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Determination of Heavy Metals in the Vegetable Farm Soils of Industrial and Non-Industrial Areas in the Kingdom of Bahrain

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Abstract
This study aimed to determine and compare the presence of heavy metals and to assess the physico-chemical properties of vegetable farm soils in Budaiya and Sitra, Kingdom of Bahrain and the results on the physicochemical analysis were compared against the environmental standard composition of farm soil. The physico-chemical analysis on the soil samples were done in the biochemistry laboratory while the analysis of heavy metals and macronutrients was done in an ISO certified laboratory. Atomic Absorption Spectroscopy was done in assessing the amount of Lead, Cadmium, $S0_4^{-2}$, $N0_3^{-1}$and $P0_4^{-3}$ while the spectrophotometer was used to determine the amount of Ca^{+2} , Mg^{+2}, K^+, and $Fe^{+2}$and have been found out through T-test that there is no significant difference on these components thus, they are comparable to the normal composition though $Mg^{+2}$and $N0_3^-$ is quite higher when compared to the normal composition of both sites of vegetable farm soils indicating the soil is slightly acidic and has that ability to absorb most of the micro-nutrients. Further, the determination of pH was carried out with an average pH of 6.87 which is still within the standard pH for garden soils ranging from 6.5 to 7.5 although slightly more acidic in Sitra. Lastly, the vegetable farm soils was found to be positive with heavy metal lead in both areas and while traces of cadmium was found in Sitra and found negative with heavy metal cadmium in Budaiya.
Keywords: Heavy metals, physico-chemical properties, elemental composition, Polyatomic ions, micronutrients, macronutrients, Atomic Absorption Spectroscopy

1. Introduction

The presence of heavy metals and mineral oil had been mentioned by experts that it is one of the common contaminants in soil. Researches mentioned that heavy metals are toxic and hazardous when found in crops and can also contaminate the ground water. The properties and composition of soil plays the function as filter that can maintain and leave toxic substances in it. Heavy metals are toxic to all forms of organisms and have approximate density of 5.0 g/ml or higher like lead, copper, mercury and cadmium that may react chemically in the environment [1]. The contamination of the soil may be caused by individual activities and industrial operations. Consequently, this urbanization can trigger soil erosion from which this stimulation makes this soil contaminated. Soils are where most of the heavy metals are deposited which through anthropogenic actions are unconfined into the environment. The heavy metals then can undergo chemical change and forms bioavailability which inhibit the biodegradation of any organic matter which may activate problems and risks to the people and to the environment as well.

Soil samples included in the study were taken from a vegetable farms in Sitra and in Budaiya. It was mentioned by E. M. Brigdes and C.P. Burnham (2006) in their study that soil formation in Bahrain are influenced by different factors like solonchaks, regosols, vermosol and fluvisols other than the effect of climate.

The Solonchaks include unique amounts of gypsum that can not undergo leaching which leads to increase in different morphological features [2]. The circulation of fluvisols, vermosols and regosols in the different areas can be attributed to the physiographical location throughout the country. Other than these factors the original material or topography is also considered [3]. The researchers also recommended that monitoring the soil properties be must be conducted much more so if the agricultural soil are raising agricultural products like vegetables.

Liu and Wang (2010) said that the bioavailability of heavy metals as environmental pollutants are not new phenomenon. However, these heavy metals are naturally found in trace amounts in natural soil already. But their presence in soil and water has its maximum limits so as not to harm humanity [4].

Suruchi and Khanna (2011) specified that the man made sources of metal contaminations are mainly associated with certain industrial activities, agricultural practices, automobile emissions, coal fired power generation plants and municipal incinerators. They mentioned that even traces of heavy metals must not be present in any food stuff since it is detrimental to humanity since they are non biodegradable in nature [5].

A study done by Norra Stefan, Schafer Jorge and Klein Daniel (2010) also stated that the sewage and mud or sludge level used and the type of industrialization where the soil samples were taken can affect the presence of heavy metals in soil [7]. It is for this reason that this study was conducted considering all these possibilities that may lead to soil contamination. This endeavor aims to help the farmers harvest produce which are free from heavy metals.

1.1 Statement of the Problem

This study aims to find out the presence heavy metal specifically mercury and cadmium in the industrial vegetable soils in Sitra area as compared to a non-industrial vegetable soil in Budaiya, Bahrain. Specifically, it sought answers to the following questions:

1. Are vegetable farm soils in the Industrial area and a non-industrial like Sitra and Budaiya, Kingdom of Bahrain contaminated with heavy metals like lead and cadmium?
2. What are the concentration levels of lead and Cadmium in the aforesaid soil samples?
3. What are the physico-chemical properties in the vegetable farm soils in the mentioned sites?
4. Is the concentration of the assessed physico-chemical properties of soils under study comparable to the Environmental Standard for Normal Garden Soil?

1.2 Significance of the Study

The occurrence of heavy metals in soil can be unsafe at certain level for humans' health because these substances are toxic once combined to soil that affect the crops and even contaminate the water that helps in the growth of the crops. The soil should be protected since it has a property that filters the toxic substances; hence, it preserves any living organism in its hold.

Soil analysis is essential in determining the fertility of a garden soil. The analysis can determine the required nutrients to maintain the soils' productivity- this can be done at least once every after 4 to 5 years as recommended by soil experts for the farmers to know and to improve the necessary possible growing environment for plants to attain maximum growth. It also includes the determination of pH level and micro nutrients content like Magnesium, Calcium, potassium and iron. Similarly, the macronutrients like nitrates, $N0_3^-$, sulfates, SO_4^{-2} and phosphate, PO_4^{-3} [6, 7] are also essential in determining the productivity of soils.

A study conducted by Blum et al., (2006) on the physico-chemical study of soil explained that other micro-elements taken from organic matter may be monitored which is essential to the productivity of soil when applied as fertilizers. A proper soil test ensures the application of enough fertilizer in meeting the requirements of the crop while taking advantage of the nutrients already present in the soil [8]. Soil Analysis can be used to diagnose problem in the area so to determine the lime requirements which is the immediate practice to neutralize the soil.

It is also very important that sampling technique is appropriate for obtaining accurate analysis. Soil testing is a requirement for farms that must complete a nutrient management plan; hence, this study was conducted.

This research will find significance to the following:

Farmers and consuming public. This study can provide information on the present characteristics of the farm soils in industrial and non industrial area and also to the consuming public on eating such agricultural products out from the said farms are safe to consume.

Future researchers. This could also serve as basis in monitoring the composition of the vegetable soils of the areas covered in the study in the future and to assess and compare the presence toxic metals and other related study.

This investigation can also help health workers, proper authorities, health workers, housewives and gardeners to become aware on the exposure of such heavy metals considering their health effects and dangers to man's health and related environmental problems once exceeded the threshold level. Furthermore, it will warn housewives to protect the members of the family to acquire and obtain health related problems in the future.

1.3 Scope and Limitation

This study focused on the determination on the level of heavy metals like lead and cadmium while the physico-chemical determination on the elemental analysis of Calcium (Ca^{2+}), potassium (K^{+1}), Magnesium (Mg^{+2}) and Iron(Fe^{+3}) likewise, the polyatomic ion nitrates (NO_3^{-1}), phosphate (PO_4^{-3}) and sulfates (SO_4^{-2}), were also determined. Soils samples were collected from industrial vegetable farm in Sitra and a Non-industrial farm in Budaiya, Kingdom of Bahrain. The amount of heavy metals, nitrates, phosphates, and sulfates from soil samples were analyzed at the Department of Science and Technology, Regions 02- Philippines when the researcher took her annual vacation on a December while the other analysis was done in the biochemistry laboratory of AMAIUB.

1.4 Research Paradigm

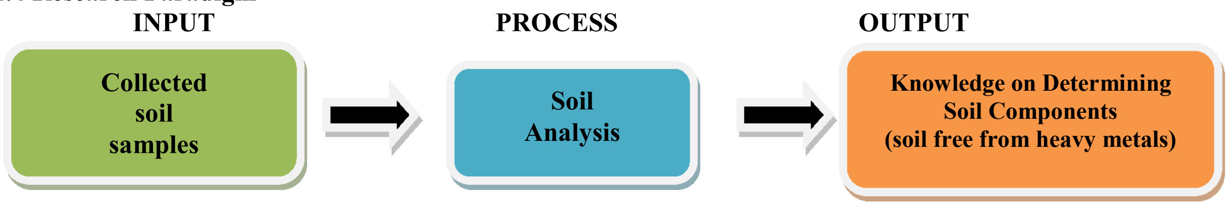

Figure 1. Heavy Metal Analysis and physico-chemical determination on the Vegetable Farm Soils of Industrial and Non-industrial Areas in the Kingdom of Bahrain

2. Literature Review

Heavy metal contamination of urban and agricultural soils could be traced from the manufacturing and using of synthetic materials. Heavy metals are by nature toxic in particular stages. Contamination with heavy metals in urban and agricultural soils could be traced from the manufacturing and using of synthetic materials leading to excessive heavy metal accumulation in soils which is lethal to all living things [9].

Basically, heavy metals turn out to be contaminants in the soil and environment as their duty of creation by the use of man-made cycles. According to solid waste management program on the Environment and Natural Resources, garbage in open dump sites is composed of five percent metal and one percent special hazardous materials [6].

Typically, due to food chain-exposure to heavy metals is generally recurring. Although rare, acute poisoning from heavy metals is eminent during intake and dermal contact. Lead, manganese, chromium, copper, mercury, nickel, and zinc are the most common cationic metals are cadmium, If these metals are not properly dispose of will find ways to come in contact with soils posing some dangers not only to siltation and flooding but infection and epidemic may result. Locally produced toxic and hazardous wastes particularly heavy metals which are left uncheck would be lethal to all forms of living organisms like people, plants and animals [7].

A study conducted by Hadiya Khalilova1 and Vagif Mammadov (2015) assessed the environmental impact of human activities in the major industrial region and mentioned that heavy metal pollution in soils and sediments are caused by various anthropogenic sources. Also, results showed that the accumulation of metals in the soils in their study is influenced mainly by industrial and vehicular sources, for which the latter is primarily responsible [8].

Liu, L., Xiuying, Z., Taiyang, Z. and Xiaoying O. L. (2015) posted an impact China's food safety when their study revealed that Cadmium sas the utmost heavy metal contamination rate of 7.75%, followed by Hg, Cu, Ni and Zn, Pb and Cr had the least contamination rates and lesser by 1%. The human actions to urban development, and industry operations such as smelting, irrigation, sewage and mining and the continuous application of fertilizers are all contributory to the increase of pollution on farmland soils because of the intense presence of heavy metals [9].

Al-Fatlawi and Al-Alwani studied the heavy metal pollution of a roadside dust at Hilla City in Iraq and characterized the properties of the roadside soils in two sites with dense traffic (60 street, high traffic volume) and secondary road with lower traffic, a local road (40 street , low traffic volume) and found out that road dust samples are contaminated with heavy metals like Chromium (Cr(III)) , Cobalt (Co), Cadmium (Cd), lead (Pb), Nicle (Ni) and zinc (Zn). They also found out that among the heavy metals studied Cadmium and chromium were found in greater amount than tolerable values in natural soils. Further, the researchers construed that the elevated amounts of these heavy metals could be due to anthropogenic property related to traffic sources [10].

A comparative study conducted by Everett and McCarthy promotes awareness on the distribution heavy metals in street dusts along the small and big areas of Birmingham and Coventry, West Midlands, UK. Accordingly, heavy metals were detected more on in a heavy streets. The high concentration values were recognized as well in association through junctions controlled by traffic lights where vehicles were likely to stop regularly. This trend was further investigated in Coventry, and found that concentrations of heavy metals through junctions controlled by traffic signals and by pedestrian controlled pelican lights (Mounted Pelican Controller, MPCs) were less as compared to those found in Birmingham, apart from Nickel [12].

Considering all these possibilities that leads to contamination of heavy metals, hence, this study was conceived by comparing the heavy metal contamination in industrial and non-industrial farm soil.

3. Research Methodology

This chapter contains the procedural methods that were utilized in gathering results on the presence of heavy metals like lead and cadmium and other soil characteristics of the vegetable farms in Sitra and Budaiya, Kingdom of Bahrain.

The Experiment Paraphernalia

The materials were washed bottle, clean plastic containers, bucket, shovel, beakers, watch glass, petri dishes, micropipets of different volumes, 0.1 mL (units) graduated cylinder, Erlenmeyer flaks, rubber, hot plate, bunsen burner, pH meter, refrigerator, water bath, digital weighing scale and Atomic Absorption Spectra which was used in determining the heavy metals of lead and cadmium, NO_3^{-1} and NO_2^{-1}, $P0_4^{-3}$ and SO_4^{-2-} and the heavy metals lead and cadmium.

The following chemical solutions and regents were used in the study: distilled water, sample reagent blanks, standard elemental reagents, HNO_3, H_2SO_4, HCl, Acetonitrile, $Mg(C_2H_3O_2)_2$, Cadmium standard solution, buffer solution at pH 9 and $Mg(NO_3)_2$.

Experimental Design

This research used of experimental method which perimeter is bound only on the existence of heavy metals like lead and cadmium and to assess other physico-chemical properties of the vegetable farm soils in Sitra and Budaiya, Kingdom of Bahrain. T-test was used to test the difference in the physico-chemical properties against the normal elemental composition of normal garden soil and further check it these properties are related thru Pearson-correlation test.

Procedures on Physico – Chemical Parameter

l. Collection of Soil Samples

Random sampling was used in gathering soil samples. About one hundred fifty grams (150g) of soil samples were collected from each aforementioned sampling site and these were kept in an individual zip-lacked plastic container and labeled accordingly. The collected farm soils were then mixed to form a composite sample which was used for the heavy metal determination and analysis of nitrates, nitrites, phosphates and sulfates. These samples were brought to the Department of Science and Technology, Regional Standards Laboratory (which is an ISO certified) in the Philippines in December 2015. Same procedure was done on the physico-chemical analysis which was done in the Biochemistry Laboratory of AMA International University – Bahrain.

2. Methods and Procedures

A. Heavy Metal Determination

1. Analysis of Lead Using Atomic Absorption Spectrometry Method

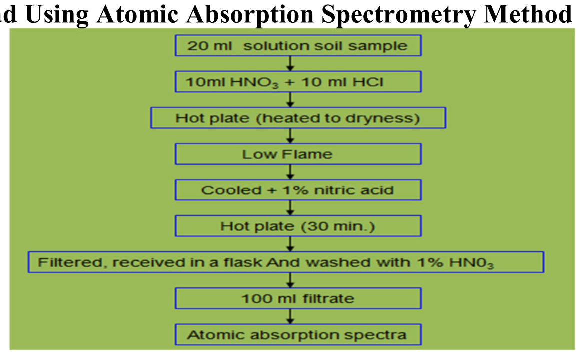

Fig. 2. Flow Chart on Lead Analysis Using Atomic Absorption Spectrometry

2. Extraction of Cadmium for **Atomic Absorption Spectrometry Method**

Analysis of cadmium requires a membrane disk to be conditioned with 20.0 mL. each of methanol and water respectively to remove all contaminants arising from previous investigation and other contaminants that will affect the analysis. The disk was allowed to dry by allowing air to pass through until almost air dry after which 8 mg of soil sample was dissolved in 3.0 mL ACN (acetonitrile) and allowed to passed through an absorbent layers for several times under gravity until the soil solution penetrated to the membrane completely. Then modified disk was applied for the extraction procedure. 100.0 mL of standard solution containing 10.0 μg of Cadmium was prepared, and the pH was adjusted with buffer solution at 9.0. This solution was loaded and allowed to pass through another membrane with the aid of a vacuum pump at a low rate for about 4.0 mL/min. Then the dissolved Cadmium ions were eluted under gravity (about 2.0 mL/min) with 5.0 mL of HNO3 (1.0 mol/L) and this was the mixture used for the AAS determination of Cadmium **[14].**

B. Determination of Anion Phosphate (PO_4^{-3}), Sulfates (SO_4^{-2}) , Nitrates (NO_3^-) and Nitrites ((NO_2^-)

1. Analysis of nitrate, (NO_3^-)

The spectrophotometer was carried out in the analysis of nitrate in the soil samples. One gram soil sample was prepared and dissolved with 50 ml de-ionized water in a100ml flask. The flask and content was stirred for about 30 minutes and the solution was filtered again into another 100ml volumetric flask allowing the mixture to stand for few minutes and the filtrates were kept and these were the ones used for the analysis of nitrate. (Lamotte, 2000 Soil Test)**.**

2. Determination of Phosphate, **(PO_4^{-3})**

The soil samples were air-dried, ground and sieved using 1mm mesh. One gram (1g) was taken from the prepared samples and this was kept in pre-weighed acid-washed porcelain crucibles and mixed with 5ml of 20% (w/v) $Mg(C_2H_3O_2)_2$ and allowed to evaporate to dryness after which it was transferred into a furnace which was preheated and set at a temperature of 500^{O}C for about 4 hours to covert mixture to ash. When all the samples had been turned to ash, it was removed from the furnace and waited to cool in a desiccators. Ten (10) ml of 6 M HCl was measured and added to the crucible and covered gradually then suddenly brought in a steam bath and heated for further another fifteen minutes to loosen the particles present in the sample. Then samples were transferred completely into different evaporating disks and each was added with 1ml of concentrated $HNO_{3,}$ 1ml of 6M HCl was again measured and added to each of the mixtures then finally 10 ml of distilled was added to keep it in a solution form. The resulting solutions were finally heated in a steam bath again to complete dissolution after which each solution was filtered using whatman no.1 filter paper. The filtrates were stored in a separate volumetric flasks and filled with distilled water up to 50 marks which was used for analysis of phosphate (PO_4^{-3})[12].

3. Determination of Sulphate, (SO_4^{-2})

The soil samples were air dried and sieved. 5ml of $Mg(NO_3)_2$ solution was added to one gram of the sieved soil samples in a separate crucibles and heated up to 180^{O}C on a hot plate until the color of the samples changed from brown to yellow (Kenneth, 2005). After heating, the samples were then transferred into a furnace at a temperature set at 500 ^{O}C for four hours. 10 ml of $Mg(NO_3)_2$ was added to each sample to prevent loss of sulfur. After 4 hours, the samples were again carefully transferred in an evaporating disk. To the disk, 10ml of concentrated HCl were again added in each and allowed the mixture to boil in a steam bath for 3 minutes then cooled. While cooling, 10ml of distilled water was added then filtered into 50ml volumetric flasks up to the marks with distilled water and these were the ones used for the determination of SO_4^{-2} [14].

C. Analysis of Elemental Composition from the Vegetable Soil Samples

Thirty grams of the soil composite samples were homogenized with the use of a magnetic stirrer. With the use of the spectrophotometer, the following macro-elements analyzed were for the elemental determination. Three cuvettes were taken and labeled 1, 2 and 3 respectively. 0ne ml of of the elemental blank reagent was measured and placed in three separate cuvettes. 0.1 ml of each of the elemental standard reagent was added to cuvette one and same volume of the homogenized soil sample was added in cuvette 2 while 1 ml of distilled water was added to cuvette number 3 which serves as blank or control. The three cuvettes and contents were incubated at 30^{0}C for five minutes in the spectrophotometer. Results on the absorbance of the standard reagent and soil sample against the reagent blank at 580 nm wavelength within 20 minutes were noted. Data were computed and recorded. All the procedures were applied on the other soil samples and the other elemental determinations with varied elemental blank reagent .

1. **Determination of Potassium (K^{+1})**
2. **Determination of Magnessium (Mg^{+2})**
3. **Determination of Calcium (Ca +2)**
4. **Determination of Iron (Fe +3)**

D. pH

pH was measured on the freshly homogenized soil samples and data obtained was repeated in three trials yielding the average.

Results and Discussion

A. Heavy Metal Lead and Cadmium Determination

The vegetable farm soil in Budaiya and Sitra are contaminated with heavy metal lead while Budaiya was found negative with lead and minimal amount was found in Sitra area. Moreover, there are traces of lead with concentration of 14 ppm and 124 ppm respectively as seen in table 1 done through Atomic absorption spectra determination and found negative with cadmium in Budaiya and 20 ppm in Sitra vegetable farm soil.

Table1. Result on the Atomic Absorption Spectroscopy Analysis of Heavy Metals

Heavy Metals	Results		
	Sitra (Industrial Area)	Budaiya (Non-Industrial Area)	Allowed Heavy metal in soil in mg/L or ppm Environmental Protection Agency Standards (2003)
Lead	124 µg/g or ppm	14 µg/g or ppm	70 ppm
Cadmium	20 µg/g or ppm	Not determined	150-400 ppm

B. Polyatomic of Anion Phosphate (PO_4^{-3}), Sulfates (SO_4^{-2}) , Nitrates (NO_3^-) and Nitrites ((NO_2^-)

Results on $PO4^{-3}$ is shown in table 2 below reveals that both garden soil is low in $PO4^{-3}$ as compared to the allowed $PO4^{-3}$ which is 0.01% by mass composition indicating that Budaiya and Sitra vegetable farm soils are quite acidic. With these results, indicate that the absorption of macro-nutrients like Fe, Zn, K and Ca are more absorbed in the soil.

Results on the analysis of $SO4^{-2}$ on same table 2 showed 2900 ppm and 2300 ppm as compared to 2000-3000 ppm or 0.2 percent by mass as soluble sulfate in soil indicates that the Budaiya & Sitra vegetable farm soils are still within soluble sulfate threshold to safe acceptable risk. Maher (2013) said that at about 0.2 to 0.3 percent is at low risk $SO4^{-2}$ and more advantageous on the absorption of macro-nutrients like Fe, Zn, K and Ca in the soil [17, 18].

Maher (2013) said that at about 0.2 to 0.3 percent is at low risk SO_4^{-2} and more advantageous on the absorption of macro-nutrients like Fe, Zn, K and Ca in the soil [19,20].

Furthermore, the analysis of NO^{-3} in both areas under study were found to be higher in composition with a percent composition by mass which is 0.207 & 0.20 % mass compositions respectively as compared to 1500-1800 ppm or 0.15- 0.18 % composition by mass as soluble nitrate in soil indicating that the Budaiya & Sitra vegetable farm soils are quite high in nitrate content.

Table 2. Result on the Analysis of polyatomic ions NO_3^- , PO_4^{-3} and SO_4^{-2} in Industrial and Non-industrial Vegetable farm soil

Anions	Result		
	Vegetable farm soil in Budaiya	Vegetable farm soil in Sitra	Allowed Anionsl in soil in mg/L or ppm
PO_4^{-3}	596 ppm	570 ppm	1000 ppm
SO_4^{-2}	2900 ppm	2300 ppm	2000 – 3000 ppm
NO_3^-	2068 ppm	2000 ppm	1500-1800 ppm

C. Analysis of Elemental Composition from the Vegetable Soil Samples

As seen in table 3 below, results on Ca^{+2} analyzed from the vegetable farm soils in industrial and non-industrial areas were 733.33 and 923.33 mg/L respectively which is within the required amount of calcium in soil as compared to the standard composition of normal garden soil which ranges from 700 – 1300 mg/L. Calcium is one of the important elements in the soil that plays a role in plant growth, nutrition and cell wall deposition as well. It can sustain and balance the chemical composition in the soil, improves water penetration and reduces soil salinity.

Potassium (K^+) - classified as a macronutrient is a basic nutrient needed for plant growth specifically on cell wall development, flowering and seed formation. Potassium affects the size, shape, color, taste and other measurements needed for development of a plant [20]. Large amounts of K^+ are absorbed from the root zone in the production of most agronomic crops. Results on the analysis of potassium (K^+) showed that it is higher in Budaiya a non-industrial vegetable farm soil than in the industrial vegetable farm soil. This may be due to the type of soil which is sandy loamy in non-industrial area as compared to industrial area which is more sandy than loamy. The average results of each area was compared to the standard amount of potassium found in garden soil which was found to be 436.67 mg/L and 233.33 mg/L against 510 mg/L. which is still within the accepted K^+ level.

Magnesium is another essential for plant metabolic processes, particularly in chlorophyll production and it aids in the uptake of phosphorous. Too much magnesium can compel the soil leading to less penetration of water and nutrients. Excessively high magnesium can also trigger increase in pH [19, 22].

Rodrigues and De Silva (2008) explained that exchangeable calcium and magnesium are attracted to the negatively charged part of the clay and other organic material in the soil where they are not totally leached to soil but are available to plants [18].

Table below shows the results on the analysis of magnesium (Mg^{+2}) which is quite high when compared to the standard amount of magnesium found in both vegetable farm soils in industrial and non-industrial area which were found to be 300 mg/L and 316.66mg/L respectively against 270 mg/L.

Iron nutrient in plants are essential for the plants to have the utmost growth. It functions like enzyme which are vital to chlorophyll production, nitrogen fixing, development and metabolism-they are all dependent from iron. Plants deficient in iron causes unpleasant yellowing of leaves and in the end death follows. Hence, iron content in soils needs to be check to reduce iron chlorosis in plants [21].

Results on the analysis of iron (Fe^{+2}) showed that it is comparable to the standard amount of iron found in the vegetable farm soils in both industrial and non-industrial areas which was found to be 60 mg/L and 60.33 mg/L respectively against 100 mg/L.

Soil pH is another important parameter to consider because it determines the availability of almost all essential plant nutrients. According to Jessica Walliser (2013) said that plants cannot access all essential nutrients necessary for growth if pH is not maintained hence the nutrients will not be released for plant use [22].

Water can dissolve CO_2 which results to being little acidic to dissolve the presence of calcium in the soil when water evaporates from it. This happens when rainwater reacts with limestone or dolomite in caves causing the melting of limestone which can react with CO_2 forming weak carbonic acid in soil [22, 23]. The acid can be maintained at a consistent level, but due to global warming like increased amounts of carbon dioxide in the environment, the absorption from vegetation and soil surrounding the area pH is sometimes difficult to maintain hence, monitoring of soil pH is required. El-Meligi (2014) in his research on Effect of Global warming on the Ice Cap Melting of Poles mentioned the effect of CO_2 in Global warming is greatly affecting the pH on soils and water [23, 24]. Micronutrients such as iron (Fe), manganese (Mn), boron (B), copper (Cu) and zinc (Zn) become less available when the pH is higher. Soil pH affects the solubility of plant nutrients. It makes the soil more soluble as pH increases while other nutrients are absorbed as the pH decreases [27].

Results on pH as shown in the table above found to be 6.16 and 6.87 in average in industrial and non-industrial area respectively which is found to be slightly acidic. Although pH result in industrial vegetable soil was found to be more acidic this may be due to the nature of the soil which is more sandy- loamy and an evident that vegetable grown in industrial area are pale in color which may be due to less nutrients uptake than those found in non-industrial area like Budaiya. The pH result in Budaiya, a non-industrial area is still comparable to the standard pH for vegetable farm soil which ranges from 6.5- 7.5. This may be due to the organic fertilizer applied and may also be due to nature of the soil in an area. Tao Ren et. al. (2014) said that the acidy is due to too much dissolved $C0_2$ in the soil. Further, they said that this must be monitored because it may harm the other vegetation planted in the soil [28]. That the aforementioned sites were found to contain the physico-chemical properties such as NO_3^-, PO_4^{-3}, SO_4^{-2}. K^+, Mg^{+2} , Ca^{+2}, Fe^{+3} and found to be slightly acidic.

Table 3. Physico – Chemical Composition of Vegetable farm Soil from Non-industrial and Industrial Area against the Standard Composition of Garden Soil

Detected Parameters On Garden Soil	**Results**								**Standard Composition of Elements in soil in mg/L or ppm**
	Trial 1 Conc. in mg/L or Ppm		Trial 2 Conc. in mg/Lor ppm		Trial 3 Conc. in mg/L or ppm		Average Conc. in mg/Lor ppm		
	Budaiya	Sitra	Budaiya	Sitra	Budaiya	Sitra	Budaiya	Sitra	Environmental Garden Soil Standards (2007)
Ca^{+2}	910	750	920	720	920	730	923.33	733.33	700-1300
K^{+1}	450	220	430	230	430	250	436.67	233.33	120-510
Mg^{+2}	350	330	300	280	300	290	316.66	300	140-270
Fe	61	55	60	65	60	60	60.33	60	100
pH results are not given ppm, rather based from pH reading)									
pH	7.0	6.0	6.8	6.5	6.8	6.0	6.87	6.16	6.5-7.5

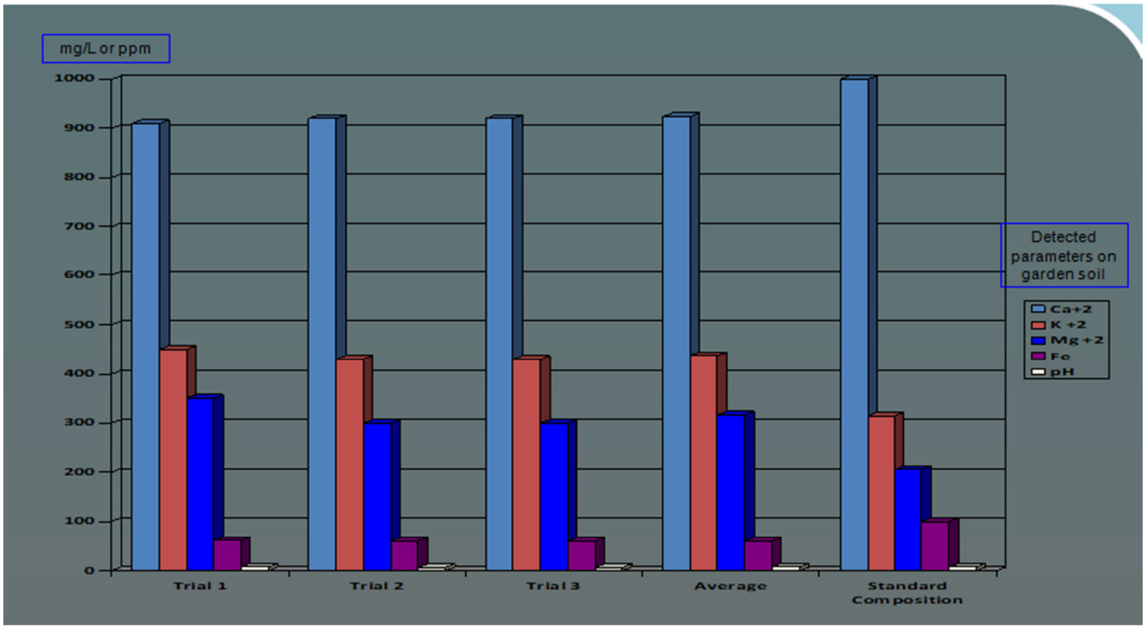

Fig. 3. Physico– Chemical Composition of Vegetable Farm Soil when Compared to the Standard Composition of Normal Garden Soil

Concentration of the assessed physico-chemical properties of soils under study are comparable to the Environmental Standard for Normal Garden Soil.T-test (two tailed) was utilized to compare if there is significant difference on the physico-chemical properties against the normal composition of garden soils from industrial and non-industrial areas. Results of the comparison reveal that there is no significant difference as seen in the table below.

It can be gleaned in table 4 that the amount of nitrates in both areas in Budaiya and Sitra are more as compared to the standard and also in pH results in Sitra area which is less as against the normal pH but the when subjected to statistical test the difference is not conclusive to mentioned that there is significant difference that exists. So in conclusion, it can be said that the physico-chemical properties of vegetable farm soils in industrial and non-industrial particularly in Sitra and Budaiya are all within the composition of normal garden soils. The same observation is applied on the amount of heavy metal on aforementioned sites which is not alarming. This observation might be due to the fractional distillation and other processes that are involved in processing the extracted oil here in Bahrain and other related industrial activities in the nearby areas.

Table 4. Test of Difference between Physico-Chemical Properties and Standard Composition of Vegetable Farm Soil

Detected Parameters On Coastal Water	**Average Conc. in mg/Lor ppm**		**Standard Composition of Elements in soil in mg/L or ppm**	**Sig. (2-tailed)**	
	Budaiya	**Sitra**	Environmental Garden Soil Standards	**Budaiya**	**Sitra**
NO_3^-	2068	2000	1500-1800	0.784 *no significant difference	0.992 *no significant difference
PO_4^{-3}	596	570	1000		
SO_4^{-2}	2900	2300	2000 – 3000		
K^{+2}	436.67	233.33	120-510		
Mg^{+2}	316.66	300	140-270		
Ca^{+2}	923.33	733.33	700-1300		
Fe	60.33	60	100		
pH	6.87	6.16	6.5-7.5		

Further, Pearson test for paired correlation was also used to compare linear association and found to be high positive in correlation and statistically significant at 0.05 level. Hence, there is sufficient evidence that the concentration in mg/L or ppm in terms of the polyatomic ions, elemental composition and pH under study is reliably correlated to the concentration in mg/L or ppm elements found in the two vegetable farm soils. It is conclusive that the sites where the samples were collected are within its ideal physico-chemical properties.

Table 5. Paired Correlation between the Concentration on Physico-chemical Properties and Standard Composition of Vegetable Farm Soil

Paired correlations		Correlations	Interpretation
Average Conc. in mg/L or ppm of Budaiya and the Standard Composition of Elements in soil in mg/L or ppm	Pearson Correlation	.993	High positive correlation and statistically significant
	Sig. (2-tailed)	.005*	
Average Conc. in mg/Lor ppm of Sitra and the Standard Composition of Elements in soil in mg/L or ppm	Pearson Correlation	.977	High positive correlation and statistically significant
	Sig. (2-tailed)	.005*	

*correlation is significant at 0.05 level

Summary of Findings

The physico-chemical analysis on the soil samples was done during the last week of May 2016 in biochemistry laboratory of AMA International University Bahrain and the heavy metal analysis and polyatomic ions or the macronutrients was done in the Philippines at the Department of Science and Technology having an ISO certified laboratory last December 2015 in time when the researcher took her annual vacation .

Visual inspection was done on the color, odor and type of the soil samples. It was found that it is odorless, blackish and somewhat sandy loamy to more sandy in soil type. Further, analysis was done using standard procedures while the other ions were analyzed using the spectrophotometer. It was observed that the amounts of K^{+1}, Mg^{+2} Ca+^{2}, Fe^{+3} , PO_4^{-3} and SO_4^{-2} were found to be comparable in mg/L or ppm concentration when compared to standard composition of a normal garden soil. The analysis on macro nutrients NO_3^{-1} found out that it is the only polyatomic ion parameter found in higher concentration and the same was obtained on elemental Mg^{+2}. These observation is evident that the site where the samples were collected rare evident of NO_3^{-1} and Mg^{+2} which are favorable on plants. This is also confirmed by observation that the soils in the said areas is still blackish-brown and still recommended for growing vegetable plants; however, the amount of lead should be monitored from the soil since these heavy metals were detected on the samples. Eventually, it was found out that the vegetable farm soils in Budaiya are free from heavy metal cadmium and while trace amounts were detected in Sitra area.

Lastly, analysis on pH was done and reveals that the garden soil Budaiya is still within the normal pH ranging from 6.5 to 7.5 while pH in the soils in Sitra area is quite more acidic but when tested statistically it was found that it is still comparable with the standard pH in garden soils. On the other hand, this must be monitored because the amount of $C0_2$ dissolved in soil may lead to acidity increase. Such increase is a threat that may harm the growing of some plants because the growing plants will be deprive in absorbing macronutrients and other elemental composition needed by plants..

Determination on PO_4^{-3}, SO_4^{-2} and NO_3^{-} was also conducted and found that macro-nutrients PO_4^{-3} and SO_4^{-2} in both areas are still within the normal percentage mass composition while NO_3^{-1} was found to be slightly higher as compared to the normal mass composition in garden soil. This is also confirmed by the observation that the soil in the said areas which is brown in color to black and yet, it still recommended for growing vegetable plants; however, the amount of lead in both areas should be monitored from the aforementioned sites because heavy metals were detected from the samples while traces of cadmium was also detected in the vegetable farm soils Sitra and found negative in Budaiya.

Lastly, the pH analysis reveals that the garden soil is still within its normal range from 6.5 to 7.5 in Budaiya and found slightly more acidic in Sitra area. Although, the pH range post no danger; it is recommended that the garden soils be monitored regularly because the amount of $C0_2$ dissolved in soil may lead to increase in acidity. This increase may harm the growth of some plants; as a result, it will deprive the plants on the absorbing macronutrients.

Conclusions

This study came up with the following conclusions:

1. The vegetable farm soils in Budaiya and Sitra contain minimal amount of heavy metal lead while traces of cadmium was found in Sitra soils while Budaiya is free from cadmium in the area.
2. The result on the analysis of Mg^{+2}, and NO3- is quite higher in both areas than the standard composition of garden soil. The result corresponds to the observation that the increase may be due to petroleum refilling station, excessive application of organic matter and to the industrial nature of the area where the samples were taken.
3. The vegetable farm soils in Budaiya and Sitra, Kingdom of Bahrain where the samples were taken are not yet polluted as seen in the result of the micronutrients Ca^{+2}, K^{+} , Fe^{+2} and macronutrient SO_4^{-2}, and PO_4^{-3} and so with pH. Although it was observed that there is a minor increase on the micronutrient Mg^{+2} and macro-nutrient NO_3^{-1} on both soil samples.

Recommendations

In light of the findings and conclusions, the following are recommended:

1. Soil samples in other sites can be collected and be subjected to parallel investigation.
2. Continuous monitoring should be done at least every after 3 -4 years so to monitor the trend on the physico-chemical components as recommended by soil experts.
3. Environmental campaign on the effects of untreated waste should be given emphasis since oil spills may present long-term ecological effects and may even lead to worst on all individuals consuming produce gathered from the site.
4. Microbial test should also be conducted on the organic matter applied in the garden soil to check on the presence of e-coli on the manure that are applied in the area.
5. Parallel studies should be conducted to test other parameters.

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