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Investigation and Evaluation on Heavy Metal Contaminations of Green Salads and Potato Fried in Different Restaurants and Fresh Vegetables in Some Egyptian Governorates

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Abstract: The content of Cd, Pb, Al, and As in fresh vegetables, green salads and potato fried purchased from the Egyptian market and restaurant were determined using atomic absorption spectrometry (AAS).The results of this study showed that there was wide variation in the concentration of these metals in vegetables collected from different sites. The highest Cd level in watercress (8.33 mg/Kg) was found in Cairo. Vegetables grown in Cairo and Alexandria had cadmium many folds higher than those of other towns. Lead concentration in potato of Alexandria is more than permitted level. Aluminium (Al) content was high concentration in all vegetable samples and arsenic (As) concentration mostly was appeared in potato. Analytical results indicated that the concentration of Cd, Pb, and As in green salad samples were so few. The highest concentration of Al was detected in salad collected from popular restaurant 8. The results show that the heavy metal content in unprocessed potato appears to be much higher than that in processed potato. The highest levels of Cd, Pb, and Al were detected in popular restaurant 9. Cd and As contents of international chain restaurant 1 were found in high level (2.958 and 0.95mg/Kg).

Keywords: Heavy Metals; Food Contaminants, Cadmium, Lead, Aluminium, Arsenic, Fresh Vegetables, Green Salad, Potato Fried

1. Introduction

Food safety is a major public concern worldwide. During the last decades, the increasing demand for food safety has stimulated research regarding the risk associated with consumption of foodstuffs contaminated by pesticides, heavy metals and/or toxins (1).Vegetables constitute an important part of the human diet since they contain carbohydrates, proteins, as well as vitamins, minerals and trace elements (2, 3).Vegetables also act as buffering agents for acidic substances obtained during the digestion process. However, these plants may contain both essential and toxic elements, such as heavy metals, at a wide range of concentrations (4).Publicity regarding the high level of heavy metals in the environment has created apprehension and fear in the public as to the presence of heavy metal residues in their daily food. The public is confused and alarmed about their food safety. Keeping in mind the potential toxicity and persistent nature of heavy metals, and the frequent consumption of vegetables and fruits, it is necessary to analyze these food items to ensure the levels of these contaminants meet agreed international requirements (5).

Heavy metals are easily accumulated in human vital organs and threaten human health. Vegetables are part of human diet to take up a lot of essential nutrients and certain trace elements in a short period. In this situation, safety of vegetables is very important (6, 7, 8, and 9). Heavy metals are one of a range of important types of contaminants that can be found on the surface and in the tissue of fresh vegetables. Heavy metals, such as cadmium, copper, lead; chromium and mercury are important environmental pollutants, particularly in areas under irrigated with waste water. Several investigations of water, soil and vegetables pollution by waste water are available (10, 11, 12, 13, 14, 15, and 16).

Strictly speaking, heavy metals are defined as those with higher density than 5 mg mL^{-1} (17) but the collective term now includes arsenic, cadmium, chromium, copper, lead, nickel, molybdenum, vanadium and zinc. Some interest also exists in aluminium, cobalt, strontium and other rare metals. Physiologic roles are known for iron (haemmoeties of heamoglobin and cytochromes), copper (amine oxidases, dopamine hydrolase and collagen synthesis), manganese (superoxide dismutase), zinc (protein synthesis, stabilization of DNA and RNA) with low requirements of chromium (glucose homeostasis). Other heavy metal ions are not believed to be essential to health even in trace amounts. Vegetables, especially those of leafy vegetables grown in heavy metals contaminated soils, accumulate higher amounts of metals than those grown in uncontaminated soils because of the fact that they absorb these metals through their leaves (18).Research findings show that at least 20 million hectares of land in North and South Africa, South America, Middle East, Southern Europe, South West America, Mexico and a significant part of Central and East Asia is irrigated by raw sewage, mainly for cultivation of vegetables. Consequently, this usage ends to soil contamination and heavy metals accumulation both in soil and crops (19). Heavy metal accumulation in soils is of concern in agricultural production due to the adverse effects on food quality (safety and marketability), crop growth (due to phytotoxicity) (20, and 21).

Metals such as lead, mercury, cadmium and copper are cumulative poisons. These metals cause environmental hazards and are reported to be exceptionally toxic. On consumption of food in the diet, the trace metal contents of food are directly taken into the body (22, and 23).These metals enter the human body mainly through two routes namely: inhalation and ingestion, and with ingestion being the main route of exposure to these elements in human population. Heavy metals may enter the human body through inhalation of dust, direct ingestion of soil and consumption of food plants grown in metal contaminated soil (24, and 25).Heavy metals intake by human populations through the food chain has been reported in many countries with this problem receiving increasing attention from the public as well as governmental agencies, particularly in developing countries(26, and 27).The allowable Limit of Heavy Metals, as safe values for copper, lead, and cadmium in fruit and vegetables recommended by the WHO / FAO are 40, 0.3, and 0.2 mg/kg, respectively. Vegetables take up metals by absorbing them from contaminated soils, as well as from deposits on different parts of the vegetables exposed to the air from polluted environments (28). It has been reported that nearly half of the mean ingestion of lead, cadmium and mercury through food is due to plant origin (fruit, vegetables and cereals).

Metal contamination soils may be widespread in urban areas due to past industrial activity and the use of fossil fuels (29).Additional sources of heavy metals for plants are: rainfall in atmospheric polluted areas, traffic density, use of oil or fossil fuels, for heating, atmospheric dusts, plant protection agents and fertilizers which could be adsorbed through leaf blades (30, 31, 32, 33).The content of essential elements in plants is conditional, the content being affected by the characteristics of the soil and the ability of plants to selectively accumulate some metals (34).

Prolong consumption of unsafe concentrations of heavy metals through foodstuffs may lead to the chronic accumulation of heavy metals in the kidney and liver of humans causing disruption of numerous biochemical processes, leading to cardiovascular, nervous, kidney and bone diseases (35).The main source of human exposure to Pb and Cd is food, which is believed to provide about 80-90% of daily doses (36, 37). Pb and Cd toxicity is well documented and is recognized as a major environmental health risk throughout the world. Pb affects humans and animals of all ages, but the effects of lead are most serious in young children. Cadmium is a toxic and carcinogenic element. The International Agency for Research on Cancer has identified Cd as a known human carcinogen. Pb and Cd poisoning results from the interaction of the metal with biological electron-donor groups, such as the sulfhydryl groups, which interferes with a multitude of enzymatic processes. Clinical manifestations of Pb toxicity include symptoms referable to the central nervous system, the peripheral nervous system, the hematopoietic system, the renal system, and the gastrointestinal systems. Cd is a cumulative nephrotoxicant that is absorbed into the body from dietary sources and cigarette smoking (37, 36).Potentially toxic metals are also present in commercially produced foodstuffs. Results of (38) indicated that the cadmium concentrations in shoots and roots varied both with different Cd levels and type of vegetable. Generally Cd accumulation in various plant parts in vegetable crops was increased with the increasing cadmium concentrations in the growth medium. Cd increased more sharply in roots than shoots. Celery contained higher Cd in the edible parts than other vegetable species. Permissible level of consumption of Cadmium, for human is $70\mu day^{-1}$.

The effect of environmental pollution on contamination of foods and on their safety for human consumption is a serious global public issue and widely addressed (39, 40). Some of these elements are toxic to humans even at a very low level. Excessive content of Pb and Cd metals in food is associated with etiology of a number of diseases especially with cardiovascular, kidney, nervous as well as bone diseases (41, 42, 43,17). They have also been implicated in causing carcinogenesis, mutagenesis and teratogenesis (44, 45).Lead is a toxic element that can be harmful to plants, although plants usually show ability to accumulate large amounts of lead without visible changes in their appearance or yield. In many plants, Pb accumulation can exceed several hundred times the threshold of maximum level permissible for human(46). The introduction of Pb into the food chain may affect human health, and thus, studies concerning Pb accumulation in vegetables have increasing importance (47).

Although a maximum Pb limit for human health has been established for edible parts of crops (0.2 mg/kg) (48), soil Pb thresholds for producing safe vegetables are not available. Further investigations Zhang and Zhou (49) showed that the Al-based coagulants at the tested concentrations had a poisonous effect on the germination of vegetable seeds. While aluminum can be toxic at higher levels, it is considerably less toxic than either mercury or lead. In fact, aluminum is found at easily measurable levels in various biological fluids and tissues. However, at high levels aluminum has the potential to cause a number of health problems such as anaemia and other blood disorders, colic, fatigue, dental caries, dementia dialactica, kidney and liver dysfunctions, neuromuscular disorders, osteomalacia and Parkinson's disease (50). Arsenic is regarded as human carcinogen from extremely low levels of exposure, having no possible beneficial metabolic functions for humans. Its low level exposure cause nausea and vomiting decreased production of RBCs and WBCs, abdominal pain and its long term exposure causes darkening of skin and appearance of small corns on palm soles. Other affect includes anorexia, fever, fluid loss, goiter, hair loss, headache, herpes, impaired healing, jaundice, keratosis, kidney and liver damage, muscle spasms, pallor, peripheral neuritis, sore throat, weakness and interferes with the uptake of folic acid (50).

There were positive curvilinear or linear relationships between the inhibitory rate of seed germination and the concentration of Al in the acidic and neutral conditions except for the toxic effects of PAC (polyaluminum-chloride) on *Brassica chinensis*in the neutral condition (49). Moreover there were obvious differences in root elongation of *Brassica chinensis* exposed to $AlCl_3$ in various pH conditions.

The aim of the present study was to evaluate the safety of selected fresh vegetables in different regions of Egypt, green salads, and potatoes fried available in Egyptian restaurants in the regions of Cairo and Giza in 2014, as determined by the content ofPb, As, Al, and Cd.

2. Materials and Methods

2.1. Materials

Various kinds of fresh vegetables (33 samples) were randomly collected from the main farmlands around the city (Cairo, Giza, Alexandria, menoufia, and kalyopia). Green salads (12 samples) and potato fried were collected from International chain, local, and popular restaurants in February and March during the year 2014 submitted to a laboratory for analysis. All reagents which used in these methods were obtained from Merck-Darmstadt.

2.2. Determination of Mineral Contents

The content of metals in vegetables and green salads samples was determined according to a procedure advised by the Regional Center for Food and Feed. The samples were brought in plastic bags to Laboratory. Vegetables samples were cleaned peeled (if necessary) and washed to obtain edible parts prior to analysis. Green salads and potato fried samples were homogenized. All samples were weighed (1g±0.01) in Pyrex tubes, add 10 ml of concentrated nitric acid, and allow standing overnight. Heat carefully on a hot plate unit the production of red NO_2 fames has ceased. Cool the beaker and a small amount (2-4 mL) of 70 % $HClO_4$. Heat again and allow evaporating to a small volume transfer the sample to a 50 mL flask and diluting to volume with distilled water (51).The samples were analyzed by Contraa 700-P, atomic absorption spectrophotometer- Analytical Jena.

2.3. Statistical Analyses

Analysis using the Dunks test was carried out to examine the statistical significance of differences in the mean concentration of metals between groups of vegetables using SPSS, version 10. A probability level of $p<0.05$ was considered statistically significant.

3. Results

Heavy metal content obtained on tomatoes, cucumber, lettuce, watercress, and potatoes collected from different agricultural locations (Cairo, north and south Giza, Alexandria, Menoufia, Kalopia, and Sohag) in Egypt are given as mean values and standard Error in Table 1. Results of monitoring studies carried out in Egypt in 2014 showed that the heavy metal content of vegetable samples were regionally dependent. The highest Cd level in watercress (8.33 mg/Kg) was found in Cairo and higher in potatoes (4.41 mg/Kg) from Kalyopia while the lowest was determined in the cucumber (0.0000198 mg/Kg) from north Giza. Cd content of potatoes were found partly high levels in Cairo, north Giza, and Alexandria (1.3, 0.33, and 0.95 mg/Kg) compared with other agricultural location. The content of Cd in lettuce from Cairo, Alexandria, Menoufia, and south Giza was 1.06, 1.69, 0.81, and 1.31 mg/Kg, respectively.

The highest Pb content was found in potatoes (61.1mg/Kg) from Alexandria while the lowest were found in Tomatoes (0.0000062, 0.000006, 0.000004, and 0.000069) from north Giza, Alexandria, Menoufia, and Kalyopia, respectively. On the other hand, the Pb content of lettuce, potatoes were high (0.57, 0.51, and 0.543 mg/Kg) in Cairo, Menoufia, and Kalyopia independent of region.

Al contents varied in agricultural locations among the vegetable samples. The highest levels were 4178.67 and 1820.85 mg/Kg in potatoes from north Giza, and lettuce from Alexandria while the lowest Al levels were found in cucumber from Cairo, Alexandria, and tomatoes from Kalypia (3.369, 3.547, 3.34 mg/Kg, respectively).

As content of vegetable samples were found at low levels. As content of vegetable samples were changed between 0.00042 (in cucumber from North Giza) to 0.319 (in potato from North Giza) mg/Kg.

Concentration of some heavy elements found in green salad collected from international chain restaurant, local restaurant, and popular restaurants were summarized in Table 2. Cd, Pb, and As contents of green salad collected from different restaurants were found at low levels. Al content of salad samples in all restaurant categories ranged from 1.603 to 914.11mg/Kg. The highest concentration of Al was detected in salad collected from popular restaurant 8 (914.11 mg/Kg) while international chain restaurant (2), local restaurants (3,6), and popular restaurant (10,11) had the lowest concentration (1.603,3.998, 4.03, 3.93, and 4.32mg/Kg).

The concentrations of heavy metals (Cd, Pb, Al, and As) in potatoes fried from three level restaurants (international chain, local, and popular) analyzed are reported in Table 3. The highest levels of Cd, Pb, and Al were detected in popular restaurant 9. Cd and As contents of international chain restaurant 1 were found in high level (2.958 and 0.95mg/Kg) compared with other restaurants, While Pb contents was found in low level (0.033 mg/Kg). As content in potatoes fried from popular restaurant 7 and 8 were non-detectable amounts. At the same form, potatoes fried contained Al at the low concentration. Al values showed a notable increase from 56.88 mg/Kg in popular restaurant 7 to 2305.87 mg/Kg in popular restaurant 9. Pb was detected at lowest levels in potatoes fried from local restaurant 6 (0.0019 mg/Kg) and Cd was lowest in potatoes fried from local restaurant 4 (0.419 mg/Kg).

Table 1. *Levels of Cd, Pb, Al, and As (mg/kg) in some vegetables*

Name of location	Vegetables	Cd	Pb	Al	As
Cairo	Tomatoes	0.00043±0.000018^{a}	0.000035±0.000022^{a}	340.92±16.38^{i}	0.0013±0.00025^{ab}
	Cucumber	0.00025±0.00034^{a}	0.000011±0.0000035^{a}	3.369±1.57^{a}	0.0014±0.00017^{ab}
	Lettuce	1.06±0.10^{e}	0.572±0.045^{h}	544.76±40.7937^{k}	0.020±0.004^{c}
	Watercress	8.33±0.197^{i}	0.38±0.01086^{c}	104.76±3.9^{bcdefg}	0.038±0.0017^{e}
	Potatoes	1.303±0.14^{f}	0.0123±0.00038^{a}	138.66±28.61^{defgh}	0.02±0.004^{cd}
North Giza	Tomatoes	0.000034±0.000017^{a}	0.0000062±0.0000025^{a}	439.60±21.24^{j}	0.0011±0.000056^{ab}
	Cucumber	0.0000198±0.000016^{a}	0.00019±0.000076^{a}	605.62±18.25^{k}	0.00042±0.000061^{a}
	Lettuce	0.00036±0.00003^{a}	0.000016±0.000003^{a}	6.30±2.05^{a}	0.0064±0.00053^{b}
	Potatoes	0.33±0.0042^{b}	0.0066±0.000032^{a}	4178.67±168.59^{n}	0.319±0.011^{k}
South Giza	Tomatoes	0.00024±0.00003^{a}	0.00074±0.00059^{a}	74.31±3.95^{abcde}	0.0018±0.00021^{ab}
	Cucumber	0.000023±0.000053^{a}	0.0000053±0.0000025^{a}	148.74±16.60^{efgh}	0.0014±0.00017^{ab}
	Lettuce	1.31±0.052^{f}	0.44±0.022^{d}	87.895±6.53^{bcdef}	0.0899±0.0038^{g}
	Watercress	0.0012±0.00025^{a}	0.447±0.007^{d}	844.39±18.47^{l}	0.023±0.00151^{cd}
	Potatoes	0.00087±0.0001^{a}	0.000006±0.000002^{a}	207.57±7.27^{h}	0.0032±0.00024^{ab}
Menoufia	Tomatoes	0.000364±0.0051a	0.000004±0.000001^{a}	12.16±1.56^{a}	0.0022±0.00028^{ab}
	Cucumber	0.000046±0.00001^{a}	0.000049±0.000023^{a}	102.37±3.0065^{bcdefg}	0.00086±0.000093^{a}
	Lettuce	0.81±0.045^{d}	0.44±0.0236^{d}	172.0023±12.57^{gh}	0.023±0.0025^{cd}
	Watercress	0.003±0.000011^{a}	0.0011±0.00039^{a}	66.17±7.99^{abcd}	0.0019±0.00034^{ab}
	Potatoes	0.12±0.268^{a}	0.51±0.0185^{f}	133.11±13.08^{defg}	0.045±0.001^{f}
Kalyopia	Tomatoes	0.00006±0.00007^{a}	0.000069±0.000102^{a}	3.34±0.22^{a}	0.0018±0.0002^{ab}
	Cucumber	0.00081±0.000023^{a}	0.000007±0.000002^{a}	842.005±9.51^{l}	0.0021±0.000095^{ab}
	Lettuce	0.00023±0.0003^{a}	0.00006967±0.000096^{a}	4.06±1. 1^{a}	0.002±0.00015^{ab}
	Watercress	0.00075±0.000041^{a}	0.0000095±0.0000028^{a}	931.85±26.05^{m}	0.0013±0.00021^{ab}
	Potatoes	4.41±0.29^{h}	0.54±0.0156^{g}	554.01±3.43^{k}	0.21±0.0032^{j}
Sohag	Tomatoes	0.00045±0.000056^{a}	0.0048±0.000196^{a}	69.42±1.25^{abcd}	0.0012±0.00021^{ab}
	Cucumber	0.00046±0.000055^{a}	0.0056±0.00058^{a}	36.23±2.07^{ab}	0.0014±0.00043^{ab}
	Lettuce	0.00021±0.000023^{a}	0.0049±0.00032^{a}	161.20±2.16f^{gh}	0.0024±0.00028^{ab}
	Potatoes	0.00021±0.000022^{a}	0.0033±0.00024^{a}	52.97±2.87^{abc}	0.0014±0.00014^{ab}
Alexandria	Tomatoes	0.000138±0.00002^{a}	0.000006±0.00003^{a}	965.59±6.7^{m}	0.00055±0.000053^{a}
	Cucumber	0.00097±0.00067^{a}	0.0020±0.000299^{a}	3.547±0.53^{a}	0.00057±0.000012^{a}
	Lettuce	1.69±0.079^{g}	0.442±0.025^{d}	1820.85±138.21^{n}	0.16±0.0035^{i}
	Watercress	0.61±0.025^{c}	0.34±0.025^{b}	121.80±8.04^{cdefg}	0.025±0.0035^{d}
	Potatoes	0.95±0.228^{e}	61.1±0.0044^{e}	106.07±4.78^{bcdefg}	0.12±0.003^{h}

Each value represents the mean ± SE; the mean values with different superscript alphabets indicate significant differences ($P<0.05$).

Table 2. *Heavy metal concentrations in green salad (mg/kg).*

Name of location level	Cd	Pb	Al	As
International chain restaurant(1)	0.0004±0.000014^{de}	0.000014±0.000056^{a}	5.31±0.17^{ab}	0.00046±0.00005^{a}
International chain restaurant(2)	0.0001±0.00002^{a}	0.000025±0.000035^{ab}	1.603±0.34^{a}	0.0033±0.0003^{g}
Local restaurant(3)	0.0003±0.00004^{bcd}	0.00023±0.000016^{e}	3.998±0.18^{a}	0.00015±0.00004^{a}
Local restaurant(4)	0.00066±0.000012^{g}	0.000038±0.000017^{abc}	12.52±0.47^{b}	0.0029±0.0004^{f}
Local restaurant(5)	0.00049±0.00017^{e}	0.000013±0.000044^{a}	293.95±5.7^{c}	0.00054±0.0004^{ab}
Local restaurant(6)	0.00023±0.0003^{bc}	0.000016±0.000041^{de}	4.03±0.21^{a}	0.0016±0.0004^{d}
Popular restaurant(7)	0.00031±0.00005^{cd}	0.000015±0.000003^{a}	290.59±5.58^{c}	0.0011±0.00005^{c}
Popular restaurant(8)	0.00015±0.000015^{ab}	0.00011±0.0000028^{bcd}	914.11±1.28^{d}	0.00035±0.00003^{a}
Popular restaurant(9)	0.00044±0.00007^{ef}	0.000006±0.000002^{a}	5.79±0.15^{ab}	0.0021±0.0001^{e}
Popular restaurant(10)	0.00014±0.00002^{ab}	0.0018±0.00015^{f}	3.93±0.33^{a}	0.00087±0.0001^{bc}
Popular restaurant(11)	0.00018±0.00003^{ab}	0.0000049±0.0000007^{a}	4.32±0.12^{a}	0.00051±0.00006^{ab}
Popular restaurant(12)	0.00082±0.00022^{h}	0.00011±0.00004^{cd}	6.51±0.15^{ab}	0.0011±0.00013^{c}

Each value represents the mean ± SE; the mean values with different superscript alphabets indicate significant differences ($P<0.05$).

Table 3. *Concentration of heavy metal in potatoes fried(mg/kg).*

Name of location level	Cd	Pb	Al	As
International restaurant(1)	2.958±0.034^{d}	0.033±0.003^{b}	88.55±7.44^{ab}	0.95±0.0028^{f}
International restaurant(2)	0.779±0.18^{ab}	0.044±0.003^{c}	78.597±6.83^{a}	0.126±0.0011^{d}
Local restaurant(3)	0.503±0.047^{a}	0.08±0.004^{d}	537.57±8.13^{d}	0.037±0.0034^{a}
Local restaurant(4)	0.419±0.085^{a}	0.031±0.003^{b}	190.44±5.27^{c}	0.121±0.0014^{c}
Local restaurant(5)	0.52±0.073^{a}	0.36±0.003^{g}	93.21±2.62^{ab}	0.054±0.0039^{b}
Local restaurant(6)	2.961±0.297^{d}	0.0019±0.0003^{a}	163.53±1.34^{bc}	0.127±0.0014^{d}
Popular restaurant(7)	1.052±0.264^{b}	0.28±0.004^{e}	56.88±4.051^{a}	Nd
Popular restaurant(8)	2.09±0.115^{c}	0.32±0.0022^{f}	78.30±5.003^{a}	Nd
Popular restaurant(9)	2.9997±0.22^{d}	0.73±0.0045^{h}	2305.87±1.25^{e}	0.199±0.305^{e}

Each value represents the mean ± SE; the mean values with different superscript alphabets indicate significant differences (P<0.05). ND = Not detected. Levels were below the detection limit

4. Discussion

The toxicity of the metals in agricultural products depends upon relative level of exposure of crops to the contaminated soils as well as the deposition of toxic elements in the polluted air by sedimentation. Different metals show the toxicity at different concentrations and can be potentially toxic at sufficiently high concentrations. However, certain metals exhibit toxic effects even at relatively low concentrations. Metal toxicity depends on the element, its chemical form and its oxidation state. The results in Table 1 show a high degree of contamination in vegetables, when compared with the permissible levels given by the FAO and WHO (36). Our data showed that the overall toxic metal accumulation was greater in leafy vegetables lettuce, watercress and tubers such as potato. Heavy metal content has been reported in various common vegetables of many towns in Egypt. Our data showed that large concentrations of cadmium (toxic trace element) in lettuce (Cairo, Alexandria, menofia, and South Giza), watercress (Cairo and Alexandria) and potatoes (Cairo, Alexandria, and Kalyopia). The above data reveal that cadmium content in same vegetable differs from town to town. According to above data, cadmium content in vegetables of Cairo and Alexandria are many folds higher than those of other towns. It might be because the metal uptake in vegetables is influenced by several factors such as metal concentrations in agricultural soils, soil pH, physico-chemical characteristics of the soil, soil classification, etc. Moreover, vegetable consumption (per person per day) is not same for the residents of different regions. Abdel-Shafy*et al*., (52) reported the levels of the metals in the surface layer of soil irrigated with the Nile water and ground water in Qatta village Egypt were arranged in the following ascending orders Fe > Zn >Mn>Pb> Cu > Cd and Fe >Mn> Zn = Cu >Pb> Cd, respectively. The level of heavy metals in different parts of potato plants irrigated with Nile and ground water for over four successive seasons in Qatta village. In the period of continuous soil irrigation with both the Nile and ground water, most of metals, namely cadmium and lead, are accumulated in plants. The level of heavy metals in soil does not depend essentially on the sources of irrigation, but first of all on the metal constituents of the fungicide applied. Okwulehie and Ogoke (53) reported that cadmium in the range of 0.7-0.94 ppm for certain mushrooms in Nigeria. Banerjee *et al*.,(54) recorded cadmium levels in some fruits and vegetables in India to be in the range of 0.03 to 7.32 μg/g dry weight. Cadmium content of tomato and cucumber analyzed in Egypt was below the WHO standards limit (0.2 mg/kg) (35).The high contamination levels found in some vegetables may be related to pollutants in irrigation water, farm soil or pollution from highway traffic (55).In a study Bahemuka and Mubofu (4) reported that the cadmium content in vegetables of Tanzania ranged between 0.1 and 0.6 mg/kg dry weight. Studies have shown that metals such as iron, copper, cadmium, chromium, lead, mercury and nickel have the ability to produce reactive oxygen species. The result of this is lipid peroxidation, DNA damage and altered calcium homeostasis (56, 57). Elsokkary and Sharaf (58) reported that the bioaccumulation ratio of Cd in the plants followed the order: Chard>Spinach> Lettuce> Parsley>Rocket> Coriander.

The main cause for concern in terms of contamination of vegetables in Alexandria and Menoufia by heavy metals relates to Lead (Pb). Although a maximum Pb limit for human health has been established for edible parts of crops in China is 0.2 mg/kg (48) but this limit by WHO standards is 0.3 mg/kg (35). Data showed that in potato of Alexandria, lead concentration is more than permitted level, so they are not suitable for consumption. Lead is a toxic element that can be harmful to plants, although plants usually show ability to accumulate large amounts of lead without visible changes in their appearance or yield. In many plants, Pb accumulation can exceed several hundred times the threshold of maximum level permissible for human (46). The introduction of Pb into the food chain may affect human health and thus, studies concerning Pb accumulation in vegetables have increasing importance (47, 3). On the whole, some vegetables that were studied in this study were contaminated by lead and they were toxic to consumer. Zhuang*et al*., (59) have found higher contents of Cd and Pb concentrations than the maximum permissible levels in vegetables collected from six sampling sites around Dabaoshan mine located at Shaoguan city, Guangdong, southern China. It was found that most of the vegetable types marketed in Kathmandu were grown along the bank of rivers, roadsides and highways irrigated with wastewater as well as from vegetable farms with possible use of fertilizers and pesticides in excessive amount (source: personal communication with vegetable grosser). Continuous irrigation of agricultural land with sewage and wastewater may cause heavy metal accumulation in the soil and vegetables (60).Besides, pesticides and fertilizers are known to be the main sources of heavy metal pollution in agricultural areas (61).Moreover, the transportation and marketing systems of vegetables play a significant role in elevating the contaminant levels of heavy metals which may pose a threat to the quality of the vegetables with consequences for the health of the consumers of locally produced foodstuffs (62, 63).It is concluded that atmospheric deposition from urban and agricultural areas may play an important role in the enrichment of agricultural produce from Cd and/ or Pb (64). Abdel-Sabour and Rabie (65) also studied ten sample of vegetable plant species, plants grown on soils (irrigated with industrial wastewater of Shebin EI-Qanater and Mostorod collectors) and (irrigated with polluted water of EI-Shaboura canal), whereas its soils have been subjected to prolonged domestic and industrial wastewater irrigation (about 35 years). Results revealed that vegetable plants species varied in their affinity to accumulate metals in their edible parts. Irrigation with different wastewater significantly increased the concentration of Pb and Cd in vegetable plants especially the leafy species. Rashad and Shalaby, (66) measured the levels of heavy metals at different sites with different distances and directions from two dumpsites in Alexandria for vegetation. The concentrations of metals in leaves and roots of tomatoes, carrots and potatoes plants were higher in plants grown at the site close to Abis (the municipal solid waste) dumpsite and decreased with increasing distance. The only difference between Abis and El-Montaza is that the recorded levels of heavy metals at Abis area were higher than obtained at El-Montaza area. This could be due to the other pollution sources found at Abis area, including the cement company and other petroleum companies near Abis area which is a serious source of their metals.

A market basket survey showed that Aluminium (Al) content was high concentration in all vegetable samples. Al content in some common vegetables in North Giza which show that potato had the highest amount while the lettuce had lowest (Table 1). In Alexandria the highest variation in Al level was observed in lettuce and tomato and lowest in cucumber. However the Kalyopia vegetables (cucumber and watercress) contain much higher amount of Al compared to Sohag. It can be seen that total Al in vegetable samples ranged from 3.34 to 4178.67 mg/kg, in green salad was 1.603 to 914.11 mg/kg, and in processed potato ranged from 56.88to 2305.87 mg/kg. Similar high concentrations of Al in black tea leaves were from 685 to 1200 mg/kg. In the other vegetable samples the concentration of Al is much higher, ranging from 70 to 400 mg/kg. The highest concentration of about 400 mg/kg of Al was found in lamb's lettuce and in garden lettuce was reported in the literature (67).Müller *et al*.,(68) also found higher Al concentrations in various sorts of lettuce (200–1000 mg/kg). Since Al-tolerant plants can accumulate Al from soil solution, higher concentrations of Al may be found in vegetables (up to 80 mg/kg) (68, 69), in different kinds of lettuce (up to 1000 mg/kg), in herbs and spices(up to 300 and 1000 mg/kg Al, respectively) and in black tea leaves (from 600 to 1200 mg/kg of Al) (68). Al enters drinking waters mainly due to the use of $Al_2(SO_4)_3$that is applied as a coagulant to clarify turbidity (70).Another possible source of the entry of Al into foodstuffs is the use of Al containing food additives, which in cheese processing may increase Al concentrations up to 70 mg/kg(68). Lokeshappa*et al*., (71) analyzed the Aluminium in selected vegetables available in Powai area, Mumbai, India. The content of Aluminium in spinach and coriander was in high concentration and in moderate concentrations in tulsi, potato and ladyfinger. Cadmium was present in small concentrations in all samples except coriander and carrot. It was found that the overall toxic metal accumulation was greater in leafy vegetables viz. spinach, coriander and tubers such as potato.

Data in Table 1 showed that arsenic (As) concentration mostly was appeared in potato and in fallow order by town: North Giza >Kalyopia> Alexandria. Several countries, including the UK and Australia, currently use a 1 ppm limit for arsenic in food and this is often cited as a "safe" level for rice. Most of the values exceeded the maximal permissible limit of food As standard 1.0 mg/kg dry weight (72), but this limit by WHO standards is 0.43 mg/kg (35). As reported in the literatures, the total arsenic contents in vegetable products were < 0.004 to 0.303 mg/kg fresh weight (73, 74, 75, 76). The average arsenic concentration in the vegetables collected from some arsenic prone areas of Bangladesh was 0.28 mg/kg fresh weight, which was higher than that of the United Kingdom, 0.003 mg/kg fresh weight (77), and Croatia, 0.0004 mg/kg fresh weight (78). Concerning plants growing on contaminated soils of Egypt, several investigators studied the accumulation of heavy metals in these plants. ElSabbagh (79) found that Cd, Cu, Pb and Zn were accumulated in vegetable plants growing on contaminated soils in industrial area. Vegetables Cd ranged from 0.03-0.34 mg/100g. The cultivated vegetables revealed that it absorbs soilPb with varying concentrations from < 0.4-2.5 mg/100g, green onion ranks the first order as it contains 2.5 mg/100g followed by Radish. Abdel-Maksoud (80) reported that using wastewater for irrigation lead to the accumulation of Fe, Cd and Pb in vegetable crops such as Spinach, Potato, Tomato and Celery growing on polluted soil at Giza Governorate. Heavy metal contents of leaves *Ficusretus*a showed that their concentrations increased with the increase in the concentration of these metals in the soil: plants grown at AbouQuir had the highest concentrations (81).

According to the results of this study, the heavy metal (Cd, Pb, and As) contents of green salad in washing samples are so small that one must draw the conclusion that migration of heavy metal from the washing into the green salad can be ignored. However Al was high in some restaurant categories as well as in vegetable samples (Table 2). Washing treatments significantly ($P \leq 0.05$) reduced concentrations of heavy metal contents in the leaves of *Ficusretus*a (81).El-Desoky and Ghallab (82) found that Contents of Pb in the unwashed plant samples (6.00-40.18 ppm) are quite high, compared with the washed samples (0.34 to 29.53 ppm) which were collected from the area around the superphosphate factory. Amounts of cadmium accumulate on plant surface from dusts carried from the factory chemnies.

The results show (Table 3) that heavy metal is widely contained in processed potato (potatoes fried). Furthermore, the heavy metal content in unprocessed potato appears to be much higher than that in processed potato. These results suggest that the presence of heavy metal from processed potato due to the containers used in the manufacturing, processes of heat, type of oil, and oil contamination. These differences in restaurant categories may be probably due to raw material, process conditions and analytical procedures. Harmankaya*et al*., (83) found that Cd and Pb contents of all chips (from several markets in Konya in Turkey) were at the low levels. Fried potatoes from the Egyptian market content of the studied metals were found to be ranged from 0.054 to 0.10 of Cd, 0.065 to 0.159 of Pb (64). Heavy metal contents in fried potatoes were found to be ranged from 0.054 to 0.10 of Cd and 0.065 to 0.159 mg/kg of Pb. The levels of Cd in all samples are higher than the permissible limits (84).

In conclusion, it is well known that environmental pollution is a product of urbanization and technology and other attendant factors of population density, industrialization and mechanization that serve to provide the necessities of the population. Aluminium (Al) content was high concentration in all vegetable samples. Data showed that potato of Alexandria, lead concentration is more than permitted level. Among the restaurant categories Cd, Pb, and As contents of green salad were found at low levels. The highest levels of Cd, Pb, and Al were detected in popular restaurant 9. Cd and As contents of international chain restaurant 1 were found in high level. If these vegetables are to be used for a short period of time or in small doses, washing can reduce the surface contamination to a great extant. Hence, it is suggested that consumers wash the vegetable prior to use. This result will therefore help the government, individuals and communities to take necessary measure in controlling heavy metal pollution and to minimize exposure of people living town of Egypt. Next study will be on the Egyptian soil and water.

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