American-Eurasian J. Agric. & Environ. Sci., 23 (3): 106-121, 2023
ISSN 1818-6769

DOI: 10.5829/idosi.aejaes.2023.106.121

Determination of Some Nutrients and Heavy Metals Content of Egyptian Wheat Grains Cultivated at the Greater Cairo Region

[1]Fathy A. Abdallah, [2]Sahar S. El-Gohery, [1]Osama M. Abonama and [1]Raafat M. El-Sanhoty

[1]Department of Industrial Biotechnology - Genetic Engineering and Biotechnology Research Institute - University of Sadat City
[2]Bread and Pasta department, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt

Abstract: This work aimed at investigation the impact of soil, irrigation water, fertilization types and wheat cultivars on the levels of heavy metals content in wheat grains during the years 2019-2020. Soil, irrigation water and wheat grain samples were collected from different sites of the governorates of the Greater Cairo region. The chemical properties of soil and water irrigation were assessed. The levels of heavy metals such as lead, chromium, cadmium, nickel, iron and zinc were estimated in the all collected samples using Inductive Coupled Plasma Mass Spectrometry instrument (ICP-MS). The results indicated that the clay soil samples collected from Kom Birah village at Giza governorate when fertilized with urea during year 2019 recoded higher concentrations than other samples of TDS, chlorides, sulfates, total carbons, Cr, Cd, Ni, Pb, Fe and Zn than other soil samples; at levels 239.08, 213.04, 110.38, 158.54, 1.352, 5.096 (revise too high maximum 3ppm), 2.898, 9.197, 17.622 and 6.462 ppm respectively, except the level of pH was (7.11). On the other side the heavy metals content of wheat grains (Giza 171) collected from the same village located at Giza governorate during year 2019, which cultivated and fertilized in the same conditions gave higher concentrations than other wheat samples; of Cr, Cd, Ni, Pb, Fe and Zn at levels 2.993, 4.749 (too high maximum 1 ppm), 2.584, 2.925, 26.136 and 10.184ppm respectively. Where, the Cr, Cd and Pb were exceeded safe limits sit by WHO/FAO [1]; in contrast Ni, Fe and Zn were within the acceptable limits according to WHO/FAO [1]. On the other hand, the irrigation water samples collected from the same site in Giza governorate during year 2019 which polluted with agricultural and human sewage recoded higher concentrations than other irrigated water samples of TDS, chlorides, sulfates, total carbons, Cr, Cd, Ni, Pb, Fe and Zn at levels 945.30, 194.52, 91.50, 290.82, 0.107, 0.005, 0.025, 0.032, 0.709 and 5.686 ppm respectively; the same water samples noted lower level of than others which recorded pH (6.31). Thus, quality control of the concentrations of heavy metals in wheat grains, soils and irrigated water were very important to avoid the potential risk of health.

Key words: Wheat · Heavy metals · Soil · Irrigated water · Greater Cairo region · Egypt

INTRODUCTION

More than 80% of sewage generated by human activities is discharged into rivers and oceans without any treatment, which results in environmental pollution and more than different fifty diseases. 80% of diseases and 50% of child deaths worldwide are related to poor water quality as reported by [2]. Moreover, industrialization has a positive and significant impact on the environment as mentioned by [3]. The industrial activities of the last century have caused massive increases in human exposure to heavy metals. Mercury, lead, chromium, cadmium and arsenic have been the most common heavy metals that induced human poisonings as registered by [4]. Contaminated irrigation water can increase trace heavy metals concentration in agricultural soil as reported by [5]. The consequences of long-term irrigation with As-contaminated groundwater for bioaccumulation in food crops and hence dietary exposure to As and other metals are a threat to the resident as concluded by [6].

Corresponding Author: Fathy A. Abdallah, Department of Industrial Biotechnology - Genetic Engineering and Biotechnology Research Institute - University of Sadat City, Egypt.

Heavy metals bios-accumulate in living organisms, pollute the food chain and possibly threaten the health of animals. Many industries, fertilizers, truck, automobile, paint, groundwater and animal feed are sources of contamination of heavy metals. Cadmium (Cd) and Pb have negative impacts on a number of physiological and biochemical processes when exposed to sub-lethal doses. The nephrotoxic effects of Pb, As and Cd are well known and high amounts of naturally occurring environmental metals as well as occupational populations with high exposures have an adverse relationship between kidney damage and toxic metal exposure as stated by [7]. Much attention was focused on cadmium (Cd) ions as one of the most toxic elements for plants as concluded by [8]. The food chain, through vegetable consumption, is considered to be an important route of heavy metal exposure. Consumption of food grown in contaminated soils may be a significant human exposure pathway to pollutants, including toxic elements. The inorganic pollutants are being discarded in our waters, soils and into the atmosphere due to the rapidly growing agriculture and metal industries, improper waste disposal, fertilizers and pesticides. Some metals affect biological functions and growth, while other metals accumulate in one or more different organs causing many serious diseases such as cancer as discussed by [9]. Heavy metals are well-known environmental pollutants owing to their toxicity, longevity in the atmosphere and ability to accumulate in the human body via bioaccumulation. Most heavy metals occur naturally, but a few are derived from anthropogenic sources. Heavy metals are categorized by their high atomic mass and toxicity to living organisms. Heavy metals can become strongly toxic by mixing with different environmental elements, such as water, soil and air and humans and other living organisms can be exposed to them through the food chain as referred by [10]. The pollution of soil by trace elements is a global problem; conventional methods of soil bioremediation are often inapplicable, so it is necessary to search intensively for novel techniques for cleaning up ecosystems, such as phytoremediation as reported by [11]. Cereal grains are the main dietary source of energy, carbohydrates and plant proteins world-wide. Currently, only 41% of grains are used for human food consumption and up to 35% are used for animal feed consumption. Cereals have been overlooked as a source of environmentally sustainable and healthy plant proteins and could play a major role in transitioning towards a more sustainable food system for healthy diets. Rapid development of new grain-based food ingredients and use of grains in new food contexts, such as dairy replacements and meat analogues, could accelerate the transition as recognized by [12]. Wheat and rice constitute important cereal crops and any contamination may pose potential adverse impacts on human health as recorded by [13]. Excessive use of phosphorus-based fertilizers may lead to environmental damage and accumulation of heavy metals (HMs) in soil and crops as mentioned by [14]. Heavy metal (HM) pollution is extremely harmful because of its toxicity on humans, animals and plants. HMs are unmanageable to degradation; therefore, insistent in the environment for a longer period adding to the concern. HMs at high concentrations have adverse effects on the production of food as they affect the metabolic activity of plants. HMs have serious consequences for human health, reaching the tissue via direct ingestion, dermal contact, inhalation and adsorption. Several methods have been explored for the eradication of HMs from the environment. Conventional methods of metal removal are restricted by the processing problems, expenses and the generation of toxic sludge, therefore more research is now focused on the use of bacteria, fungi, plants and diatoms for the removal of metal ions from the environment as reported by [15].

There was no enough information about the relationship between the content of heavy metals in wheat and the usage of irrigation waters, soils, fertilizers and wheat's genotypes inside the Greater Cairo region. Therefore, this work was planned to study the impact of the irrigation water quality, fertilizers, soil type and wheat's genotype on specific heavy metals (Cr, Cd, Ni and Pb) and nutritional elements (Fe and Zn) content of wheat grains.

MATERIALS AND METHODS

Sampling: All samples (water, soil and wheat) were personally collected from the Greater Cairo region (Cairo, Giza and Qalioubiya governorates) during years of 2019 and 2020 according to the Figure (1).

Irrigation Sources and Sampling: Through three governorates of the Greater Cairo region, 100 ml of water samples were collected from five types of irrigation water i.e., (Nile River, artesian water, rainwater, agricultural wastewater and sewage water). Samples collected in polypropylene bottles pre-treated with nitric acid (1%) then transported using Ice box and kept refrigerated at 4 °C until delivered to the Environmental and Food Biotechnology laboratory located at Genetic Engineering and Biotechnology Research Institute (GEBRI), University of Sadat City, Egypt and maintained at 4 °C until analyzed.

Fig. 1: Egypt country from Google Earth

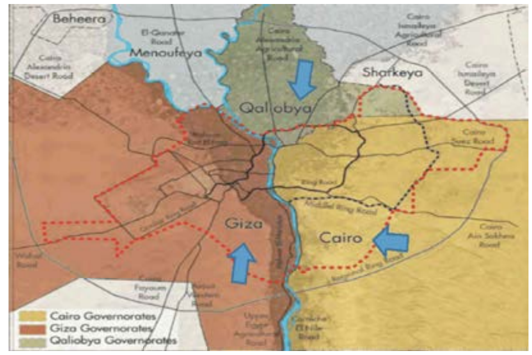

Fig. 2: The Greater Cairo region (Cairo, Giza and Qaliobya governorates)

Sampling of Soil: The targeted land points to obtain soil samples were drilled to a depth of 10-15 cm using a stainless-steel drill and all collected soils were partially manually cleaned from foreign remains then transported using Ice box and kept refrigerated at 4°C until delivered to the same laboratory, then maintained at 4°C until analyzed. The soil samples were dried using a forced-air oven (MMM Venticell55 made in Germany S.N B072925) at 72 °C for 47 hr. Dried samples were placed in polyethylene bags, labelled and sealed until chemically analyzed as recorded by [16].

Sampling of Wheat: Wheat grain samples were collected as a whole wheat plant from the field and packed in paper bags and the wheat grains were separated manually then partially manually cleaned to remove foreign particles and packed in the same paper bags then delivered to the same laboratory. The wheat grain samples were placed in a forced-air oven at 72 °C for 48 h. After the moisture was removed, the samples were ground into a fine powder using an electric domestic grinder model (Fresh, Egypt).

Explanation of the Studying Area

Map of the Greater Cairo Region (Cairo, Giza and Qalioubiya Governorates)

Collected Samples from Qalioubiya Governorate: Samples of Qalioubiya governorate at years 2019 and 2020 were collected from (Bahadah and Al Bradah villages at Al Qanater Al Khairia city) and from Moshtohor village at Toukh city according to the Figure (1).

Collected Samples from Cairo Governorate: Samples of Cairo governorate at years 2019 and 2020 were collected from Al Marj district.

Collected Samples from Giza Governorate: Samples of Giza governorate at year 2019 and 2020 were collected from (Kom Birah and Kafr Hakeem (Ezbat El-Shimy) villages and the other samples were collected from (Nahya village) at year 2019, (Kafr Hakeem village) at year 2019 and 2020 and (Shabramant village) at year 2020.

Samples Preparation

Soil and Wheat Sample Preparation: Samples of soil and wheat were dried at 105°C for 48 hours even weigh stability and mineralized with nitric acid 65% (Merck, Germany) and hydrochloric acid 36% (Merck, analytical grade, Germany) as ratio 1:3 in molar ratio until clear digestion then centrifuged with 6000 rpm for 10 min using Centrifuge (HERMLE a product of HERMLE LABORTECHNIK, Germany) according to the method described by [17]. The extracts were filtered through disposable 0.2 µm PTFE syringe filters (DISMIC-25HP, Advantech, Tokyo, Japan). The metal concentrations in these extracts were determined by means of inductively coupled plasma-mass spectroscopy (ICP-MS) (iCAP, Thermo, Germany). Certified reference materials (Merck, Germany) were included in the analyses. The recovery of metals was within the certified limits. Qtegra (USA) software was used for average and relative standard deviation calculation as requirement of APHA [18].

Water Samples Preparation: The water samples were filtered through disposable 0.2 µm PTFE syringe filters (DISMIC-25HP, Advantech, Tokyo, Japan). The metal concentrations in these extracts were determined by means of inductively coupled plasma-mass spectroscopy (ICP-MS) (iCAP, Thermo, Germany). Certified reference materials (Merck, Germany) were included in the analyses. The recovery of metals was within the certified limits. Qtegra software was used for average and relative standard deviation calculation as registered by APHA [18, 19].

Table 1: Materials, chemicals, reagents and media.

Test	Materials, Chemicals, Reagents and Media
pH	Standard pH technical buffers (7.0 model: STP7 order No. 108 708, 10.01 Model: STP10 order No. 108 722 and 4.01 model STP4 order No. 108 706), Provided by WTW.
TOC	STABLCAL® Formazan standards model HACH are used (<0.1 NTU Calibration Solution-Cat NO. 2659701, LOT A3123, 20 NTU-Cat NO. 2660101, LOT A3140 and 200 NTU- Cat NO. 2660401, LOT A3135.
TDS	Standards of 1413 ìS/cm by WTW model E/SET, order no. 300 572(APHA, 2005(81).
Chlorides	a. Potassium chromate indicator. K_2CrO_4 b. Silver nitrate. $AgNO_3$ (0.0141N).
Sulfate	a) Sulfate reagent b) Barium chloride crystal
ICP-MS	Concentrated HNO_3

Instruments, Apparatuses, Equipment's and Glassware:

- pH meter (WTW Model InoLab pH 7110, WTW, Germany, Serial No.: 13321210) fitted with a combined glass electrode and a temperature probe.
- Total organic carbons (TOC) analyzer (HACH model 2100 N, HACH Co., USA, Serial No.: 13040C030093) with measuring cell.
- Electric conductivity meter and total dissolved solids (TDS) meter (WTW Model InoLab cond 720, WTW, Germany Serial No.: 7420286) fitted with conductivity probe.
- Spectrophotometer (CECIL of CECIL INSTRUMENTS, CAMBRIDGE, ENGLAND. Serial No.: 146-189).
- Inductively couple plasma- mass spectroscopy by ICAQ (Scientific Fisher, USA).
- Oven (MMM Venticell55 made in Germany S.N B072925).
- Filter Holder Manifold: the manifold may be used for simultaneous filtration. of three or six test samples. Each filter holder support station accepts any Millipore filter holder fitted with a No. 8 silicone perforated stopper.
- Balance (Redgeway made in Romania S.N 1422588).
- Heater with magnetic stirrer (VWR: CAT No.: 12365-508, serial number: 071009026, Made in the USA by HENRY TROEMNER L.L.C.
- Centrifuge. (HERMLE a product of HERMLE LABORTECHNIK, Germany).

Physical and Chemical Analyses of Water Samples: The quality of water samples was determined by measuring pH, Total Dissolved Solids (TDS), TOC (Total Organic carbons), chloride and sulfate. All the physicochemical analyses were done in duplicates and determined by the procedures of Standard Methods done for the Examination of Water and Wastewater APHA [18].

pH: pH values were measured using an analytical pH meter fitted with a combined glass electrode and a temperature probe. The instrument was calibrated daily using standard pH technical buffers as registered by APHA [18]. Distilled water used for electrode washing by instrument M-Q water (Purelab, Flex), Veolia, UK Water, Solutions and Technologies.

Conductivity & Total Dissolved Solids (TDS): Conductivity and TDS were measured using an analytical unit conductivity meter, fitted with conductivity probe after being calibrated by standards of 1413 ìS/cm as recorded by APHA [18]. Distilled water was used for probe washing.

Chloride Determination: Chloride, in the form of chloride (Cl^-) ion was determined by using argent metric method. A sample of 100 ml was introduced into 500 ml clean flask and then 3 drops of potassium chromate indicator were added to the sample. The sample was titrated against $AgNO_3$ (0.0141N) till the end point of red color precipitates of silver chromate as recorded by APHA, (2005).

Calculation:

$$\text{mg Cl}^- / \text{L} = \frac{(A-B) \times N \times 35\,450}{\text{mL sample}}$$

where:
A = ml titration for sample,
B = ml titration for blank and
N = normality of AgNO3.

Heavy Metals: Apparatus Atomic absorption spectrometer and associated equipment:

Reagents: Air, cleaned and dried through a suitable filter to remove oil, water and other foreign substances. The source may be a compressor or commercially bottled gas.

Argon gas cylinder (99.9992%)*,* standard commercial grade. Argon which always is present in Argon cylinders, can be prevented from entering and damaging the burner head by replacing a cylinder when its pressure has fallen to 689 Kilopascal (kPa) (150 pound per square inch (psi) pressure.

Metal-free Water: Metal-free water was used for preparing all reagents and calibration standards and as dilution water. metal-free water Prepared by deionizing tap water and/or by using one of the following processes, depending on the metal concentration in the sample: single distillation, re-distillation, or sub-boiling. Always check deionized or distilled water to determine whether the element of interest is present in trace amounts. If the source water contains Mercury (Hg) or other volatile metals, single- or redistilled water may not be suitable for trace analysis because these metals distill over with the distilled water. In such cases, use sub-boiling to prepare metal-free water.

Multi-elements Standard Solution: The samples described below was tested in the environmental and food biotechnology laboratory by using NIST National Institute of Standards and Technology (s) traceable reference equipment and materials (Merck kgaa, icp multi-elements standard solution iv, lot # hc379062) in accordance with ISO/IEC 17025:2017 requirements and the testing methods referenced below meets ISO/IEC 17025:2017 and accreditation bodies requirements.

Statistical Analysis: Statistical analysis data were analyzed using one or two ways ANOVA and mean compared was conducted using $LSD_{0.05}$. Analysis was conducted using SAS program [20].

RESULTS AND DISCUSSION

Effect of Fertilization Types and Types of Soil on the Chemical Analysis and Metals Content of Soil in Greater Cairo from 2019 to 2020: The data in Table 1. outlined the effect of fertilization and soil types on the chemical analysis and metals content of soil in Greater Cairo region during years 2019 - 2020. Information appeared that the cruel esteem of pH of soil tests was 7.75; the least esteem was 7.11 in the clay soil (ClayGz4) fertilized by the urea fertilizer (UreGZ4) collected from Giza governorate amid year 2019 and the greatest esteem was 8.35 in the clay soil in the clay soil (ClayQ2) fertilized by the urea fertilizer (UreQ2) collected from Qalioubiya governorate *amid* year 2020. The mean esteem of the entire broken down solids (TDS) of soil tests was 176.29 ppm; the least esteem was 126.48 ppm within the clay soil (ClayGz5) fertilized by the urea fertilizer (UreGz5) collected from Giza governorate amid year 2020 and the most extreme value was 239.08 ppm within the clay soil (ClayGz4) fertilized by the urea

Table 1: Effect of fertilization types and types of soil on the chemical analysis and metals content of soil in Greater Cairo region during years 2019-2020

					Chemical analysis (ppm)					Metals content (mg/kg)				Nutritional elements (mg/kg)	
Years	region	Govern.	Types of fertilizer	Type of soil	PH	TDS	Chlorids	Sulfates	Total Carbon	Cr	Cd	Ni	Pb	Fe	Zn
2019	Greatwr Cairo	Cairo	NitCa1	ClayCa1	7.94^{a}	222.88^{b}	106.22^{c}	49.62^{c}	142.92^{c}	0.187^{d}	0.886^{c}	0.503^{c}	1.600^{c}	3.064^{c}	1.124^{c}
			NitCa4	ClayCa4	7.77^{ab}	203.70^{e}	95.28^{c}	45.66^{c}	128.04^{c}	0.244^{c}	0.920^{c}	0.523^{c}	1.659^{c}	3.180^{c}	1.166^{c}
			NitCa7	ClayCa7	7.76^{ab}	201.78^{e}	94.29^{c}	44.68^{c}	126.94^{c}	0.229^{c}	0.880^{c}	0.493^{c}	1.589^{c}	3.090^{c}	1.096^{c}
		Giza	UreGZ1	ClayGz1	8.03^{a}	210.26^{d}	138.20^{b}	104.160^{b}	120.60^{b}	0.616^{b}	2.325^{b}	1.322^{b}	4.196^{b}	8.039^{b}	2.948^{b}
			UreGZ4	ClayGz4	7.11^{c}	239.08^{a}	213.04^{a}	110.38^{a}	158.54^{a}	1.352^{a}	5.096^{a}	2.898^{a}	9.197^{a}	17.622^{a}	6.462^{a}
			UreGZ7	SiltGZ1	8.03^{a}	217.26^{d}	108.20^{b}	94.16^{b}	108.60^{b}	0.616^{b}	2.325^{b}	1.322^{b}	4.196^{b}	8.039^{b}	2.948^{b}
		Qalioubiya	NitrQ1	ClayQ1	7.75^{ab}	201.70^{e}	92.28^{c}	42.66^{c}	125.04^{c}	0.214^{c}	0.820^{c}	0.423^{c}	1.639^{c}	3.080^{c}	1.066^{c}
			NitrQ4	SiltQ1	7.49^{bc}	169.66^{c}	103.22^{c}	48.64^{c}	137.98^{c}	0.151^{e}	0.406^{d}	0.231^{d}	0.732^{d}	1.404^{d}	0.515^{d}
			NitrQ7	SiltQ4	7.47^{bc}	149.69^{c}	101.82^{c}	46.94^{c}	136.99^{c}	0.140^{e}	0.386^{d}	0.171^{d}	0.582^{d}	1.294^{d}	0.475^{d}
		LSD	---------	--------	0.38	124.80	34.95	16.71	16.63	0.027	0.103	0.059	0.186	0.357	0.131
2020		Cairo	UreCa2	ClayCa2	7.49^{b}	155.84^{c}	59.16^{cd}	24.32^{c}	31.18^{c}	0.014^{d}	0.002^{b}	0.005^{d}	0.077^{f}	0.107^{c}	0.624^{c}
			UreCa5	ClayCa5	8.34^{b}	149.90^{c}	56.88^{cd}	23.32^{c}	29.98^{c}	0.016^{d}	0.004^{b}	0.004^{d}	0.125^{e}	0.116^{c}	0.267^{e}
			UreCa8	ClayCa8	7.41^{b}	147.90^{c}	56.08	23.02^{c}	29.58^{c}	0.029^{c}	0.001^{b}	0.005^{d}	0.184^{b}	0.125^{c}	0.348^{d}
		Giza	UreGz2	ClayGz2	7.70^{b}	126.76^{a}	118.12^{a}	48.64^{a}	62.54^{a}	0.052^{b}	0.060^{a}	0.058^{a}	0.136^{d}	0.217^{b}	1.100^{a}
			UreGz5	ClayGz5	7.69^{b}	126.48^{a}	114.17^{a}	46.95^{a}	60.86^{a}	0.049^{b}	0.048^{a}	0.048^{a}	0.140^{d}	0.210^{b}	1.080^{a}
			UreGz8	SiltGZ2	7.39^{b}	158.80^{bc}	60.24^{cd}	24.72^{c}	31.76^{c}	0.054^{b}	0.002^{b}	0.006^{d}	0.162^{c}	0.186^{b}	0.609^{c}
		Qalioubiya	UreQ2	ClayQ2	8.35^{a}	169.74^{bc}	64.42^{b}	26.50^{b}	33.94^{b}	0.030^{c}	0.004^{b}	0.052^{b}	0.130^{de}	0.115^{c}	0.218^{f}
			UreQ5	SiltQ2	8.31^{a}	167.96^{bc}	63.86^{b}	23.94^{b}	31.99^{b}	0.028^{c}	0.003^{b}	0.050^{b}	0.130^{de}	0.115^{c}	0.2100^{f}
			UreQ8	SiltQ5	7.39^{b}	153.86^{c}	58.36^{cd}	24.02^{c}	30.80^{c}	0.063^{a}	0.005^{b}	0.011^{c}	0.224^{a}	2.091^{a}	0.700^{b}
		LSD	----------	--------	0.38	11.92	3.73	1.53	1.98	0.002	0.001	0.002	0.007	0.035	0.032

Means with the same letter are not significantly different within the same column at level 0.05

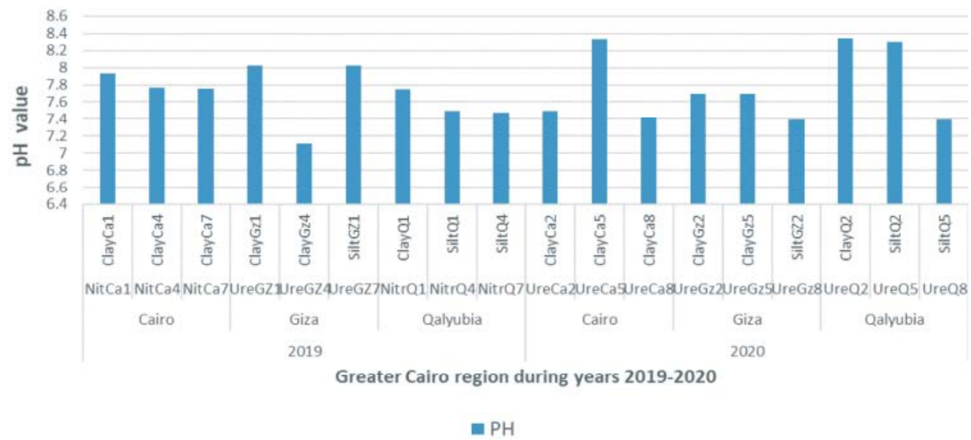

Fig. 3: The relation between types of soil and fertilizer in the Greater Cairo region during years 2019- 2020 and pH values of soil.

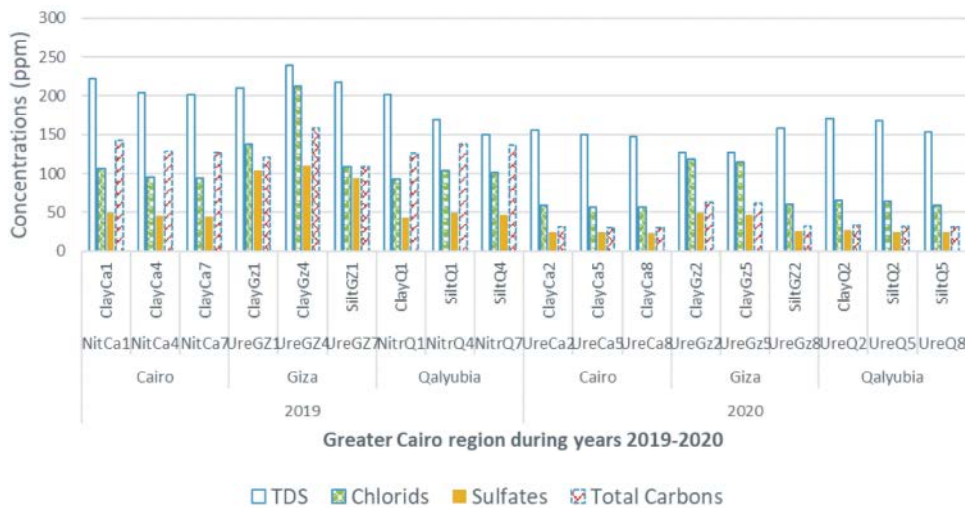

Fig. 4: The relation between types of soil and fertilizer in the Greater Cairo region during years 2019- 2020 and concentration of Total Dissolved Solids (TDS), Chlorides, Sulfates and Total Organic Carbons(TOC) (ppm) of soil.

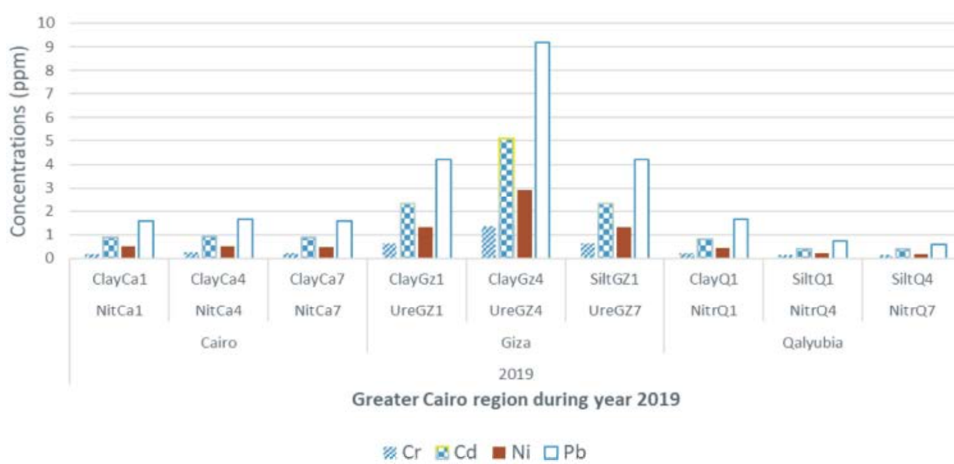

Fig. 5: The relation between types of soil and fertilizer in the Greater Cairo region during year 2019 and concentration of heavy metals content (Cr, Cd, Ni and Pb) (ppm) of soil.

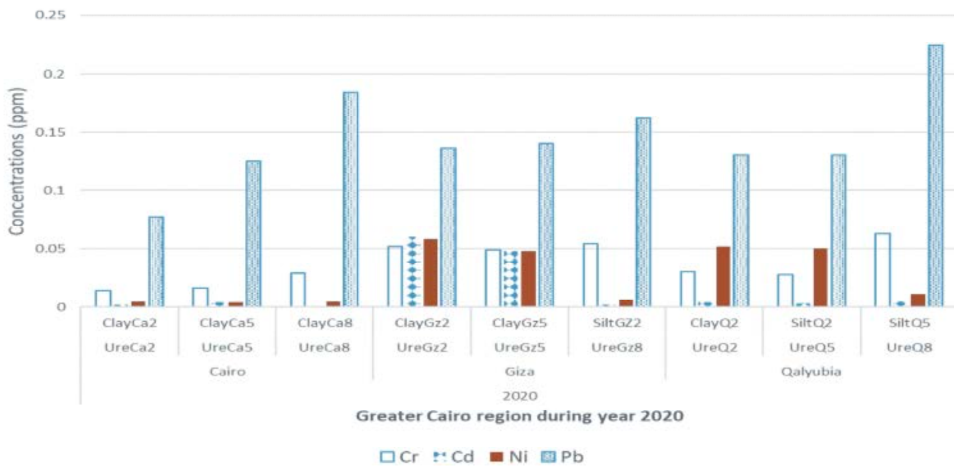

Fig. 6: The relation between types of soil and fertilizer in the Greater Cairo region during year 2020 and concentration of heavy metals content (Cr, Cd, Ni and Pb) (ppm) of soil.

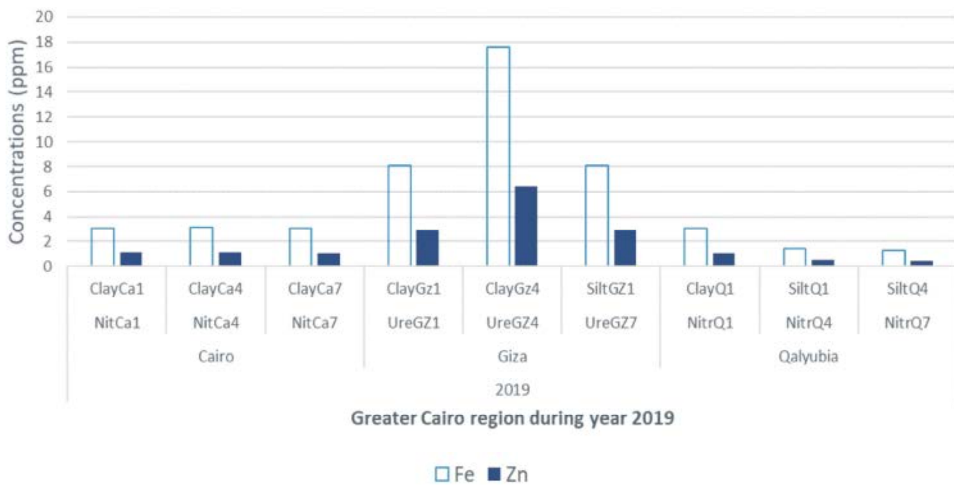

Fig. 7: The relation between types of soil and fertilizer in the Greater Cairo region during year 2019 and concentration of nutritional elements content (Fe and Zn)) (ppm) of soil.

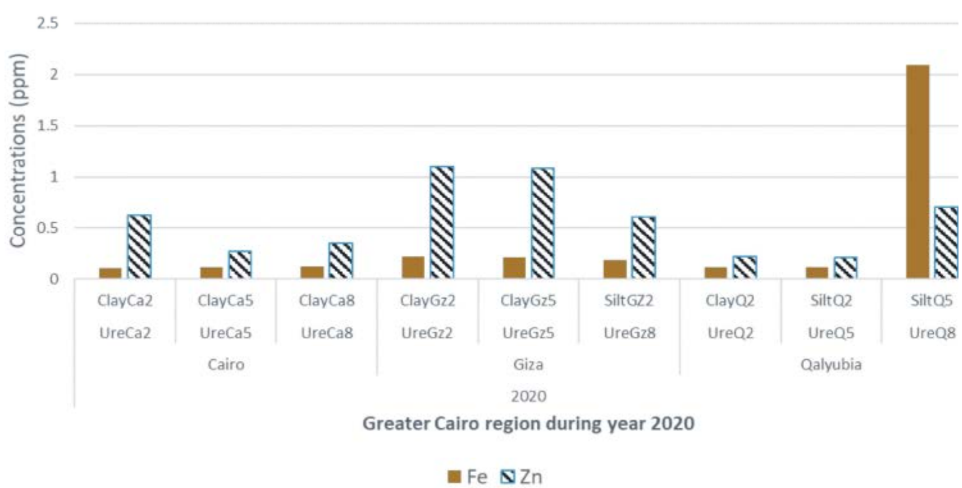

Fig. 8: The relation between types of soil and fertilizer in the Greater Cairo region during year 2020 and concentration of nutritional elements content (Fe and Zn)) (ppm) of soil.

fertilizer (UreGZ4) collected from Giza governorate *amid* year 2019.The cruel esteem of the chloride of soil tests was 94.66 ppm; the least esteem was 56.08 ppm within the clay soil (ClayCa8) and fertilized by the urea fertilizer (UreCa8) collected from Cairo governorate amid year 2020 and the greatest esteem was 213.04 ppm within the clay soil (ClayGz4) fertilized by the urea fertilizer (UreGZ4) collected from Giza governorate amid year 2019. The mean value of the Sulfate of soil tests was 47.35 ppm; the least esteem was 23.02 ppm within the clay soil (ClayCa8) fertilized by the urea fertilizer (UreCa8) collected from Cairo governorate amid year 2020 and the most extreme esteem was 110.38 in the clay soil (ClayGz4) fertilized by the urea fertilizer (UreGZ4) collected from Giza governorate amid year 2019. The cruel esteem of the overall carbons of soil tests was 84.90 ppm; the least value was 29.58 within the clay soil (ClayCa8) fertilized by the urea fertilizer (UreCa8) collected from Cairo governorate amid year 2020 and the most extreme esteem was 158.54 ppm within the clay soil (ClayGz4) and fertilized by the urea fertilizer (UreGZ4) collected from Giza governorate amid year 2019. The cruel esteem of the Chromium (Cr) of soil tests was 0.227 ppm; the least esteem was 0.014 ppm within the clay soil (ClayCa2) fertilized by the urea fertilizer (UreCa2) collected from Cairo governorate amid year 2020 and the most extreme value was 1.352 ppm within the clay soil (ClayGz4) and fertilized by the urea fertilizer (UreGZ4) collected from Giza governorate amid year 2019.The cruel esteem of the Cadmium (Cd) of soil tests was 0.787 ppm; the least esteem was 0.001 ppm within the clay soils (ClayCa8) fertilized by the urea fertilizer (UreCa8) collected from Cairo governorate *amid* year 2020 and the most extreme esteem was 5.096 ppm within the clay soil (ClayGz4) fertilized by the urea fertilizer (UreGZ4) collected from Giza governorate amid year 2019.The cruel esteem of the Nickel (Ni) of soil tests was 0.451 ppm; the least esteem was 0.004 ppm within the clay soil (ClayCa5) fertilized by the urea fertilizer (UreCa5) collected from Cairo governorate *amid* year 2020 and the most extreme esteem was 2.898 ppm within the clay soil (ClayGz4) and fertilized by the urea fertilizer (UreGZ4) collected from Giza governorate *amid* year 2019. The cruel esteem of the Lead (Pb) of soil tests was 1.483 ppm; the least esteem was 0.077 ppm within the clay soil (ClayCa2) fertilized by the urea fertilizer (UreCa2) collected from Cairo governorate *amid* year 2020 and the most extreme value was 9.197 ppm within the clay soil (ClayGz4) fertilized by the urea fertilizer (UreGZ4) collected from Giza governorate amid year 2019. The cruel esteem of Iron(Fe) of soil tests was 2.894 ppm; the least esteem was 0.107 ppm within the clay soil (ClayCa2) fertilized by the urea fertilizer (UreCa2) collected from Cairo governorate amid year 2020 and the greatest esteem was 17.622 ppm within the clay soil (ClayGz4) and fertilized by the urea fertilizer (UreGZ4) collected from Giza governorate amid year 2019.The *cruel* esteem of the Zinc (Zn) of soil tests was 1.275 ppm; the least esteem was 0.210 ppm within the silt soil (SiltQ2) fertilized by the urea fertilizer (UreQ5) collected from Qalioubiya governorate amid year 2020 and the most extreme esteem was 6.462 ppm within the clay soil (ClayGz4) fertilized by the urea fertilizer (UreGZ4) collected from Giza governorate amid year 2019 and prosecuted that there were critical contrasts at ($p \leq 0.05$) within the chemical investigation (pH, TDS, chloride, sulfate and add up to carbons values) and metals substance (Cr, Cd, Ni, Pb, Fe and Zn values) in all governorates within the more noteworthy Cairo locale. Comparable comes about were gotten by [21] who explore the inconstancy of chemical applications on Cd, Pb and As concentrations of wheat grain-cultivated soils and shown that the result demonstrated that Cd, Pb and As concentrations were expanded within the developed soils due to fertilizer application. Fertilizers can altogether increment edit yields but can too harm the soil supplement adjust and can cause natural contamination as recorded by [22]; [23]. In streams and water bodies with intemperate fertilizer runoff, eutrophication can happen, which makes an overabundance of supplements. In expansion, intemperate fertilizer utilize can sully the groundwater with inorganic chemicals as reported by [24]; [25].

Impact of Fertilization Types and Soil Types on the Metals Content of Wheat Grain Types in the Greater Cairo Region and its Governorates During Years 2019-2020: The data in Table 2 showed the Impact of fertilization types and soil types on the metals content of wheat grain types in the Greater Cairo region and its governorates during years 2019-2020. The data showed an average value of 1.232 ppm for chromium (Cr); the lowest value was 0.018 ppm in Gemmiza 9 (Gem9Ca1) wheat grain samples collected in Cairo governorate in 2020 when grown on clay soil (ClayCa1) and fertilized with urea fertilizer (UreCa1) and the *peak* value was 2.993 ppm in Giza 171 (Giz171Gz2) wheat grain sample collected from Giza governorate in 2019 when grown on clay soil (ClayGz4) and fertilized with urea fertilizer (UreGz4). The average value of Cadmium (Cd) in wheat grain samples was 0.923 ppm; the lowest value was 0.001 ppm in Gemmiza11 (Gem11Q1) wheat grain sample collected in Qalioubiya governorate when grown on silt soil (SiltQ1)

Table 2: Effect of fertilization types and types of soil on the metals content of wheat grain types in Greater Cairo region and its governorates during years 2019-2020.

Years	Region	Govern.	Types of fertilizer	Type of soil	Types of wheat grain	Heavy metals content (mg/kg) Cr	Cd	Ni	Pb	Nutritional elements (mg/kg) Fe	Zn
2019	Greater Cairo	Cairo	NitCa2	ClayCa2	Gem9Ca2	1.208^{d}	1.522^{b}	2.393^{b}	0.828^{e}	25.072^{a}	10.006^{a}
			NitCa5	ClayCa5	Gz71Ca2	2.932^{b}	4.732^{a}	2.162^{d}	2.725^{a}	22.116^{b}	10.10^{b}
			NitCa8	ClayCa8	Gz71Ca5	2.991^{b}	4.727^{a}	2.283^{d}	2.631^{a}	23.106^{b}	10.124^{b}
		Giza	UreGZ5	SiltGZ2	Gem11Gz2	0.151^{e}	0.001^{e}	0.036^{e}	2.113^{b}	0.245^{f}	0.369^{e}
			UreGz4	ClayGz4	Giz171Gz2	2.993^{b}	4.749^{a}	2.584^{d}	2.925^{a}	26.136^{b}	10.184^{b}
			UreGZ8	ClayGz5	Sak95Dz2	2.502^{c}	0.182^{d}	2.184^{cd}	0.529^{f}	22.241^{c}	0.910^{d}
		Qalioubiya	NitrQ5	SiltQ2	Gem11Q2	2.972^{a}	0.523^{c}	2.107^{a}	1.337^{c}	10.470^{e}	3.272^{c}
			NitrQ8	SiltQ5	Gem9Q2	0.090^{e}	0.001^{e}	0.015^{e}	2.825^{a}	0.330^{f}	0.307^{e}
			NitrQ2	ClayQ2	Misr1Q2	2.956^{b}	0.142^{de}	2.227^{c}	1.037^{d}	17.274^{d}	3.021^{c}
		LSD	----------	----------	----------	0.125	0.136	0.118	0.105	1.002	0.349
2020		Cairo	UreCa1	ClayCa1	Gem9Ca1	0.018^{f}	0.017^{a}	0.006^{f}	1.454^{a}	0.067^{f}	0.486^{a}
			UreCa4	ClayCa4	Gem9Ca4	1.434^{a}	0.004^{b}	0.071^{d}	2.128^{b}	0.279^{a}	0.252^{e}
			UreCa7	ClayCa7	Gz71Ca1	0.619^{b}	0.003^{c}	0.042^{e}	1.607^{c}	0.236^{b}	0.377^{b}
		Giza	UreGz7	SiltGZ1	Gem11Gz1	0.620^{b}	0.003^{c}	0.041^{e}	0.606^{de}	0.177^{c}	0.202^{f}
			UreGz4	ClayGz4	Misr1GZ1	0.074^{e}	0.004^{b}	0.085^{c}	1.393^{c}	0.054^{g}	0.185^{g}
			UreGz1	ClayGz1	Skh95GZ1	0.177^{cd}	0.001^{e}	0.198^{a}	0.733^{d}	0.135^{d}	0.262^{e}
		Qalioubiya	UreQ1	SiltQ1	Gem11Q1	0.170^{d}	0.001^{e}	0.191^{b}	0.403^{e}	0.123^{e}	0.352^{c}
			UreQ4	SiltQ4	Gem11Q4	0.200^{c}	0.002^{d}	0.192^{ab}	0.504^{de}	0.232^{b}	0.287^{d}
			UreQ7	ClayQ1	Misr1Q1	0.070^{e}	0.003^{c}	0.087^{c}	1.619^{c}	0.053^{g}	0.180^{g}
		LSD	----------	----------	----------	0.028	0.0000	0.006	0.258	0.008	0.015

Means with the same letter are not significantly different within the same column at level 0.05

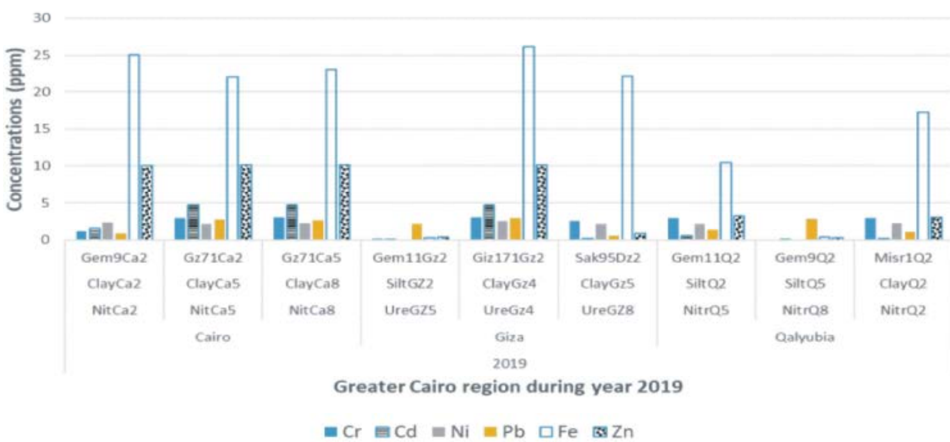

Fig. 9: The relation between types of soil and fertilizer in the Greater Cairo region during year 2019 and concentration of heavy metals (Cr, Cd, Ni and Pb) and nutritional elements content (Fe and Zn) (ppm) of wheat grains.

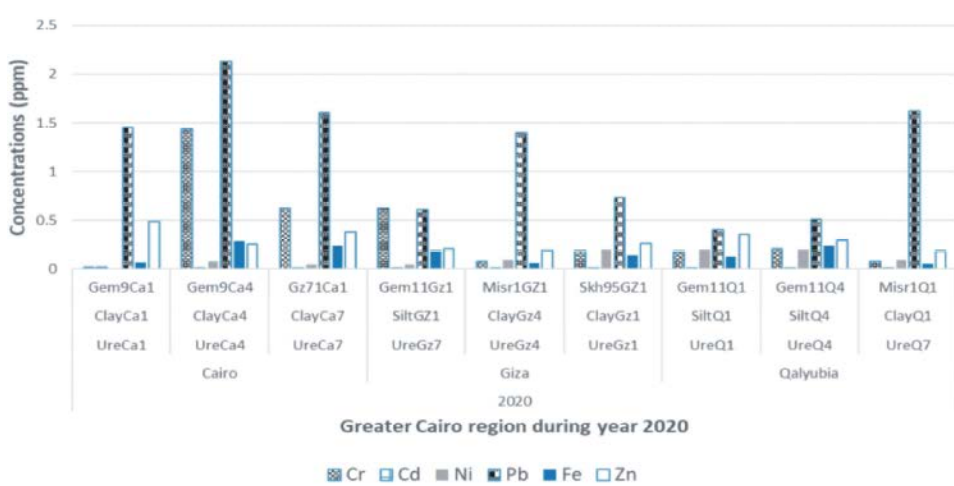

Fig. 10: The relation between types of soil and fertilizer in the Greater Cairo region during year 2020 and concentration of heavy metals (Cr, Cd, Ni and Pb) and nutritional elements content (Fe and Zn) (ppm) of wheat grains.

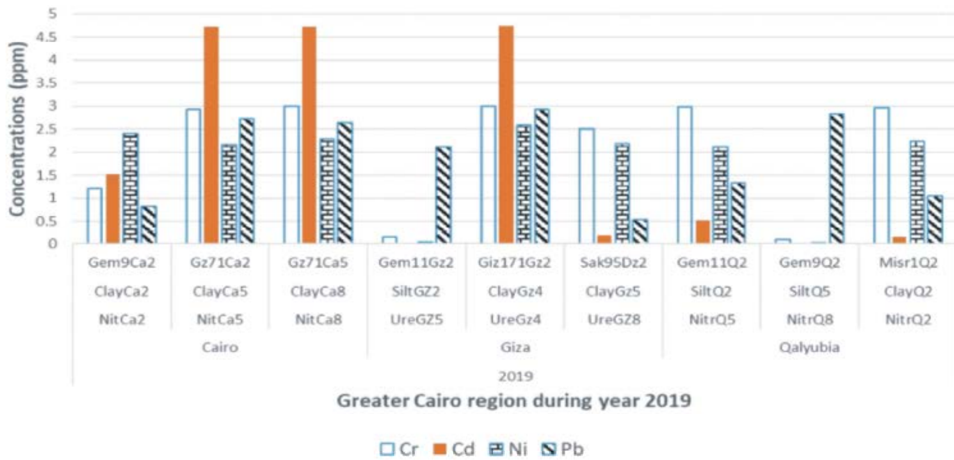

Fig. 11: The relation between types of soil and fertilizer in the Greater Cairo region during year 2019 and concentration of heavy metals (Cr, Cd, Ni and Pb) (ppm) of wheat grains.

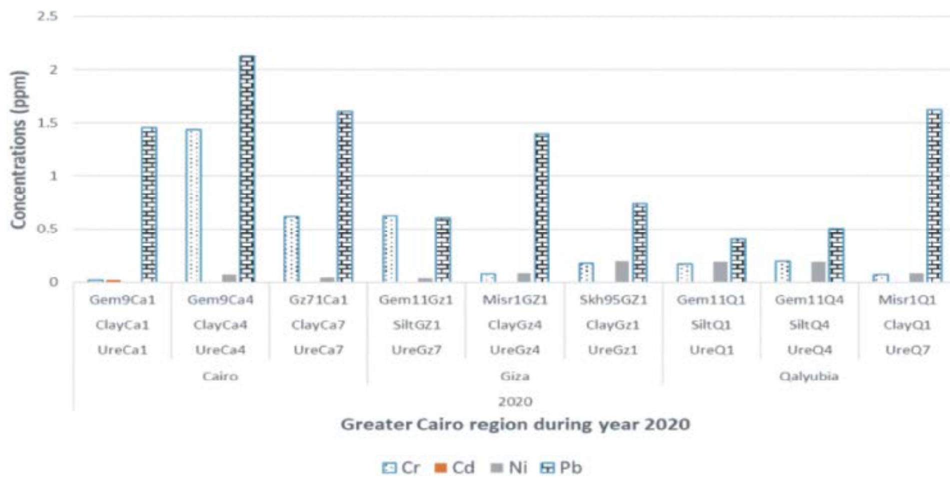

Fig. 12: The relation between types of soil and fertilizer in the Greater Cairo region during year 2020 and concentration of heavy metals (Cr, Cd, Ni and Pb) (ppm) of wheat grains.

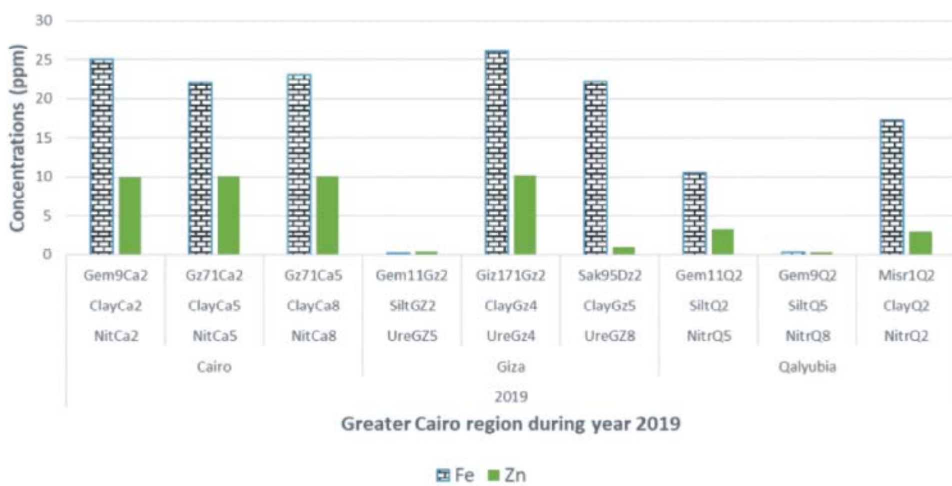

Fig. 13: The relation between types of soil and fertilizer in the Greater Cairo region during year 2019 and concentration of nutritional elements content (Fe and Zn) (ppm) of wheat grains.

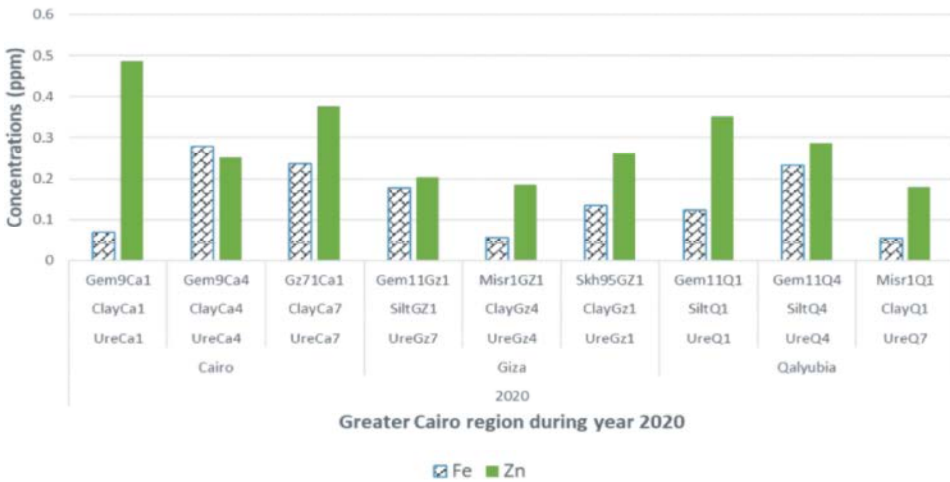

Fig. 14: The relation between types of soil and fertilizer in the Greater Cairo region during year 2020 and concentration of nutritional elements content (Fe and Zn) (ppm) of wheat grains.

and fertilized with urea fertilizer (UreQ1) in 2020 and the maximum value was 4.749 ppm in Giza 171 (Giz171Gz2) wheat grain samples collected from Giza Governorate when grown on clay soil (ClayGz4) and fertilized with urea fertilizer (UreGz4) in 2019. The mean value of the Nickel (Ni) in wheat grain samples was 0.939 ppm; the lowest value was 0.006 ppm in Gemmiza 9 (Gem9Ca1) wheat grain samples collected in Cairo governorate in 2020 when grown on clay soil (ClayCa1) and fertilized with urea fertilizer (UreCa1) and the peak value was 2.584 ppm in Giza171 (Giz171Gz2) wheat grain sample collected in Giza *province* in 2019 when grown on clay soil (ClayGz4) and fertilized with urea fertilizer (UreGz4). The mean value of lead (Pb) in wheat grain samples was 1.522 ppm; the lowest value was 0.403 ppm in Gemmiza11 (Gem11Q1) wheat grain samples collected from Qalioubiya governorate in 2020 when grown on silt soil (SiltQ1) and fertilized with urea fertilizer (UreQ1) and the maximum value was 2.925 ppm in wheat grain sample Giza 171 (Giz171Gz2) collected in Giza governorate in 2019 when grown on clay soil (ClayGz4) and fertilized with urea fertilizer (UreGz4). The average value of Iron (Fe) in wheat grain samples was 8.241 ppm; the lowest value was 0.053 ppm in Misr 1 (Misr1Q1) wheat grain samples collected from Qalioubiya governorate in 2020 when grown on clay soil (ClayQ1) and fertilized with urea fertilizer (UreQ7) and the peak value was 26.136 ppm in Giza 171 (Giz171Gz2) collected in Giza governorate in 2019 when grown on clay soil (ClayGz4) and fertilized with urea fertilizer (UreGz4). The average value of zinc (Zn) in wheat grain samples was 2.826 ppm; the lowest value was 0.180 ppm in wheat grain sample Misr 1 (Misr1Q1) collected from Qalioubiya governorate in 2020 when grown on clay soil (ClayQ1) and fertilized with urea fertilizer (UreQ7) and the Giza 171 (Giz171Gz2) collected in Giza governorate in 2019 when grown on clay soil (ClayGz4) and fertilized with urea fertilizer (UreGz4) had a peak value of 10.184 ppm. Data indicated that there were significant difference $P \leq 0.05$) in metals contents (Cr, Cd, Ni, Pb, Fe and Zn) in all governorates of Greater Cairo. The results obtained were consistent with those of [26, 27], who reported rapid changes in metal concentrations in agricultural land and its products. On the other hand, indiscriminate and prolonged use of fertilizers is a major cause of soil and water pollution as referred by [28-30], damaging pristine terrestrial and aquatic ecosystems and human health downstream, is brought to risk. Soil naturally contains heavy metals (HM) such as cadmium (Cd), mercury (Hg), arsenic (As), chromium (Cr) and lead (Pb), but excessive fertilizer application can damage the soil.

Chemical Analysis and Metals Content of Irrigation Water in the Greater Cairo Region and its Governorates During Years 2019 - 2020: The data in Table 3 summarized the chemical analysis and metals content of irrigation water in Greater Cairo and its governorates during 2019-2020. The data showed that the average pH of the irrigation water samples was 7.23; the lowest value was 6.31 for agricultural and human sewages irrigation water samples (AgSeHGz2) collected in Giza governorate in 2019 and the identical values ??for the artesian and rainwater irrigation water samples (ArtRnCa4) collected in Cairo governorate in 2020 was 7.75. The average of total dissolved solids (TDS) of the irrigation water samples was

Table 3: Chemical analysis and metals content of irrigated water in the Greater Cairo region and its governorates during years 2019 - 2020.

Years	Region	Governorate	Irrigated water	Chemical analysis (ppm) PH	TDS	Chloride	Metals content (mg/kg) Sulfates	Total Carbons	Cr	Cd	Ni	Pb	Nutritional elements (mg/kg) Fe	Zn
2019		Cairo	AgSeHCa3	7.33^{a}	805.93^{a}	253.12^{a}	91.30^{a}	290.80^{a}	0.037^{c}	0.002^{d}	0.009^{c}	0.011^{c}	0.156^{c}	1.749^{a}
			AgSeHCa6	7.31^{a}	800.90^{a}	212.02^{a}	91.32^{a}	290.72^{a}	0.107^{a}	0.004^{a}	0.025^{a}	0.031^{a}	0.176^{c}	1.742^{a}
			ArtCa3	7.20^{a}	604.44^{b}	90.34^{d}	60.56^{e}	155.84^{e}	0.079^{b}	0.003^{c}	0.019^{b}	0.024^{b}	0.278^{b}	1.299^{c}
		Giza	AgSegGz3	7.29^{a}	803.92^{a}	120.12^{c}	80.42^{b}	207.44^{d}	0.022^{d}	0.004^{b}	0.024^{a}	0.012^{c}	0.644^{a}	1.618^{b}
			AgSeHGz2	6.31^{a}	945.30^{a}	194.52^{b}	91.50^{a}	290.82^{a}	0.107^{a}	0.005^{a}	0.025^{a}	0.032^{a}	0.709^{a}	5.686^{a}
			ArtGz6	7.31^{a}	521.30^{b}	94.32^{d}	78.49^{c}	262.02^{b}	0.082^{b}	0.004^{b}	0.018^{b}	0.025^{b}	0.286^{b}	1.335^{c}
		Qalioubiya	NileQ3	7.00^{a}	605.90^{a}	223.11^{a}	65.54^{d}	224.30^{c}	0.107^{a}	0.004^{a}	0.025^{a}	0.031^{a}	0.176^{c}	1.549^{a}
			NilHuQ3	7.31^{a}	301.72^{c}	94.32^{d}	65.50^{d}	226.30^{c}	0.037^{c}	0.002^{d}	0.009^{c}	0.011^{c}	0.128^{d}	1.593^{b}
			ArtQ3	7.31^{a}	621.30^{b}	194.51^{b}	73.41^{c}	260.12^{b}	0.062^{b}	0.004^{b}	0.019^{b}	0.022^{b}	0.236^{b}	1.315^{c}
		LSD	---------	0.36	32.11	9.01	3.79	12.15	0.004	0.000	0.001	0.001	0.014	0.076
2020		Cairo	ArtRnCa3	7.25^{b}	585.58^{e}	77.42^{d}	49.62^{e}	124.10^{d}	0.013^{d}	0.002^{b}	0.008^{c}	0.011^{d}	0.459^{d}	2.086^{d}
			ArtRnCa4	7.75^{a}	304.63^{c}	98.28^{a}	87.34^{a}	82.40^{f}	0.015^{cd}	0.002^{b}	0.005^{e}	0.010^{d}	0.128^{d}	1.593^{b}
			NilRnCa3	6.85^{b}	481.40^{e}	71.50^{e}	44.70^{f}	112.18^{e}	0.010^{d}	0.002^{b}	0.004^{f}	0.009^{e}	0.598^{b}	1.614^{e}
		Giza	ArtRnGZ3	7.13^{b}	645.12^{d}	93.30^{e}	59.56^{d}	148.88^{b}	0.013^{b}	0.002^{b}	0.009^{b}	0.011^{d}	0.461^{d}	2.101^{d}
			ArtsGZ3	7.05^{b}	791.04^{c}	76.44^{d}	65.50^{c}	136.00^{c}	0.016^{c}	0.002^{b}	0.004^{g}	0.014^{c}	0.321^{e}	2.577^{c}
			NilRnGz3	7.64^{a}	538.38^{b}	87.34^{c}	77.42^{b}	73.44^{g}	0.030^{b}	0.000^{b}	0.003^{g}	0.026^{a}	0.509^{c}	4.885^{b}
		Qalioubiya	ArtRanQ3	7.74^{a}	228.28^{g}	70.50^{e}	59.56^{d}	125.06^{b}	0.005^{f}	0.003^{a}	0.006^{d}	0.004^{f}	0.094^{g}	0.761^{g}
			ArtsnQ3	7.19^{b}	602.49^{de}	90.29^{bc}	60.48^{d}	153.89^{a}	0.070^{a}	0.003^{a}	0.017^{a}	0.022^{b}	0.278^{f}	1.299^{f}
			ArtsnQ6	7.18^{b}	601.99^{de}	90.23^{bc}	60.37^{d}	152.89^{a}	0.070^{a}	0.003^{a}	0.016^{a}	0.021^{b}	0.278^{f}	1.299^{f}
		LSD	---------	0.36	47.45	4.11	3.11	6.18	0.002	0.000	0.001	0.001	0.022	0.143

Data within the same letter are not significantly different within the same column at level 0.05

Fig. 15: The relation between the geographical location in the Greater Cairo region during years 2019-2020 and pH values of irrigation water.

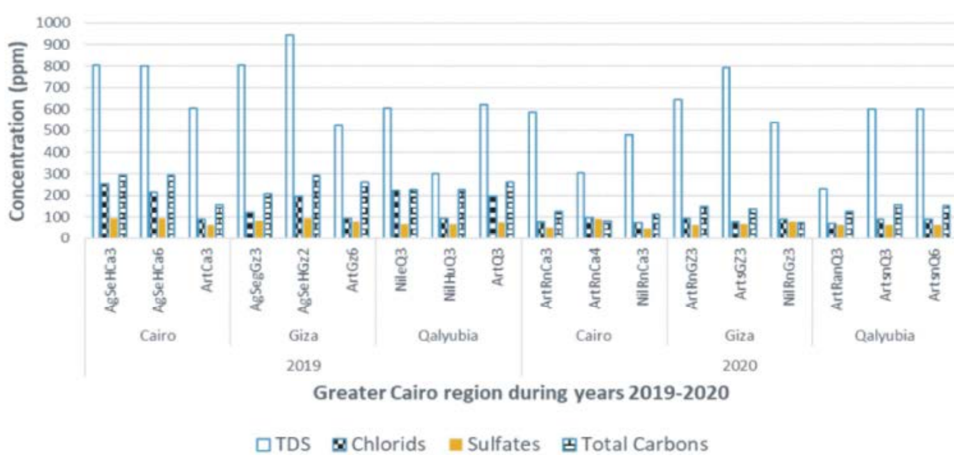

Fig. 16: The relation between the geographical location in the Greater Cairo region during years 2019-2020 and concentration of TDS, Chloride, Sulfate and Total Carbons (ppm) of irrigation water.

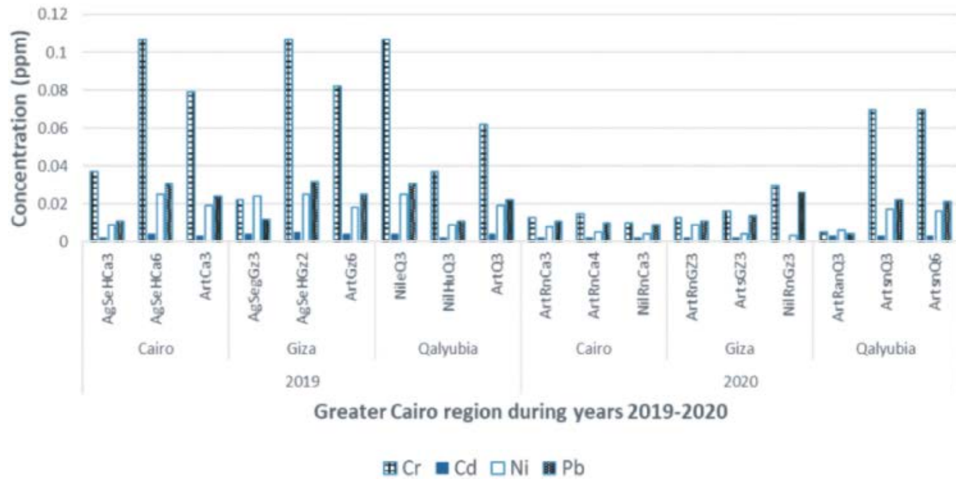

Fig. 17: The relation between the geographical location in the Greater Cairo region during years 2019-2020 and concentration of heavy metals content (Cr, Cd, Ni and Pb) (ppm) of irrigation water.

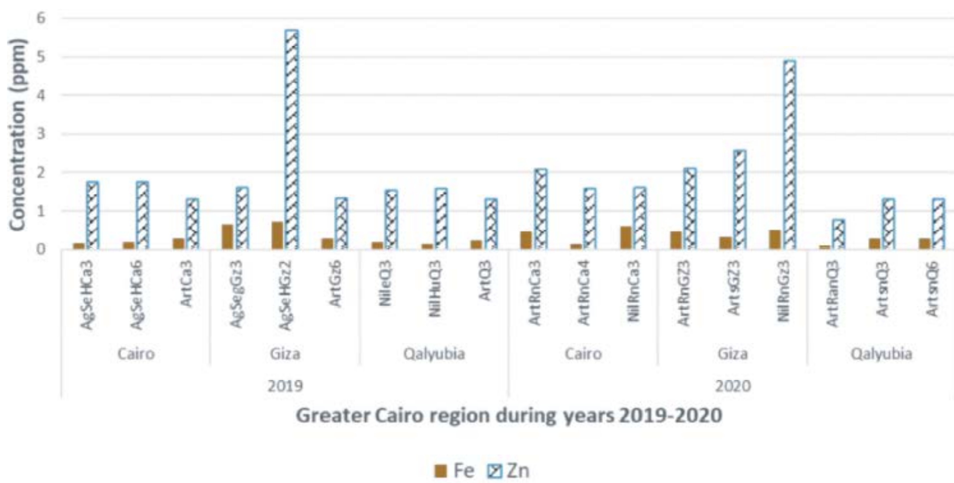

Fig. 18: The relation between the geographical location in the Greater Cairo region during years 2019-2020 and concentration of nutritional elements content (Fe and Zn)) (ppm) of irrigation water.

599.42 ppm; the lowest value was 228.28 ppm in the artesian and rainwater (ArtRanQ3) collected from Qalioubiya in 2020 and the peak value was 945.30 ppm in 2019 for agricultural and human sewages irrigation water samples (AgSeHGz2) collected in Giza governorate in 2019. The average chloride value was 123.98 ppm; the lowest value was 70.50 ppm for Artesian and rainwater irrigation water (ArtRanQ3) collected in Qalioubiya governorate in 2020 and the maximum value was 194.52 ppm in agricultural and human sewages irrigation water samples (AgSeHGz2) collected in Giza governorate in 2019. The average sulfate level was 70.14 ppm; the lowest level was 44.70 ppm in Nile and rainwater irrigation water (NilRnCa3) collected in Cairo governorate in 2020 and the maximum value was 91.50 ppm in agricultural and human sewages irrigation water samples (AgSeHGz2) collected in Giza governorate in 2019. Average total carbon was 184.29 ppm; the lowest level was 73.44 ppm in Nile River and rainwater (NilRnGz3) collected in Giza governorate in 2020 and the peak value was 290.82 ppm in agricultural and human sewages irrigation water samples (AgSeHGz2) collected in Giza governorate in 2019. Chromium (Cr) had an average value of 0.049 ppm; the lowest value was 0.005 ppm for *confined* water and rainwater (ArtRanQ3) collected in Qalioubiya province in 2020 and the maximum value was 0.107 ppm in agricultural and human sewages irrigation water samples (AgSeHGz2) collected in Giza governorate in 2019. Cadmium (Cd) averaged 0.003 ppm; the minimum value was 0.000 ppm for Nile and rainwater irrigation water (NilRnGz3) collected in Giza governorate in 2020 and the maximum value was 0.005 ppm in agricultural and human sewages irrigation water samples (AgSeHGz2) collected in Giza governorate in 2019. Average nickel (Ni) was 0.014 ppm; the lowest value was 0.003 ppm for Nile and rain irrigation water (NilRnGz3) collected in Giza governorate in 2020 and the maximum value was 0.025 ppm in agricultural and human sewages irrigation water samples (AgSeHGz2) collected in Giza governorate in 2019. The average value for lead (Pb) was 0.018 ppm; the lowest value was 0.004 ppm for confined water and rainwater (ArtRanQ3) collected in Qalioubiya province in 2020 and the maximum value was 0.032 ppm in agricultural and human sewages irrigation water samples (AgSeHGz2) collected in Giza governorate in 2019. The average value for iron (Fe) was 0.329 ppm; the lowest value was 0.094 ppm for confined water and rainwater (ArtRanQ3) collected in Qalioubiya province in 2020 and the peak was 0.709 ppm in agricultural and human sewages irrigation water samples (AgSeHGz2) collected in Giza governorate in 2019. The average value for zinc (Zn) was 2.006 ppm; the lowest value was 0.761 ppm and for confined water and rainwater (ArtRanQ3) collected from Qalioubiyain 2020 and with a peak value of 5.686 ppm, in agricultural and human sewages irrigation water samples (AgSeHGz2) collected in Giza governorate in 2019. Data showed significant differences in chemical analysis (pH, TDS-, chloride, sulfate, total carbon values) and metals. ($p \leq 0.05$). All administrative district contents (Cr, Cd, Ni, Pb, Fe and Zn values gave Greater Cairo. From the data obtained, it was possible to conclude that the levels of chemical analysis, heavy metals and food metals in all irrigation waters in all governorates of Greater Cairo were within acceptable limits as recorded by WHO [31]. The results obtained were not consistent with those of [32] who reported that sewage-irrigated soils contained permissible concentrations of heavy metals, with the exception of Cd, Cu and Zn [33]. This is consistent with the results of [34]. Soils irrigated with drainage had concentrations of iron, cadmium, copper and zinc above safe levels as registered by [35] obtained similar results for coal soils irrigated with industrially contaminated water in the El Teppen area.

CONCLUSION

The present study discovered that use of contaminated irrigation water and overdoes of agrochemicals lead to accumulation of toxic heavy metals in soils and their application by the crops developed over there. The content of heavy metals in wheat grains varied in different parts. The eatable parts especially crop seed/grain revealed high increase of heavy metals. Good agricultural practices and consistent monitoring of soil, crop and water quality with avoidance of bad agronomic practices to agricultural crops is a way to reduction the potential health risks for inhabitants. Using low quality water in cultivation has bad belongings on both soil properties and establishing crop by either accumulative their contents of heavy metals which distresses badly on the human health or by increasing salinity intensities. Heavy metal toxicity is one of foremost environmental health complications and potentially hazardous due to bioaccumulation. Therefore, heavy metals pollution of soils and plants has developed an increasing problem. Based on the achieved results, the subsequent recommendations could be assumed for the best managing of soil quality:

- Treat wastewater in order to boundary toxic heavy-metal pollution from this source.
- Carefully accomplish fertilizer and pesticide use and teach farmers about the side-effects of using excessive and uncontrolled fertilizers and pesticides.
- Use the appropriate method for remediation and washing soil that undergoes from pollution.
- Factory locations must have environment-friendly plants over the real use of resources and application of environmental administration to save biodiversity through the proper controlling of chemicals and collaboration with local societies.
- Monitor the polluted soil occasionally.

REFERENCES

1. WHO/HPR/OCH 96.2, 1996. Distr.: General, Biological Monitoring of Chemical Exposure in the Workplace Guidelines World Health Organization Geneva 1996 Volume 2, World Health Organization Geneva 1996 Volume 2 Contribution to the International Programme on Chemical Safety (IPCS).
2. Li Lin, Haoran Yang and Xiaocang Xu, 2022. Research Center for Economy of Upper Reaches of the Yangtse River/School of Economics, Chongqing Technology and Business University, Chongqing, China, 2 School of Economics and Management, Huzhou University, Huzhou, China, published: 30 June 2022 doi: 10.3389/fenvs.2022.880246, volume 10, article 880246. Ahmed El Nemr, National Institute of Oceanography and Fisheries (NIOF), Egypt Reviewed by: Behzad Shahmoradi, Kurdistan University of Medical Sciences, Iran Atik Kulakli, American University of the Middle East, Kuwait.

3. Farhan Ahmed, Imtiaz Ali, Shazia Kousar, Saira Ahmed, Environmental Science and Pollution Research, 2022. 29:29778-29792, Environmental Science and Pollution Research, 29: 29778-29792
4. Mahdi Balali-Mood, Kobra Naseri, Zoya Tahergorabi, Mohammad Reza Khazdair and Mahmood Sadeghi, 2021. Toxic Mechanisms of Five Heavy Metals: Mercury, Lead, Chromium, Cadmium and Arsenic, published: 13 April 2021 doi: 10.3389/fphar.2021.643972
5. Hamed Soleimani, Borhan Mansouri, Amir Kianid, Abdullah Khalid Omer, Moslem Tazika, Gholamreza Ebrahimzadehg, Kiomars Sharafih, 2023. Ecological risk assessment and heavy metals accumulation in agriculture soils irrigated with treated wastewater effluent, river water and well water combined with chemical fertilizers, Heliyon, 9: 14580.
6. Md. Shazzadur Rahman, A.H.M. Selim Reza, Md. Abu Bakar Siddique, Md. Ahedul Akbor and Mehedi Hasan, 2023. Accumulation of arsenic and other metals in soil and human consumable foods of Meherpur district, southwestern Bangladesh and associated health risk assessment, Rahman et al. Environmental Sciences Europe, 35: 47.
7. Ifrah Tahir and Khalid Ali Alkheraije, 2023. A review of important heavy metals toxicity with special emphasis on nephrotoxicity and its management in cattle, 10.3389/fvets.2023.1149720, PUBLISHED 29 March 2023.
8. Evgenia A. Goncharuk and Natalia V. Zagoskina, 2023. Heavy Metals, Their Phytotoxicity and the Role of Phenolic Antioxidants in Plant Stress Responses with Focus on Cadmium: Review, Molecules 2023, 28, 3921.https://doi.org/10.3390/molecules 28093921.
9. Jessica Briffa, Emmanuel Sinagra and Renald Blundell, 2020. Heavy metal pollution in the environment and their toxicological effects on humans, Heliyon, 6: e04691.
10. Saikat Mitra, Arka Jyoti Chakraborty, Abu Montakim Tareq, Talha Bin Emran, Firzan Nainu, Ameer Khusro, Abubakr M.Idris, Mayeen Uddin Khandaker, Hamid Osman, Fahad A. Alhumaydhi and Jesus Simal-Gandara, 2022. Impact of heavy metals on the environment and human health: Novel therapeutic insights to counter the toxicity, Journal of King Saud University-Science, 34: 101865.
11. Agnieszka Mocek-Płóciniak, Justyna Mencel, Wiktor Zakrzewski and Szymon Roszkowski, 2023. Phytoremediation as an Effective Remedy for Removing Trace Elements from Ecosystems, Plants, 12: 1653.
12. Kaisa S. Poutanen, Anna O. Ka°rlund, Carlos G_omez-Gallego, Daniel P. Johansson, Nathalie M. Scheers, Ingela M. Marklinder, Anne K. Eriksen, Pia C. Silventoinen, Emilia Nordlund, Nesli Sozer, Kati J. Hanhineva, Marjukka Kolehmainen and Rikard Landberg, 2022. Grains - a major source of sustainable protein for health, Nutrition Reviews VR, 80(6): 1648-1663, doi: 10.1093/ nutrit. /nuab084,2022.
13. Almas HAMID, Amen WASIM, Amna AZFAR, Ramsha AMJAD and Rabia NAZIR, 2020. Monitoring and health risk assessment of selected trace metals in wheat rice and soil samples, Food Sci. Technol., Campinas, 40(4): 917-923, Oct.-Dec. 2020.
American Public Health Association [APHA] 2005. Standard Methods for the Examination of Water and Wastewater 22nd ed. APHA, Inc. Washington, D.C.
14. Sabiha-Javied, N. Siddque, S. Waheed, Q. uz Zaman, A. Aslam, M. Tufail and R. Nasir, 2023. Uptake of heavy metal in wheat from application of different phosphorus fertilizers, Journal of Food Composition and Analysis, 115: 104958.
15. Kushneet Kaur Sodhi, Lokesh Chandra Mishra, Chandra Kant Singh and Mohit Kumar, 2022. Perspective on the heavy metal pollution and recent remediation strategies, Current Research in Microbial Sciences, 3: 100166.
16. Rhue R.D. and G. Kidder, 1983. Analytical procedures used by the IFAS Extension Soil Testing Laboratory and the interpretation of results. Soil Science Department, University of Florida, Gainesville.
17. Ibeto, C.N. and C.O.B. Okoye, 2010. High levels of Heavy metals in Blood of Urban population in Nigeria. Research Journal of Environmental Sciences, 4(4): 371-382.
18. APHA (American public health association), 2005. Standard methods for examination of water and wastewater. APHA, AWWA, Washington, IC.
19. Lambers, H., F.S. Chapin and T.L. Pons, 2008. Plant Physiological Ecology. Second Edition, (Springer Science, LLC, 233, New York, USA)
20. Anonymous, 2003. SAS statistics and graphics guide, release 9.1. SAS Institute, Cary, North Carolina 27513, USA.
21. Atafar, Z., A. Mesdaghinia, J. Nouri, M. Homaee, M. Yunesian, M. Ahmadimoghaddam and A.H. Mahvi, 2010. Effect of fertilizer application on soil heavy metal concentration. Environmental Monitoring and Assessment. Springer Science + Business Media B.V., 160(1-4): 83-89.

22. Cai, A., M. Xu, B. Wang, W. Zhang, G. Liang, E. Hou and Y. Luo, 2019. Manure acts as a better fertilizer for increasing crop yields than synthetic fertilizer does by improving soil fertility. Soil Tillage Res., 189: 168-175.
23. Kumar R., R. Kumar and O. Prakash, 2019. Chapter-5 the Impact of Chemical Fertilizers on Our Environment and Ecosystem. Chief Ed, 35: 69.
24. Rashmi, I., T. Roy, K.S. Kartika, R. Pal, V. Coumar, S. Kala and K.C. Shinoji, 2020. Organic and inorganic fertilizer contaminants in agriculture: Impact on soil and water resources. In Contaminants in Agriculture; Springer: Cham, Switzerland, pp: 3-41.
25. Wei, B., J. Yu, Z. Cao, M. Meng, L. Yang and Q. Chen, 2020. The availability and accumulation of heavy metals in greenhouse soils associated with intensive fertilizer application. Int. J. Environ. Res. Public Health, 17: 5359.
26. Zhengqian Ye, Keli Zhao, Luyao Zhang, Jiaqi Dong, Jiasen Wu, Weiming Zhao, Lizhong Ding and Weijun Fu, 2020. Risk assessment, spatial patterns and source apportionment of soil heavy metals in a typical Chinese hickory plantation region of southeastern China, Geoderma, 360: 114011.
27. Saira Naz, Francesco Fazio, Syed Sikandar Habib, Ghazala Nawaz, Sobia Attaullah, Mujeeb Ullah, Adil Hayat and Imtiaz Ahmed, 2022. Incidence of Heavy Metals in the Application of Fertilizers to Crops (Wheat and Rice), a Fish (Common carp) Pond and a Human Health Risk Assessment, Sustainability 2022, 14(20), 13441; https://doi.org/10.3390/su142013441, Received: 30 August 2022 / Revised: 27 September 2022 / Accepted: 30 September 2022 / Published: 18 October 2022.
28. Hudak, P.F., 2000. Regional trends in nitrate content of Texas groundwater, Journal of Hydrology, 228(1-2): 37-47.
29. Hanson, C.R., 2002. Nitrate concentrations in Canterbury groundwater: a review of existing data. Environment Canterbury. Report No. R02/17, ISBN 1-86937-457-6, August 2002.
30. Mohammad N. Almasri and Jagath J. Kaluarachchi, 2004. Assessment and management of long-term nitrate pollution of ground water in agriculture-dominated watersheds, Journal of Hydrology, 295(1-4): 225-245.
31. World Health Organization. 2006. WHO guidelines for the safe use of wastewater excreta and greywater (Vol. 1). World Health Organization.
32. Asmaa A. Ahmed, Mona N. abd El-Wahed, Seliem M. Madbouly and Zinab A. Abdelgawad, 2023. Effects of Untreated Wastewater Irrigation on Peanut (Arachis hypogea) Productivity and Human Health. Egypt. J. Bot., 63(1): 209-231.
33. Cal/EPA. 2010. Soil-screening numbers (mg/kg soil) for nonvolatile chemicals based on total exposure to contaminated soil: Inhalation, ingestion and dermal absorption.
34. El-Degwy, A., 2016. Chemical studies on the aquatic environment of El-Sharkawia Canal at El-Qalyubia Governorate. M.Sc. Thesis, Fac. of Sci, Benha University
35. Galal, T.M., A.A. Khalafallah, O.E. Elawa and L.M. Hassan, 2018. Human health risks from consuming cabbage (Brassica oleracea L. var. capitata) grown on wastewater irrigated soil. International Journal of Phytoremediation, 20(10): 1007-1016.