristics of chromium (III) uptake in hyperaccumulator Leersiahexandra Swartz. . *Environ. Exp. Bot.* , 122–126.

Loonker, A. A. (2011). A Comparative Analysis of Trace Metals in Vegetables. *Research Journal of Environmental Toxicology*, 125-132.

López-Luna, J. M.-C.-G.-V. (2009). Toxicity assessment of soil amended with tannery sludge, trivalent chromium and hexavalent chromium, using wheat, oat and sorghum plants. *Journal of Hazardous Materials*, 829–834.

Maigari, E. E. (2018). Health risk assessment for exposure to some selected heavy metals via drinking water from Dadinkowa Dam and river gombe abbain gombe state, Northeast Nigeria. *Elsevier B.V.*, 1-9.

Mason, C. (1991). Biology of freshwater pollution. *Longman Scientific and Technical*.

Masood, S. B. (2005). Hazardous effects of sewage water on the environment. *Management of Environmental Quality*, 16.

Masscheleyn, P. H. (1992). Chromium redox chemistry in a Lower Mississippi Valley bottomland hardwood wetland. *Environmental Science and Technology*, 1217–1226.

McGrath SP, C. A. (1994). Land application of sewage sludge: Scientific perspectives of heavy metal loading limits in Europe and the United States. *Environ Rev.* .

Michael, A. F. (2014). *Soil classification system of England and Wales.* UK: Cranfield University, UK, National Soil Resources Institute.

Miroslav, R. P. (2009). Statistical Perspective and Pollution Indicator in Mengkabong Mangrove Sediment Sabah. *Modern Applied Science*, 10.5539/mas.v2n4p131.

Mishra, S. V. (1995). Studies on uptake of trivalent and hexavalent chromium by maize (Zea mays). *Food and Chemical Toxicology*, 393–397.

MohamedAbou Auda, I. Z. (2011). Accumulation of heavy metals in crop plants from Gaza Strip, Palestine and study of the physiological parameters of spinach plants. *Journal of the Association of Arab Universities for Basic and Applied Sciences*, 27.

Morel, F. M. (1993). Principles and Applications of Aquatic Chemistry. *John Wiley and Sons, Inc., New York City, NY*.

Mosbaek H, T. J. (1989). Atmospheric lead input to agricultural crops in Denmark. *Chemosphere*.

Mustafa, O. (2006). Impact of Sewage Wastewater on the Environment of Tanjero River and Its Basin within Sulaimani City/NE-Iraq. *Council of the college of science, university of Baghdad. Iraq*.

Nejem, R. M.-A.-S. (2009). Detection of Some Heavy Metals Due to Sewage Water Diffusion into Planted Land. *Journal of Environmental Science and Technology*, 88-94.

Nriagu, J. (1988). Chromium in Natural and Human Environments. *New York, NY, USA: Wiley Interscience*, 81–104.

Ogoko, E. O. (2014). Bioconcentration and Transfer of Heavy Metal from Soil into Verninia amydalina, Telfera occidendalis, and Amarathus spinosus. *Journal of Applied Phytotechnology in Environmental Sanitation*, 117-121.

Oliveira, H. (2012). Chromium as an environmental pollutant: insights on induced planttoxicity. .

Parvez, M. M. (2013). Evaluating the Wastewater Impacts on Groundwater and Irrigated Soil. *World Applied Sciences Journal*, 24.

Racikovitch, S. M. (1961). MICROELEMENTS IN SOILS OF ISRAEL. *Soil Science*, 85-89.

Radojevic, M. B. (1999). Market basket survey for some heavy metals in Egyptian fruits and vegetables. *The Royal Society of Chemistry Cambridge*, 1273–1278.

Radwan, A. M. (2006). Market basket survey for some heavy metals in Egyptian fruits and vegetables. *ELSEVIER*, 1273-1278.

Rafat M. Nejem, N. M.-A.-S. (2009). Detection of Some Heavy Metals Due to Sewage Water Diffusion into Planted Land, Gaza, Palestine . *Journal of Environmental Science and Technology*, 6.

Randall, J. S. (2005). *Soils: Genesis and Geomorphology.* UK: Cambridge University Press.

Rattan, R. S. (2005). Long-term impact of irrigation with sewage effluents on heavy metal content in soils, crops and groundwater. *Agric. Ecosyst. Environ.*, 109: 310-322.

Rehder, D. (1999). The concentration chemistry of vanadium in related to its biological function. *Coord. Chem. Rev.*, 297-322.

Reifenberg, A., & Whittles, C. L. (1938). The soils of Palestine; studies in soil formation and land utilisation in the Mediterranean. *London, T. Murby & Co.*

Reisenauer, B. T. (2008). Manganese-iron interactions in the plant-soil system. *Journal of Plant Nutrition*, 7 - 30.

Renuka, G. K. (2016). Heavy and toxic metal uptake by mesoporous hypercrosslinked SMA beads: Isotherms and kinetics. *Journal of Saudi Chemical Society*, 579-590.

Richard, S.-S. P. (2009). Further evidence that beet western yellows virus is not a component in potato leafroll disease. *Canadian Journal of Plant Pathology*, 191-196.

Ronaghi, R. G.-F. (2008). Interaction of Iron with Copper, Zinc, and Manganese in Wheat as Affected by Iron and Manganese in a Calcareous Soil. *Journal of Plant Nutrition*, 839-848.

Rosas, I. R.-P. (1989). Some aspects of the environmental exposure to chromium residues in Mexico. *Water, Air, and Soil Pollution*, 463–475.

Rule, K. C. (2006). Diffuse sources of heavy metals entering an urban wastewater catchment. *Chemosphere*, 64-72.

Ruyters, S. M. (2011). The red mud accident in Ajka (Hungary): Plant toxicity and trace metal bioavailability in red mud contaminated soil. *Environmental Science & Technology*, 1616-1622.

Salariy, A. M. (2003). Effect of polluted water on accumulation of heavy metals in commonly consumed vegetables. *J. Chem. Soc. Pak*, 161 – 165.

Säumel I, K. I. (2012). How healthy is urban horticulture in high traffic areas? Trace metal concentrations in vegetable crops from plantings within inner city neighbourhoods in Berlin, Germany. *Environ Pollut.*

Sciences, N. A. (2004). Food and Nutrition Board . Dietary Reference Intakes [DRIs]: recommended intakes for individuals. *National Academy of Sciences*.

Serdula, M. K. (1996). The association between fruit and vegetable intake and chronic disease risk factors. *Epidemiology*, 6.

Shanker, A. e. (2004). Expression of metallothionein 3-like protein mRNA insorghum cultivars under chromium (VI) stress. . *Curr. Sci.*, 901–902.

Shankle, R. &. (1988). Acute paralysis from inhaledbarium carbonate. *Archives of Neurology*.

Sharma, A. K. (2016). Heavy metals in vegetables: screening health risks involved in cultivation along wastewater drain and irrigating with wastewater. *SpringerPlus*.

Smichowski P, G. D. (2004). Monitoring trace metals in urban aerosols from Buenos Aires city. Determination by plasma-based techniques. *J Environ Monit.*

Strahorn. (1929). Agriculture and Soils of Palestine. *American Geographical Society*, 581-602.

Sunil, P. N. (2017). Onion (Allium cepa L.) Vegetable waste management View project Phytochemicals of Fruits and Vegetables View project. *Department of Agriculture and Environmental Sciences, National Institute of Food Technology Entrepreneurship and Management (NIFTEM)*.

Tarvainen, T. L. (1997). Source of trace metals in streams and headwater lakes in Finland. *Water, Air, Soil Pollution* , 1-32.

Tsdale, F. M. (2004). Trace and Macro Elements Concentrations in Selected Fresh Fruits, Vegetables, Herbs, and Processed Foods in North Carolina, USA. *Scientific Research*, 12.

Tulonen, T. P. (2006). Concentrations of heavy metals in food web components of small, boreal lakes. *Boreal Environ. Res*, 185-194.

US EPA. National Center for Environmental Assessment. (1997). Exposure Factors Handbook: 1997 Edition. *Environmental Protection Agency; Washington, DC*.

Warner, N. C. (2013). Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania. *Environmental science & technology*.

Warner, N. C. (2013). Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania. *Division of Earth and Ocean Sciences, Nicholas School of the Environment, Dukes University, Durham, North Carolina 27708, United States. Environ. Sci. Technol.,*, 20.

Warsito, T. E. (2006). *An Ecological Guide to Potato Integrated Crop Management.* EU: FAO.

Welch, R. (1973). Vanadium uptake by plant. *Plant Physiology*, 183-158.

WQA, T. W. (2019). *Cadmium in Drinking Water*. Lisle, USA : The Water Quality Association.

Xingmei, L. Q. (2013). Human health risk assessment of heavy metals in soil–vegetable. *Science of the Total Environment*, 11.

Yasser, J. F. (2010). Delivering Access to Safe Drinking Water and Adequate Sanitation in Pakistan. *Pakistan Institute of Development Economics*, 58.

Zasoski, S. E. (1992). Chromium(III) oxidation by δ-MnO2. 1. Characterization. *Environmental Science and Technology*, 79–85.

Appendixes

Descriptive Statistics Heavy Metals Concentrations in Vegetables Samples in the study area

	Cr		Ni		Co		Mn		Ba		Pb		Fe		V		Cd	
Sample Name	**mg/kg**	**RSD**	**mg/kg**	**RSD**	**mg/kg**	**RSD**	**mg/kg**	**RSD**	**mg/kg**	**RSD**	**mg/kg**	**RSD**	**mg/kg**	**RSD**	**mg/kg**	**RSD**	**mg/kg**	**RSD**
zucchini	6.71	0.30	0.66	0.08	0.01	0.00	1.01	0.01	0.54	0.03	0.05	0.01	42.08	1.58	0.02	0.00	0.00	0.00
zucchini	N/D	N/A	0.06	0.01	0.00	0.00	1.19	N/A	0.89	0.05	0.06	0.04	17.37	0.04	0.00	0.00	0.00	0.00
zucchini	8.06	2.64	0.82	0.03	0.03	0.00	0.92	0.08	0.45	0.10	0.03	0.01	50.60	29.01	0.04	0.01	0.00	0.00
zucchini	29.74	0.99	1.40	0.07	0.01	0.00	1.46	0.02	0.17	0.01	0.05	0.04	141.80	4.93	0.09	0.01	0.00	0.00
zucchini	28.05	0.71	N/D	N/A	N/D	N/A	1.00	0.01	0.42	0.00	0.05	N/A	109.45	1.15	0.07	0.00	N/D	N/A
zucchini	29.78	1.35	0.10	0.01	0.03	0.00	2.08	0.01	0.06	0.00	0.05	0.02	121.49	1.80	0.10	0.00	0.01	0.00
potatoes	36.89	25.02	2.38	0.19	0.04	0.00	2.72	0.66	0.35	0.01	0.06	0.01	154.10	7.05	0.23	0.00	0.01	0.00
potatoes	29.43	3.17	2.44	0.05	0.01	0.00	1.25	0.02	1.80	0.01	0.06	0.08	119.89	9.33	0.09	0.00	0.00	0.00
potatoes	29.79	1.57	2.64	0.10	0.03	0.00	1.92	0.01	1.61	0.01	0.06	0.03	116.54	1.78	0.09	0.00	0.00	0.00
potatoes	28.84	1.24	2.82	0.07	0.03	0.00	1.32	0.01	1.45	0.03	0.05	0.01	110.78	0.50	0.07	0.00	0.02	0.00
eggplant	28.90	0.75	0.01	0.00	0.02	0.00	0.33	0.00	0.53	0.00	0.05	1.26	116.82	11.24	0.09	0.00	0.00	0.00
eggplant	30.94	0.57	0.05	0.00	0.02	0.00	0.85	0.01	0.44	0.00	0.04	N/A	133.50	59.16	0.12	0.00	N/D	N/A
eggplant	N/D	N/A	0.67	N/A	0.04	0.00	0.60	N/A	0.14	0.03	0.05	N/A	1.20	3.49	N/A	N/A	N/D	N/A
eggplant	N/D	0.00	0.47	0.01	0.03	0.00	0.17	N/A	0.09	0.01	0.09	0.03	31.59	6.87	0.10	0.00	0.01	0.00
onions	18.46	6.81	2.60	0.13	0.12	0.00	1.56	0.17	0.95	0.03	0.09	0.02	407.33	3.87	0.68	0.02	0.00	0.00
onions	24.90	0.24	2.59	0.10	0.16	0.00	1.77	0.01	1.60	0.00	0.06	0.10	123.23	1.16	0.13	0.00	0.00	0.00
onions	N/D	N/A	2.72	0.33	0.05	0.00	1.70	N/A	1.32	0.22	0.15	0.10	5.66	0.49	N/D	N/A	0.00	0.00
onions	N/D	N/A	2.86	0.11	0.09	0.00	2.82	N/A	1.72	0.05	0.07	0.01	13.98	0.63	N/D	N/A	0.00	0.00