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Determination of some nutrients and heavy metals content of Egyptian wheat grains cultivated at the Nile Delta region

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ABSTRACT

The existence of heavy metals in the environment is one of the most significant environmental challenge due to the potential health risk for human and animal. The aim of this study was to investigate the impact of wheat varieties genotype, type of soil, type of fertilization and type of irrigation water on specific heavy metals and nutritional elements content in wheat grains at Nile Delta region, Egypt during the years 2019-2020. Soil, irrigation water and wheat grain samples were collected from all the Nile Delta Governorates in Egypt (Dakahlia, Damietta, Monufia, Kafr Al-Sheikh and Gharbia).The chemical properties (PH, TDS, Chlorides, Sulfate and Total carbons) of soil and irrigation water samples were assessed and the level of specific heavy metals; Chromium(Cr), Nickel (Ni), Cadmium (Cd) and lead (Pb), and specific nutritional elements; Iron (Fe) and Zinc (Zn) were estimated in all collected samples using Inductive Coupled Plasma Mass Spectrometry instrument (ICP-MS). The obtained results were Statistically analyzed using one or two ways ANOVA and mean compared was conducted using Duncan's LSD. The results that obtained indicated that the clay soil samples collected from the Nile Delta region when fertilized with urea during year 2019recoded higher concentrations than year 2020 of TDS, chlorides, sulfates, total carbons, Cr, Cd, Ni, Fe and Zn, except for the level of pH than other soil samples. On the other side the heavy metals content of wheat grains Gemmiza 11, Giza 11 and Giza 175 collected from the Nile Delta region specially at Kafr El-Sheikh and Damietta governorates during year 2019, which cultivated in the clay soils and fertilized with urea or nitrate gave higher concentrations of Cr, Cd, Ni, Pb, Fe and Zn than year 2020.On the other hand, the Nile irrigation water, Nile and human sewage irrigation water, artesian irrigation water samples collected from Gharbia and Damietta governorates during year 2019 recoded higher concentrations of pH, chlorides, sulfates, total carbons, Cr, Cd, Ni, Pb levels than year 2020. On contrast TDS, Fe and Zn at year 2020 for Nile irrigation water and artesian irrigation water collected from Kafr Al-Sheikh and Damietta recoded higher concentrations than other irrigation water samples. 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 by treatment of wastewater source is important to limit its content of toxic heavy-metal.

Keywords: Wheat, Heavy metals, Fertilization, water Irrigation, nutritional elements,Egypt.

1. Introduction

The rapid growth of the human population, industrialization and urbanization considerably reduce agricultural areas, but various harmful factors also adversely affect the agricultural soils and production of edible plants as recorded by Ali *et al.,* (2019); Ning *et al.* (2022). As these areas are closer to the main pollutants in the ecosystem, the effects on cultivated plants become more common as mentioned by Abrahams (2002); Rajkovi´c *et al.* (2012). All living organisms are negatively affected by

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environmental pollution as reported by Ning *et al.*(2022); Bhunia (2017). Environmental toxins include both organic and inorganic pollutants represented a significant threat to the ecosystem as a whole as mentioned by Alengebawy *et al.*(2021). According to previous studies performed all over the world, anthropogenic industrial activity is a major cause of heavy metal pollution in the environment as referred by Trumbulovic (2008); Li *et al.*(2014); Cao *et al.* (2020), Yu and Liu, (2021); Zhang *et al.*(2022). Modern agriculture practices are a substantial anthropogenic source of heavy metals due to the use of inorganic mineral fertilizers, pesticides and fuel burning as recorded by Ali *et al.* (2019); Loncari´ (2012); Toth *et al.*(2016); Marrugo *et al.* (2017); Waheed *et al.* (2017). Heavy metals and metalloids, including Cr, Zn, Cu, Cd, Sn, Mn, Co, Ni, Pb and Hg, can result insignificant toxic impacts as concluded by Waheed *et al.* (2017); Mitra *et al.* (2022). The ability of heavy metals to enter water and food supply systems and their failure to break down could have long-term effects on human food safety as referred by Khan *et al.* (2015); Zhang *et al.* (2018). The harmful effects of heavy metals on humans, animals, and plants are contributed by their persistent nature, bioavailability, high toxicity, and potential risk for superior bioaccumulation as mentioned by Jiang *et al.* (2022). Such contaminants can cause acute and chronic diseases, such as osteoporosis, lung cancer, renal dysfunction and cardiovascular diseases as reported by Lei *et al.* (2015); Turner *et al.* (2016); as well as the occurrence of various neurological diseasesin children and adults as discussed by Lu *et al.*(2014); Tsatsakis *et al.,*(2017); Mitra *et al.* (2022). Plants grown on polluted soil can accumulate high amounts of heavy metals and may act as the main pathway for transferring metals via the food chain as registered by Alengebawy *et al.* (2021); Al-Othman *et al.*(2016); Yang *et al.*(2018). Due to the aforementioned considerations, it is urgently critical to monitor and control the amount of heavy metals in the agricultural soil and their absorption by plants. The accumulation of heavy metals in plants occurs both in the roots and shoots of the plantas recorded by Rattan *et al.*(2005); Mickovski-Stefanovic *et al.* (2012); Clemens and Ma, (2016); and the study of the bioavailability, accumulation, and translocation of heavy metals has attracted further studies by researchers. Therefore, water resource scarcity has been occurred everywhere in the world. The limitation of freshwater resources has attracted researchers and officials to use unconventional water, such as rain water, saltwater, and wastewater as recorded by Soleimani *et al.* (2022); Badeenezhad *et al.* (2021); Karamia, *et al.* (2019). Physical soil qualities, soil structure, fertility, and organic matter content can all be improved by irrigation with treated wastewater as mentioned by Sharafi *et al.* (2012) So, wastewater reuse projects, especially municipal wastewater, are being applied in developing countries in a large-scale as recorded by Pirsaheb *et al.,* (2017). Treated domestic wastewater used in agricultural irrigation became an alternative source to compensate for the lack of fresh water as described by Kormoker *et al.* (2022). The combination of domestic wastewater effluents and fresh water supply can meet the nutritional needs of plants; on contrast, an important point that should be considered is investigating the physical and chemical properties of usage treated domestic wastewater on cultivated edible crops therefore human health and ecosystem as summarized by Proshad *et al.* (2021). Prolonged usage of wastewater effluents for irrigation often increases soil heavy metal content and buildup decreases soil fertility and crop quality while interfering with the soil's ecological function and effects on other ecosystem elements. Furthermore, HMs can be released as solutions, which the rhizosphere of the plants can then absorb when the soil's capacity to contain heavy metals declines due to a rise in HMs at the soil level as discussed by Kormoker *et al.* (2021). Wheat (*Triticum aestivum* L.) is a staple food that is consumed by around half of the world's population and provides almost 20% of the total calories and protein in the daily diet as concluded by Shewry (2009); Shiferaw *et al.*(2013); Giraldo *et al.*(2019); Dolijanovic *et al.* (2019); Iqbal *et al.* (2021). Regarding the contamination of the human food chain by heavy metals, pollution of wheat is a major issue as described by Orisakwe *et al.*(2012), Liu *et al.* (2017). In terms of food security and human health, more concern should be given to the safety of wheat grain. The content of heavy metals in wheat is mainly relatedto their content in the soil as recorded by Yang *et al.* (2022),and so the content of organic matter, PH of the soil, the mechanical composition of the soil,capacity of exchangeable cations as referred by Feszterová *et al.* (2021); Zhang *et al.* (2021), the cultivation system as mentioned by Dolijanovic *et al.*(2022), temperature, soil moisture, and plant physiology as registered by Khan *et al.* (2015). A significant influence on the accumulation of heavy metals in soil and plants related to the atmospheric deposition and prevailing wind direction as reported by Yu and Liu, (2021); Hermanson *et al.* (2020); Xing *et al.*(2020), Yu *et al.* (2022); Korzeniowska, (2023).

This work aimed to assess the heavy metal contamination in Egyptian wheat grain varieties, irrigation water and agricultural soils randomly in the Nile Delta region, Egypt (Dakahlia, Damietta, Monufia, Kafr Al-Sheikh and Gharbia Governorates).

2. Materials and Methods

2.1. Sampling

All samples (irrigation water, soil, and wheat grains) were collected from the Nile Delta region (Dakahlia, Damietta, Monufia, Kafr Al-Sheikh and Gharbia governorates), Egypt, during two seasons 2019 and 2020 according to the map of the Nile Delta region provided by the Field Crops Research Institute, Agricultural Research Center, Giza, Egypt.
Figure (1and 2).

Fig. 1: Egypt country (Google earth).

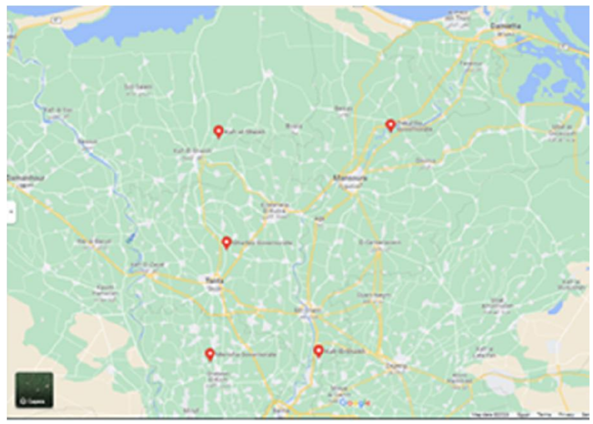

Fig. 2: Nile Delta region, Egypt (Google earth**)**

2.2. Irrigation sources and sampling

Through five governorates of the Nile Delta region, 100 ml of water samples were collected from five types of irrigation water i.e., Nile fresh water, artesian water, mixed water (Nile fresh water and rain water, 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 chemically analyzed**.**

2.3. 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 analyzedas concluded by Rhue and Kidder, (1983).

2.4. 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 and cleaned manually 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.as described by Hermanson *et al.* (2020). After the moisture was removed, the samples were milled into a fine powder using an electric domestic grinder model (Fresh, Egypt).

2.5. Study Area Description

2.5.1. Nile Delta region and its governorates (Dakahlia, Damietta, Monufia, Kafr Al-Sheikh and Gharbia)

Collected samples from Dakahlia Governorate at year 2019 were from Dikirnis, Belkas and Shirbin, while the samples collected at year 2020 were from MitGhamr, Aga and Talkha.

Collected samples from Damietta Governorate at year 2019were from Kafr Saad, Al Zarqa and Kafr Al Battikh, while the samples collected at year 2020 were from Faraskur, as Sirw and Ras Al-Bar.

Collected samples from Monufia governorate at year 2019 were from Sadat city, El-Salam village (KafrDawoud), Minuf (Dibirki vellage)and El-Bagour (Kafr Al Khadrah), while the samples collected at year 2020 were from Minuf (ZawiatRazien village), Minuf (Dibirki village) and El-Bagour (Kafr Al Khadrah).

Collected samples from Kafr al-Shaykh Governorateat year 2019 were from Biyala,Desouk and Sidi Salem, while the samples collected at year 2020 were from Qillin,Mutubas and El-Hamoul.

Collected samples from Gharbia Governorateat year 2019were from [El-Mahalla El-Kubra (Bashbish,El-Ensha El-Hadeisa village), As Santah and Kafr El-Zayat, while the samples collected at year 2020 were from Zifta, Samannoud and Qutur.

2.6. Samples preparation

2.6.1. Soil and wheat sample preparation

Samples of soil and wheat were dried at 105ºC 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 by Centrifuge. (HERMLE a product of HERMLE LABORTECHNIK, Germany) according to the method described by Ibeto *et al.* (2010).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 (American public health association), (2005).

2.7. Instruments, apparatuses, equipment's and glassware

pH meter (WTW Model Ino Lab 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 InoLabcond 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).

2.8. Physical and chemical analyses of water samples

The quality of water samples was determined by measuring pH, total dissolved solids (TDS), TOC, 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 Wastewateras recorded by APHA, (2005).

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 μS/cm by WTW model E/SET, order no. 300 572(APHA ,2005(81).
Chlorides	Potassium chromate indicator. K_2CrO_4 Silver nitrate. $AgNO_3$ (0.0141N).
Sulfate	Sulfate reagent Barium chloride crystal
ICP-MS	Concentrated HNO_3

2.9. 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 buffersas registered by APHA, (2005). Distilled water used for electrode washing by instrument M-Qwater (Purelab, Flex), Veolia, UK Water, Solutions and Technologies.

2.10. Conductivity & Total Dissolved Solids

Conductivity and TDS were measured using an analytical unit conductivity meter, fitted with conductivity probe after being calibrated by standards of 1413 μS/cm as recorded by APHA, (2005). Distilled water was used for probe washing.

2.11. 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 $AgNO_3$ (0.0141*N*) 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 $AgNO_3$.

2.12. Heavy metals

Apparatus Atomic absorption spectrometer and associated equipment:

2.13. 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.

2.14. 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.

2.15. 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.

2.16. Statistical analysis

Statistical analysis data were analyzed using one or two ways of Analysis of variance (ANOVA) and mean compared was conducted using Duncan's Least significant difference (LSD). Significance level was $p>0.05$. Analysis was conducted using SAS program Anonymous (2003). SAS statistics and graphics guide, release 9.1. SAS Institute, Cary, North Carolina 27513, USA.

3. Results and Discussion

3.1. Effect of the geographical location, fertilization and soil types on chemical analysis, heavy metals and nutritional elements content of soil in the Nile Delta region during year 2019.

The data in Figures (3, 4, 5 and 6) relate to the effect of the geographical location, fertilization and soil types on chemical analysis, heavy metals and nutritional elements content of soil in the Nile Delta region during year 2019. The data showed that the average pH value of the soil samples was 7.56;the minimum value was 6.97 in the silt soil samples (SiltDm1) collected from Damietta governorate when fertilized with the nitrate fertilizer (NitraDa2);the maximum value was 7.99 in the clay soil samples (ClayMe2) collected from Monufia governorate when fertilized with the urea fertilizer (UreaMe2).The mean value of the total dissolved solids (TDS) was 459.85 ppm; the minimum value was 159.59 ppm in the clay soil samples (ClayKr3) collected from Kafr al-Sheikh governorate when fertilized with the urea and nitrate fertilizer (UreNitKr); the maximum value was 927.88 ppm in the clay soil samples (ClayDm4) collected from Damietta governorate when fertilized with the nitrate fertilizer (NitrDa2).The mean value of the chloride was 186.95 ppm; the minimum value was 63.52 ppm in the silt soil samples (SiltMe1) collected from Monufia governorate when fertilized with the nitrate fertilizer (NitMe1); the maximum value was 620.34 ppm in the clay soil samples (ClayKr2) collected from Kafr al-Sheikh governorate when fertilized with the urea fertilizer (UreKr2). The mean value of the Sulfate was 76.11 ppm; the minimum value was 29.78 ppm in the silt soil samples (SiltMe1) collected from Monufia governorate when fertilized with the nitrate fertilizer (NitMe1); the maximum value was 143.94 in the clay soil samples (ClayKr2) collected from Kafr al-Sheikh governorate when fertilized with the urea fertilizer (UreKr2). The mean value of the total carbons was 143.45 ppm; the minimum value was 76.49 in the clay soil samples (ClayMe2) collected from Monufia governorate when fertilized with the urea fertilizer (UreaMe2); the maximum value was 383.10 ppm in the clay soil samples (ClayDK2) collected from Dakahlia governorate when fertilized with the urea fertilizer (UreaDk1). The mean value of the Chromium (Cr) was 0.252 ppm; the minimum value was 0.040 ppm in the clay soil samples (ClayMe2) collected from Monufia governorate when fertilized with the urea fertilizer (UreaMe2); the maximum value was 0.736 ppm in the clay soil samples (ClayDK2) collected from Dakahlia governorate when fertilized with the urea fertilizer (UreaDk1). The mean value of the Cadmium (Cd) was 0.813 ppm; the minimum value was 0.045 ppm in the clay soil samples (ClayKr2) collected from Kafr al-Sheikh governorate when fertilized with the urea fertilizer (UreKr2); the maximum value was 2.777 ppm in the clay soil samples (ClayDK2) collected from Dakahlia governorate when fertilized with the urea fertilizer (UreaDk1). The mean value of the Nickel (Ni) was 0.460 ppm; the minimum value was 0.030 ppm in the clay soil samples (ClayDk3) collected from Dakahlia governorate when fertilized with the urea and nitrate fertilizer (UreNitDk); the maximum value was 1.579 ppm in the clay soil samples (ClayDK2) collected from Dakahlia governorate when fertilized with the urea fertilizer (UreaDk1). The mean value of the Lead (Pb) was 1.522 ppm; the minimum value was 0.130 ppm in the clay soil samples (ClayMe2)

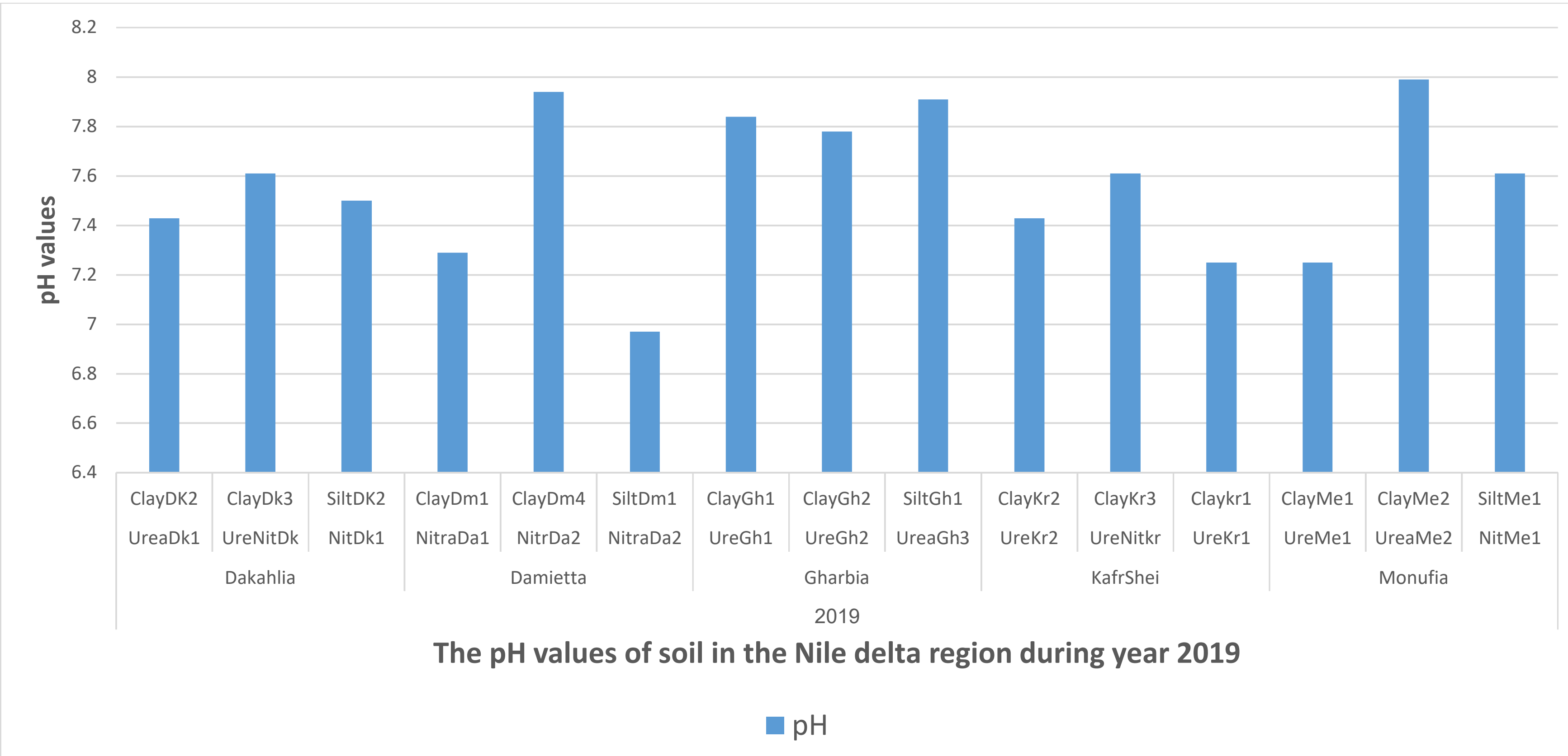

Fig. 3: The relation between types of soil and fertilizer in the Nile Delta region during year 2019 and pH values of soil.

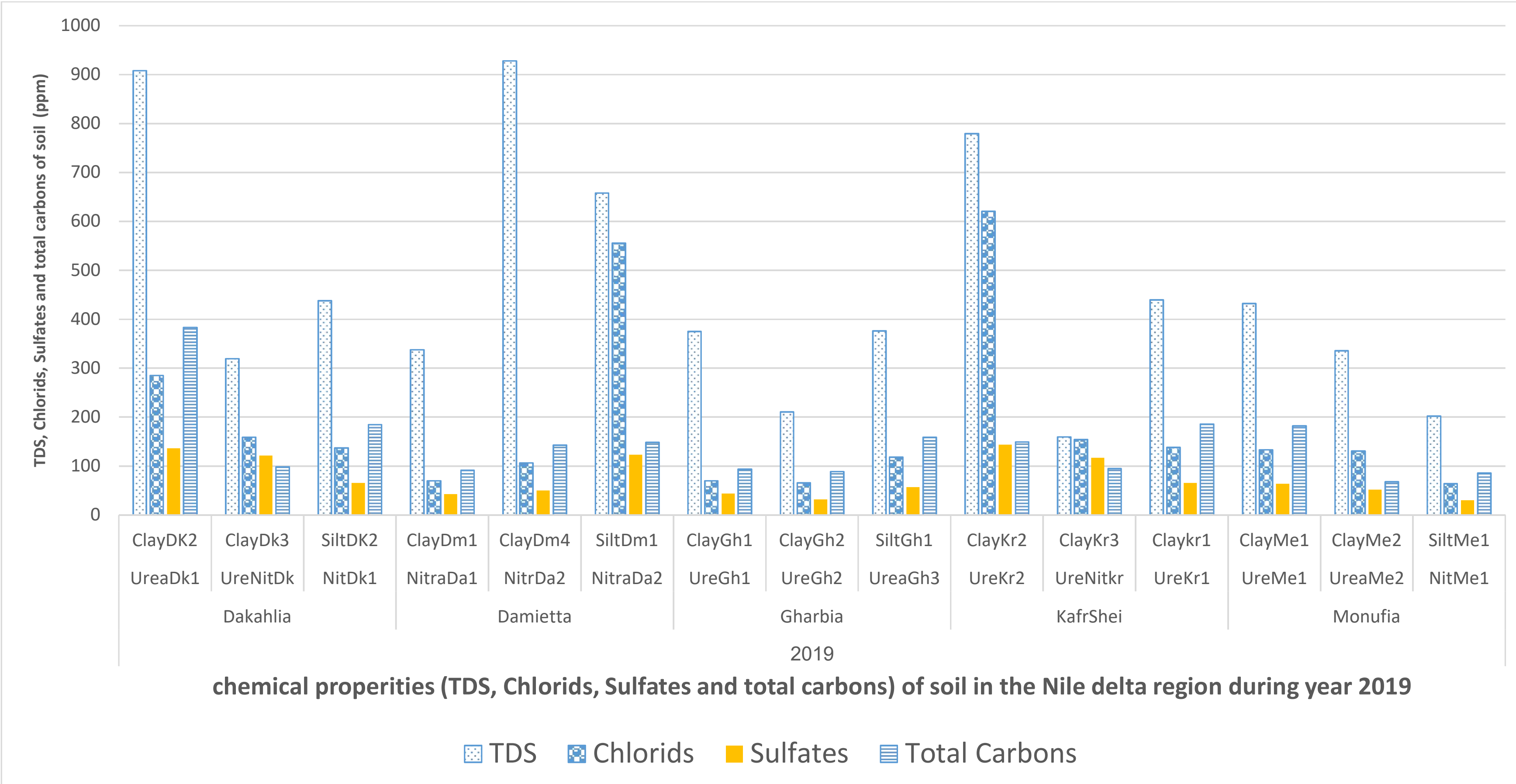

Fig. 4: The relation between types of soil and fertilizer in the Nile Delta region during year 2019 and concentration of TDS, Chloride, Sulfate and Total Carbons (ppm) of soil.

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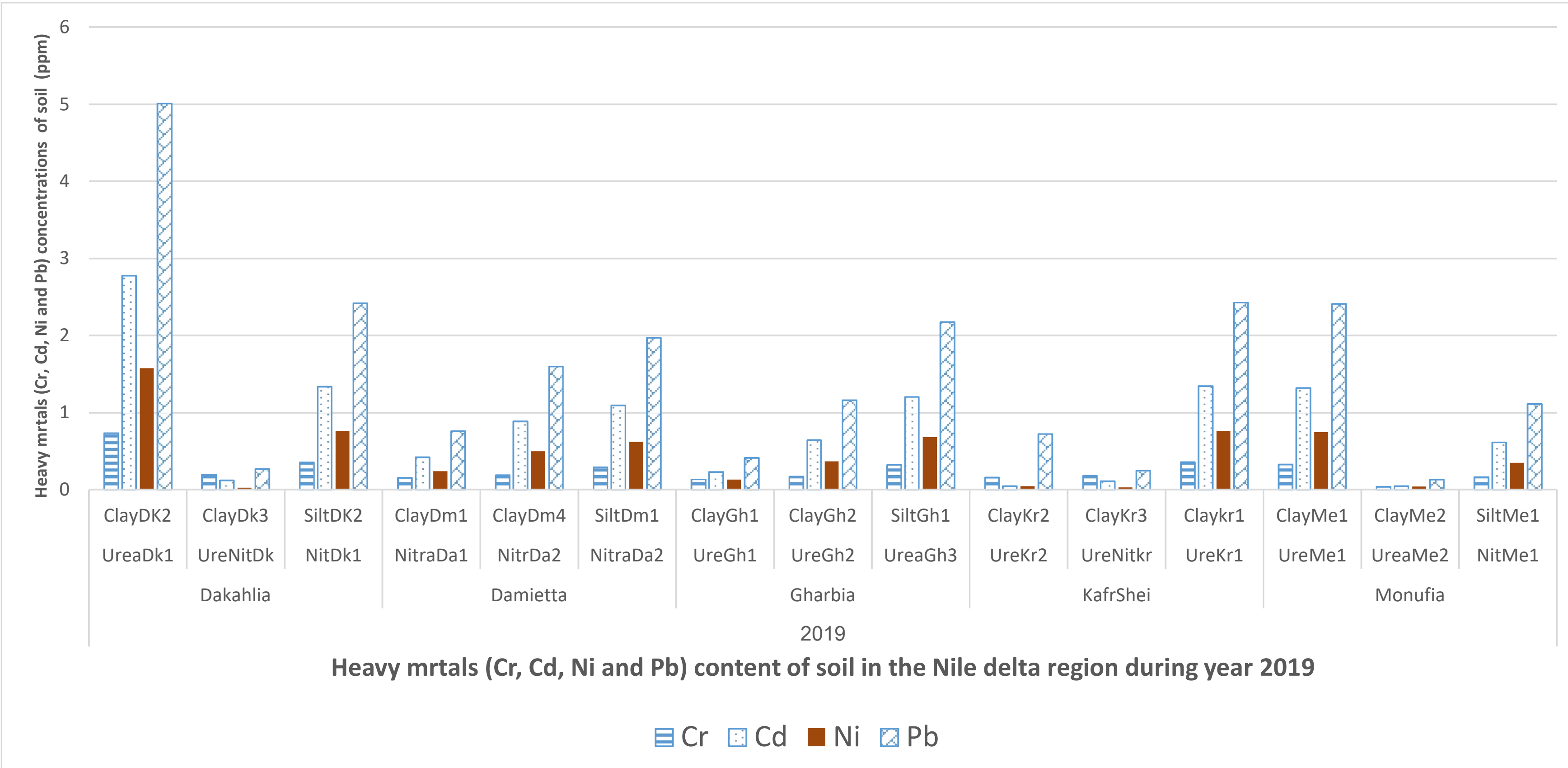

Fig. 5: The relation between types of soil and fertilizer in the Nile Delta region during year 2019 and concentration of heavy metals content (Cr, Cd, Ni and Pb) (ppm) of soil.

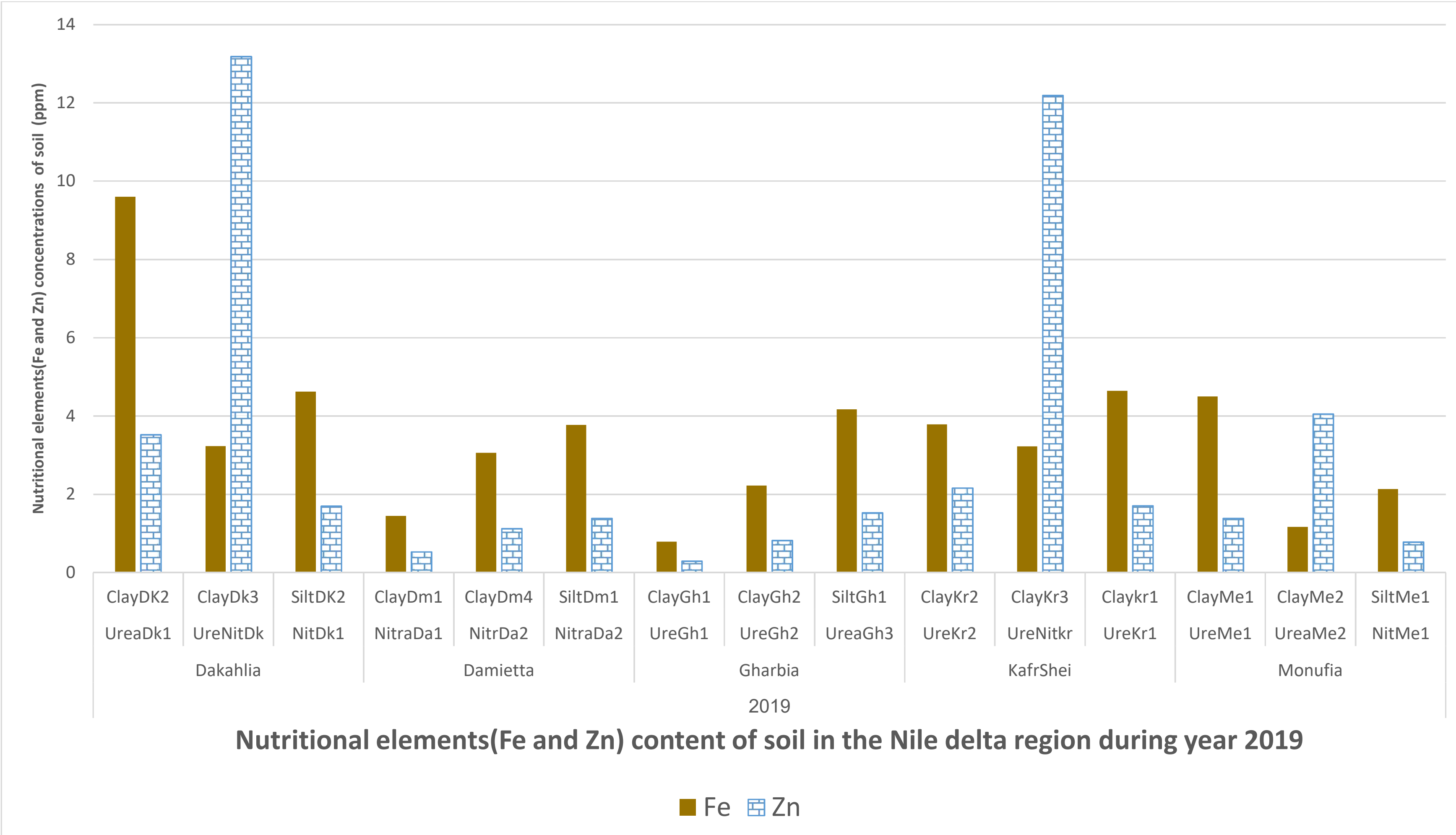

Fig. 6: The relation between types of soil and fertilizer in the Nile Delta region during year 2019 and concentration of nutritional elements content (Fe and Zn) (ppm) of soil.

collected from Monufia governorate when fertilized with the urea fertilizer (UreaMe2); the maximum value was 5.012 ppm in the clay soil samples (ClayDK2) collected from Dakahlia governorate when fertilized with the urea fertilizer (UreaDk1). The mean value of the Iron (Fe) was 3.494 ppm. The minimum value was 0.792 ppm in the clay soil samples (ClayGh1) collected from Gharbia governorate when fertilized with the urea fertilizer (UreGh1); the maximum value was 9.603 ppm in the clay soil samples (ClayDK2) collected from Dakahlia governorate when fertilized with the urea fertilizer (UreaDk1). The mean value of the Zinc (Zn) was 3.089 ppm; the minimum value was 0.291 ppm in the clay soil samples (ClayGh1) collected from Gharbia governorate when fertilized with the urea fertilizer (UreGh1); the maximum value was 13.180 ppm in the clay soil samples (ClayDk3) collected from Dakahlia governorate when fertilized with the urea and nitrate fertilizer (UreNitDk), and indicated that there were significant differences at ($p \leq 0.05$) in the chemical analysis (pH, TDS, chloride, sulfate and total carbons values) and metals content (Cr, Cd, Ni andPb);(Fe and Zn values) in all governorates in the Nile Delta region. Similar results were obtained by Khan *et al.* (2018) who indicated that the fertilizers used in the agriculture sector, cause contamination of soils and waters. Fertilizers contain vital nutrients required for soil improvement and proper growth of crop plants. Being extremely vital for agriculture, on the other hand fertilizers have a harmful effect to the environment, human, and livestock. The results obtained were consistent with those of Atafar *et al.* (2010) who showed that Cd, Pb and As concentration sin potting soil increased with fertilizer application. Statistical analysis indicated that these heavy metals were significantly increased (P-value<0.05), while lead and arsenic concentrations increased dramatically compared with Cd concentration. This may be related to over-application of fertilizers and pesticides used to control crop pests, herbsandrats. Further similar results were obtained from **Salem *et al.* (2022)** who showed that three sources of heavy metals were determined.

3.2. The effect of fertilization types and soil types on the chemical analysis,heavy metals and nutritional elements content of soil in the Nile Delta region during year 2020.

Data in Figures (7, 8, 9 and 10) indicated the effect of fertilization types and soil types on the chemical analysis, heavy metals and nutritional elements content of soil in the Nile Delta region during year2020. Data showed that the mean value of pH in soil samples was 7.90; the minimum value was 7.52 in the clay soil samples (ClayDa1) collected from Damietta governorate when fertilized with the urea fertilizer (UreaDa1); the maximum was 8.55 in the clay soil samples (Clay2Gh) collected from Gharbia governorate without fertilizer (Without F); the mean value of the total dissolved solids (TDS) was 482.10 ppm; the minimum value was 145.92 ppm in the clay soil samples (ClayDk2) collected from Dakahlia governorate when fertilized with the urea fertilizer (UreaDk); the maximum value was 843.62 ppm in the clay soil samples (Clay1Gh) collected from Gharbia governorate when fertilized with the urea fertilizer (UreaGh2).The mean value of the chloride was 197.34 ppm; the minimum value was 55.38 ppm in the clay soil samples (ClayDk2) collected from Dakahlia governorate when fertilized with the urea fertilizer (UreaDk); the maximum value was 319.58 ppm in the clay soil samples (Clay Me) collected from Monufia governorate when fertilized with the urea fertilizer (Urea Me3).The mean value of the Sulfate was 80.91 ppm; the minimum value was 22.72 ppm in the clay soil samples (Clay Dk2) collected from Dakahlia governorate when fertilized with the urea fertilizer (Urea Dk); the maximum value was 131.00 in the clay soil samples (Clay Me) collected from Monufia governorate when fertilized with the urea fertilizer (Urea Me3).The mean value of the total carbons was 104.41 ppm; the minimum value was 29.18 in the clay soil samples (Clay Dk2) collected from Dakahlia governorate when fertilized with the urea fertilizer (Urea Dk); the maximum value was 169.74 ppm in the clay soil samples (Clay Me) collected from Monufia governorate when fertilized with the urea fertilizer (Urea Me3). The mean value of the Chromium (Cr) was 0.100 ppm; the minimum value was 0.023 ppm in the silt soil samples (SiltMe1) collected from Monufia governorate when fertilized with the urea fertilizer (Urea Me1); the maximum value was 0.351 ppm in the clay soil samples (ClayDk2) collected from Dakahlia governorate when fertilized with the urea fertilizer (UreaDk). The mean value of the Cadmium (Cd) was 0.093 ppm; the minimum value was 0.002 ppm in the silt soil samples (SiltMe1) collected from Monufia governorate when fertilized with the urea fertilizer (UreaMe1); the maximum value was 0.335 ppm in the clay soil samples (Clay Dk2) collected from Dakahlia governorate when fertilized with the urea fertilizer (Urea Dk).The mean value of the Nickel (Ni) was 0.119 ppm; the minimum value was 0.054 ppm in the clay soil samples (Clay2 Gh) collected from Gharbia governorate without fertilizer (Without F); the maximum value was 0.391 ppm in the clay soil

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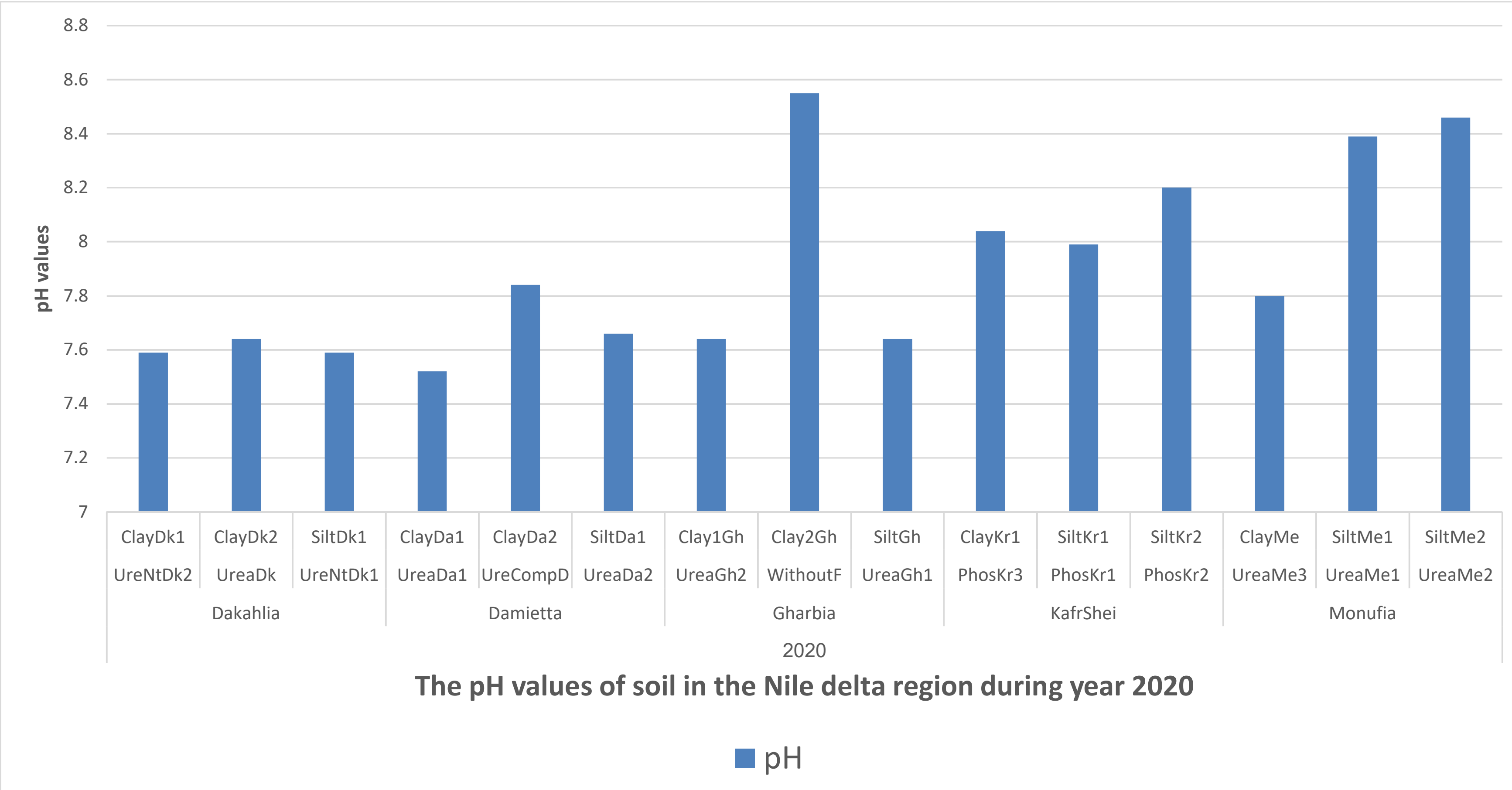

Fig. 7: The relation between types of soil and fertilizer in the Nile Delta region during year 2020 and pH values of soil.

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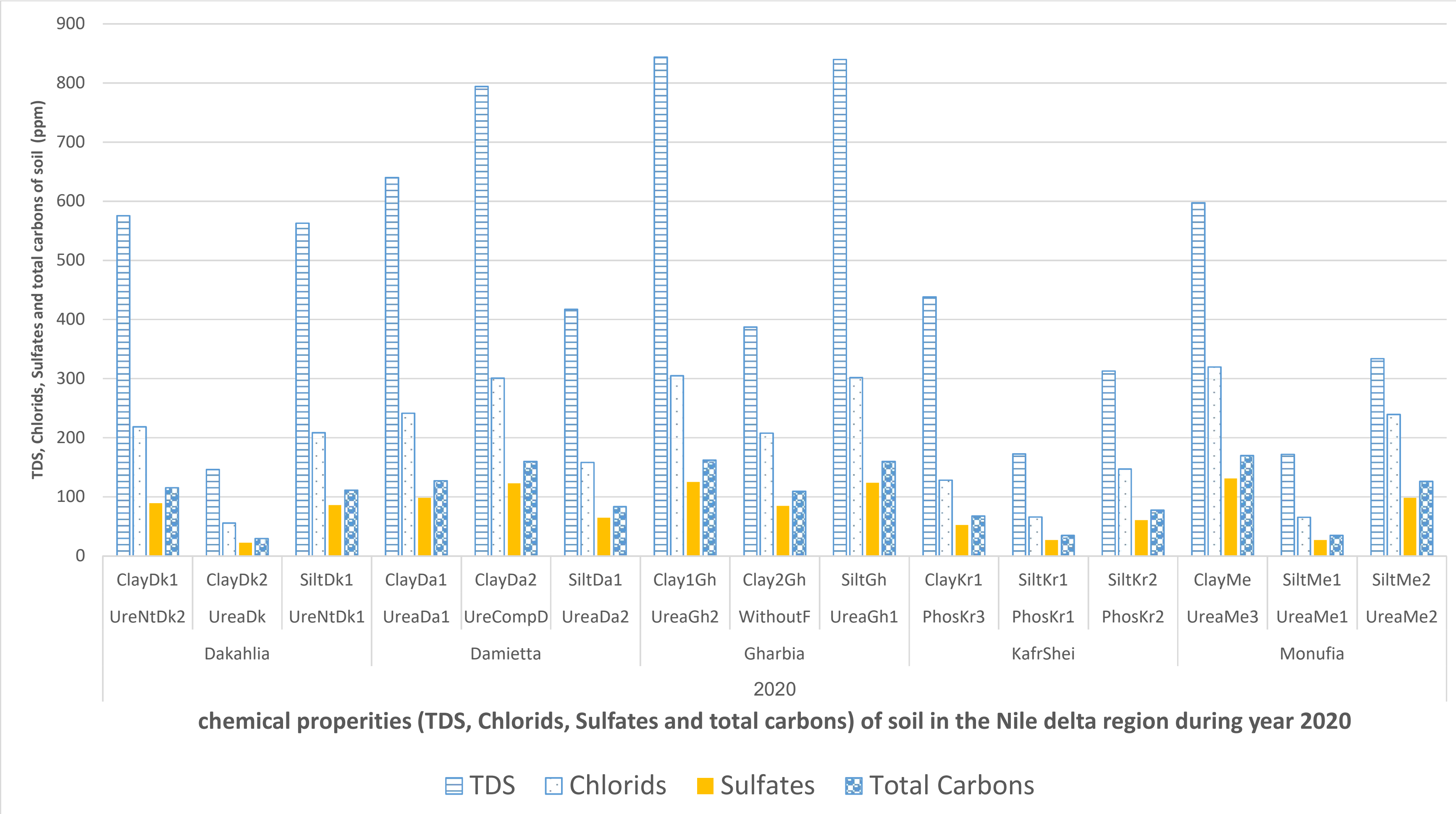

Fig. 8: The relation between types of soil and fertilizer in the Nile Delta region during year 2020 and concentration of TDS, Chloride, Sulfate and Total Carbons (ppm) of soil.

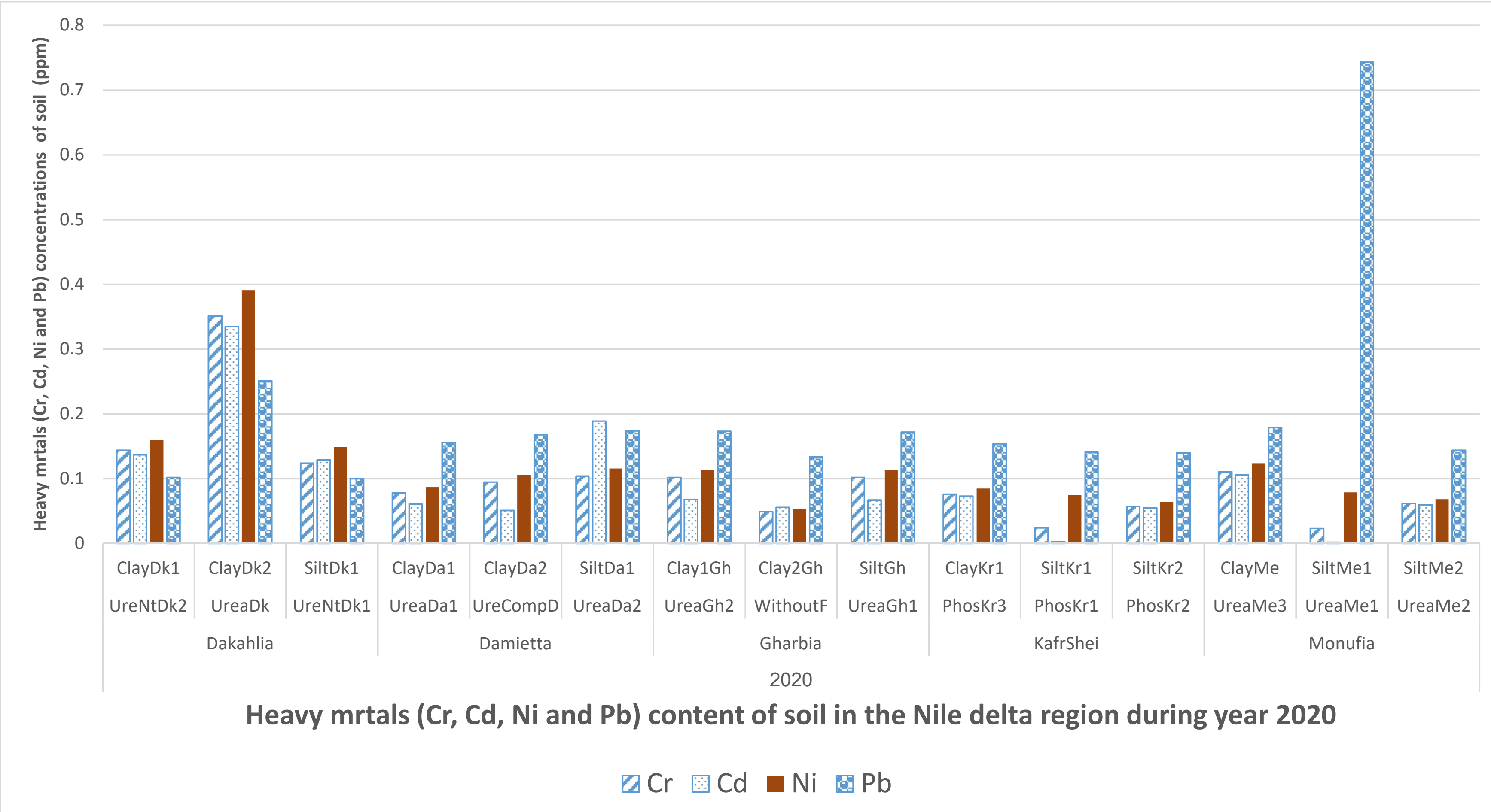

Fig. 9: The relation between types of soil and fertilizer in the Nile Delta region during year 2020 and concentration of heavy metals content (Cr, Cd, Ni and Pb) (ppm) of soil.

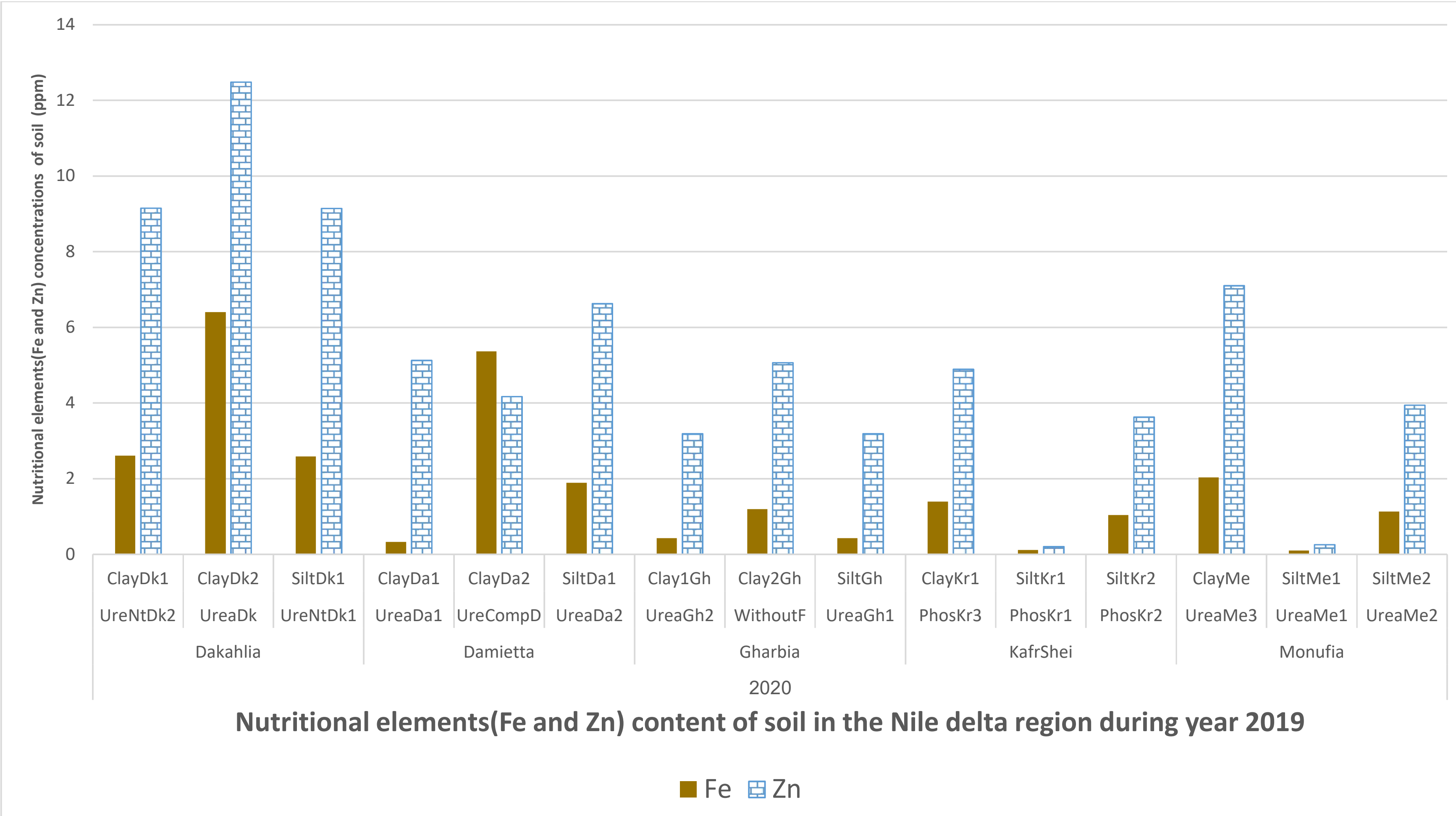

Fig. 10: The relation between types of soil and fertilizer in the Nile Delta region during year 2020 and concentration of nutritional elements content (Fe and Zn)) (ppm) of soil.

samples (ClayDk2) collected from Dakahlia governorate when fertilized with the urea fertilizer (Urea Dk).

The mean value of the Lead (Pb) value was 0.195 ppm; the minimum value was 0.100 ppm in the silt soil samples (SiltDk1) collected from Dakahlia governorate when fertilized with the urea and nitrate fertilizer (UreNtDk1); the maximum value was 0.743 ppm in the silt soil samples (SiltMe1) collected from Monufia governorate when fertilized with the urea fertilizer (UreaMe1).The mean value of the Iron (Fe) was 1.803 ppm; the minimum value was 0.102 ppm in the silt soil samples (SiltMe1) collected from Monufia governorate when fertilized with the urea fertilizer (UreaMe1); the maximum value was 6.402 ppm in the clay soil samples (ClayDk2) collected from Dakahlia governorate when fertilized with the urea fertilizer (UreaDk). The mean value of the Zinc (Zn) was 5.210 ppm; the minimum value was 0.202 ppm in the silt soil samples (SiltKr1) collected from Kafr al-Sheikh governorate when fertilized with the phosphate fertilizer (PhosKr1); the maximum value was 12.481 ppm in the clay soil samples (ClayDk2) collected from Dakahlia governorate when fertilized with the urea fertilizer (UreaDk), and indicted that there were significant differences at ($p\leq0.05$) in the chemical analysis (pH, TDS, chloride, sulfate and total carbons values) and metals content (Cr, Cd, Ni, Pb, Fe and Zn values) in all governorates in the Nile Delta region. Addition of excessive fertilizers that contain high concentrations of metals in soil can significantly increase crop yields, but also impair soil nutrient balance and cause pollution as recorded by Cai *et al.*(2019) and Kumar *et al.* (2019). The results obtained are consistent with those of Nyika *et al.,* (2022) and Naz *et al.* (2022) who reported rapid changes in metal concentrations in agricultural land and its products. On the other hand, indiscriminate and prolonged use offertilizers is major cause of soil and water pollution as reported by Hudak, (2000); Hanson, (2002); Almasri and Kaluarachchi, (2004).

3.3. The effect of fertilization types and soil types on the heavy metals and nutritional elements content of wheat types in the Nile Delta region and its governorates during years 2019.

The data in Table 2. show the effect of fertilization types and soil types on the heavy metals and nutritional elements content of wheat types in the Nile Delta region and its governorates during years 2019. The data showed an average value of chromium (Cr) of 2.366 ppm; the minimum value was 0.027 ppm in wheat samples Gemmiza 9 (Gem9Ka1) collected from Kafr al-shiekh governorate when cultivated in the clay soil (ClayKr3) and fertilized by the urea and nitrate fertilizer (UreNitkr); the maximum value was 6.970 ppm in wheat samples Gemmiza 11 (Gemm11K) collected from Kafr al-shiekh governorate when cultivated in the clay soil (Claykr1) and fertilized by the urea fertilizer (UreKr1). The mean value of the Cadmium (Cd) was 0.691 ppm; the minimum value was 0.000 ppm in wheat samples Giza 168 (Giza168) collected from Dakahlia governorate when cultivated in the clay soil (ClayDk3) and fertilized by the urea and nitrate fertilizer (UreNitDk); the maximum value was 4.651 ppm in wheat samples Gemmiza11 (Giz11GH2) collected from Gharbia governorate when cultivated in the clay soil (ClayGh2) and fertilized by the yrea fertilizer (UreGh2).

The mean value of the Nickel (Ni) was 2.415 ppm; the minimum value was 0.004 ppm in wheat samples Giza 168 (Giza168) collected from Dakahlia governorate when cultivated in the clay soil (ClayDk3) and fertilized by the urea and nitrate fertilizer (UreNitDk); the maximum value was 6.796 ppm in wheat samples Giza 175 (Giza175) collected from Damietta governorate when cultivated in the clay soil (ClayDm1) and fertilized by the nitrate fertilizer (NitraDa1).The mean value of the Lead (Pb) was 0.819 ppm; the minimum value was 0.006 ppm in wheat samples Giza 175 (Giza175) collected from Damietta governorate when cultivated in the clay soil (ClayDm1) and fertilized by the nitrate fertilizer (NitraDa1); the maximum value was 2.417 ppm in wheat samples Gemmiza 11 (Gemm11K) collected from Kafr Al-Shiekh governorate when cultivated in the clay soil (Claykr1) and fertilized by the urea fertilizer (UreKr1).The mean value of the Iron (Fe) was 19.735 ppm; the minimum value was 0.093 ppm in wheat samples Gemmiza 9 (Gemm9M1) collected from Menoufia governorate when cultivated in the clay soil (ClayMe1) and fertilized by the urea fertilizer (UreMe1); the maximum value was 68.309 ppm in wheat samples Giza175 (Giza175) collected from Damietta governorate when cultivated in the clay soil (ClayDm1) and fertilized by the nitrate fertilizer (NitraDa1).The mean value of the Zinc (Zn) was 4.335 ppm; the minimum value was 0.103 ppm in wheat samples Giza168 (Giza168) collected from Dakahlia governorate when cultivated in the clay soil (ClayDk3) and fertilized by the urea and nitrate fertilizer (UreNitDk); the maximum value was 16.831 ppm in wheat samples Giza175 (Giza175) collected from Damietta governorate when cultivated in the clay soil (ClayDm1)

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and fertilized by the nitrate fertilizer (NitraDa1), and indicted that there were significant differences at ($p \leq 0.05$) in the metals content (Cr, Cd, Ni, Pb, Fe and Zn values) in all governorates in the Nile Delta region.

Table 2: Effect of the geographical location, fertilization types and types of soil on the metals content of wheat types in Nile Delta region and its governorates during year 2019.

Years	Region	Govern.	Types of fertilizer	Type of soil	Type of wheat	Metals content (mg/kg)				Nutritional elements (mg/kg)	
						Cr	Cd	Ni	Pb	Fe	Zn
2019	Nile Delta	Dakahlia	NitDk1	SiltDK2	Gem9DK1	0.959^{ghij}	0.140^{g}	2.695^{f}	1.025^{e}	7.262^{g}	2.985^{gh}
			UreaDk1	ClayDK2	Gem9DK2	1.009^{ghij}	0.023^{h}	3.402^{b}	0.216^{k}	8.128^{fg}	3.073^{gh}
			UreNitDk	ClayDk3	Giza168	0.040^{j}	0.000^{h}	0.004^{h}	0.121^{i}	0.844^{h}	0.103^{j}
		Damietta	NitrDa2	ClayDm4	Gem9Da1	1.208^{gh}	1.522^{b}	2.893^{de}	0.828^{f}	29.272^{b}	11.406^{b}
			NitraDa2	SiltDm1	Gemm11D	2.757^{de}	0.616^{c}	3.322^{bc}	0.720^{g}	26.371^{c}	4.862^{c}
			NitraDa1	ClayDm1	Giza175	3.485^{d}	0.470^{d}	6.796^{a}	0.006^{m}	68.309^{a}	16.831^{a}
		Gharbia	UreGh1	ClayGh1	Giz11GH1	5.875^{c}	0.243^{e}	3.195^{c}	0.498^{i}	13.444^{e}	3.474^{f}
			UreGh2	ClayGh2	Giz11GH2	5.493^{b}	4.651^{a}	2.793^{ef}	2.094^{b}	9.412^{fg}	2.942^{h}
			UreaGh3	SiltGh1	Giz11GH3	1.335^{fg}	0.558^{c}	3.004^{d}	0.461^{i}	19.104^{d}	4.398^{de}
		KafrShei	UreNitkr	ClayKr3	Gem9Ka1	0.027^{j}	0.001^{h}	0.012^{h}	0.115^{i}	0.893^{h}	0.109^{j}
			UreKr1	Claykr1	Gemm11K	6.970^{a}	0.551^{c}	2.969^{d}	2.417^{a}	67.914^{a}	4.345^{de}
			UreKr2	ClayKr2	Giza11K	2.201^{ef}	0.210^{ef}	3.179^{c}	0.574^{h}	12.806^{e}	4.062^{e}
		Monufia	NitMe1	SiltMe1	Gemm11Me	1.052^{ghi}	0.154^{fg}	2.956^{d}	1.125^{d}	7.967^{g}	3.275^{fg}
			UreMe1	ClayMe1	Gemm9M1	0.072^{ij}	0.002^{h}	0.008^{h}	0.278^{j}	0.093^{h}	0.125^{j}
			UreaMe2	ClayMe2	Gemm9M2	0.239^{hij}	0.002^{h}	0.267^{g}	1.412^{c}	0.121^{h}	0.418^{i}
		LSD	--------	--------	--------	0.887	0.062	0.146	0.051	1.347	0.289

Similar results were obtained by Maji and Mistri, (2022) showing that chemical fertilizer-based fields were the major pathway for heavy metals (PLI=1.96) and the reference limit (PLI=1.96) and reference limit analyzed that DAP, superphosphate, and zinc sulfate were the largest potential sources of the major contaminant metals (Cd, Pb, and Zn), according to the National Agricultural Sciences. Academy (NAAS) by India. Excessive and continuous use of fertilizers accumulates these contaminants in the soil to environmentally unfriendly levels as recognized by Atafar *et al.* (2010); Alengebawy *et al.* (2021). Elements produce several other toxic effects compared to individual pollutants Haiyan and Stuanes, (2003).

3.4. The effect of fertilization and soil types on the heavy metals and nutritional elements content of wheat types in the Nile Delta region and its governorates during years 2020.

The data in Table 3. relate to the effect of fertilization types and soil types on the heavy metals and nutritional elements content of wheat types in the Nile Delta region and its governorates during years2020.Thedatashowedanaveragevalueofchromium(Cr) was 0.541ppm; the minimum value was 0.005 ppm in wheat samples Seds 14 (Sids14Dk) collected from Dakahlia governorate when cultivated in the clay soil (ClayDk1) and fertilized by the urea and nitrate fertilizer (UreNtDk2); the maximum value was2.339 ppm in wheat samples Gemmiza 11 (Gem11Dk2) collected from Dakahlia governorate when cultivated in the clay soil (ClayDk2) and fertilized by the urea fertilizer (UreaDk). The mean value of the Cadmium (Cd) was 0.002 ppm; the minimum value was 0.000 ppm in wheat samples Misr 1 (Misr1Da) collected from Damietta governorate when cultivated in the clay soil (ClayDa2) and fertilized by the urea and compost fertilizer (UreCompD); the maximum value was 0.005 ppm in wheat samples Gemmiza 11 (Gem11Dk2) collected from Dakahlia governorate when cultivated in the clay soil (ClayDk2) and fertilized by the urea fertilizer (UreaDk).

Table 3. Effect of the geographical location, fertilization types and types of soil on the metals content of wheat types in Nile Delta region and its governorates during year 2020.

Years	Region	Govern.	Types of Fertilizer	Type of soil	Types of wheat	Metals content (mg/kg)				Nutritional elements (mg/kg)	
						Cr	**Cd**	**Ni**	**Pb**	**Fe**	**Zn**
2020	**Nile Delta**	**Dakahlia**	**UreNtDk1**	**SiltDk1**	**Gem11Dk1**	0.223^{d}	0.002^{d}	0.263^{c}	0.476^{k}	).119^{ghi}	0.322^{de}
			UreaDk	**ClayDk2**	**Gem11Dk2**	2.339^{a}	0.005^{a}	2.045^{a}	1.608^{b}	1.359^{a}	0.353^{c}
			UreNtDk2	**ClayDk1**	**Sids14Dk**	0.005^{d}	0.001^{e}	0.003^{c}	0.154^{m}	0.024^{j}	0.093^{k}
		Damietta	**UreaDa1**	**ClayDa1**	**Gem11Da**	0.669^{c}	0.003^{c}	0.043^{c}	0.227^{i}	0.222^{c}	0.233^{h}
			UreaDa2	**SiltDa1**	**Gem12Da1**	0.217^{d}	0.003^{c}	0.228^{c}	2.349^{a}	0.198^{d}	0.532^{a}
			UreCompD	**ClayDa2**	**Misr1Da**	0.007^{d}	0.000^{f}	0.002^{c}	0.103^{m}	0.035^{j}	0.107^{k}
		Gharbia	**UreaGh2**	**Clay1Gh**	**Gem11Gh1**	0.207^{d}	0.002^{d}	0.214^{c}	1.466^{d}	0.144^{f}	0.404^{b}
			WithoutF	**Clay2Gh**	**Gem11Gh2**	0.199^{d}	0.001^{e}	0.216^{c}	0.622^{i}	0.136^{fg}	0.313^{e}
			UreaGh1	**SiltGh**	**Giza171G**	0.170^{d}	0.001^{e}	0.014^{c}	1.262^{e}	0.107^{i}	0.122^{j}
		KafrShei	**PhosKr3**	**ClayKr1**	**Gem11Kr1**	0.217^{d}	0.002^{d}	0.267^{c}	0.894^{f}	).120^{ghi}	0.330^{d}
			PhosKr1	**SiltKr1**	**Misr2Kr1**	0.614^{c}	0.003^{c}	0.041^{c}	1.540^{c}	0.179^{e}	0.257^{fg}
			PhosKr2	**SiltKr2**	**Misr2Kr2**	1.451^{b}	0.004^{b}	0.070^{c}	0.812^{g}	0.242^{b}	0.200^{i}
		Monufia	**UreaMe1**	**SiltMe1**	**Gem11Me 1**	1.294^{b}	0.001^{e}	1.670^{b}	0.686^{h}	).130^{fgh}	0.268^{f}
			UreaMe2	**SiltMe2**	**Gem9Me1**	0.281^{d}	0.001^{e}	0.017^{c}	1.268^{e}	0.113^{hi}	0.105^{k}
			UreaMe3	**ClayMe**	**Gem9Me2**	0.222^{d}	0.002^{d}	0.268^{c}	0.539^{j}	0.112^{hi}	0.244^{gh}
		LSD	---------	---------	---------	**0.291**	**0.000**	**0.398**	**0.054**	**0.018**	**0.014**

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

The mean value of the Nickel (Ni) was 0.357 ppm; the minimum value was 0.002 ppm in wheat samples Misr 1 (Misr1Da) collected from Damietta governorate when cultivated in the clay soil (ClayDa2) and fertilized by the urea and compost fertilizer (UreCompD); the maximum value was 2.045 ppm in wheat samples Gemmiza 11 (Gem11Dk2) collected from Dakahlia governorate when cultivated in the clay soil (ClayDk2) and fertilized by the urea fertilizer (UreaDk). The mean value of the Lead (Pb) was 0.934 ppm; the minimum value was 0.103 ppm in wheat samples Misr 1 (Misr1Da) collected from Damietta governorate when cultivated in the clay soil (ClayDa2) and fertilized by the urea and compost fertilizer (UreCompD); the maximum value was 2.349 ppm in wheat samples Gemmiza 12 (Gem12Da1) collected from Damietta governorate when cultivated in the silt soil (SiltDa1) and fertilized by the urea fertilizer (UreaDa2). The mean value of the Iron (Fe) was 0.216 ppm; the minimum value was 0.024 ppm in wheat samples Seds 14 (Sids14Dk) collected from Dakahlia governorate when cultivated in the clay soil (ClayDk1) and fertilized by the urea and nitrate fertilizer (UreNtDk2); the maximum value was 1.359 ppm in wheat samples Gemmiza 11 (Gem11Dk2) collected from Dakahlia governorate when cultivated in the clay soil (ClayDk2) and fertilized by the urea fertilizer (UreaDk). The mean value of the Zinc (Zn) was 0.259 ppm; the minimum value was 0.093 ppm in wheat samples Seds 14 (Sids14Dk) collected from Dakahlia governorate when cultivated in the clay soil (ClayDk1) and fertilized by the urea and nitrate fertilizer (UreNtDk2); the maximum value was 0.532 ppm in wheat samples Gemmiza12 (Gem12Da1) collected from Damietta governorate when cultivated in the silt soil (SiltDa1) and fertilized by the urea fertilizer (UreaDa2), and indicted that there were significant differences at ($p \leq 0.05$) in the metals content (Cr, Cd, Ni, Pb, Fe and Zn values) in all governorates in the Nile Delta region. The results obtained were agreed with those found by Tadesse, (2006); Al-Gahri and Almussali, (2008), Dai *et al.* (2018); Yang *et al.* (2018); Alexander and Akoto, (2018) who noted that the development of metal resources, especially heavy metals, in arablesoils is currently the most important research project pointed out to be one of the similar results were reported by Yang *et al.* (2018) mentioned that the very high iron content of flour produced in Turkey and confirmed the health benefits of using this flour due to its fortification Zinc, etc. the content of other nutritionally important elements is also has a positive effect on human health.

3.5. Chemical analysis, heavy metals and nutritional elements content of wheat samples irrigation water in the Nile Delta region and its governorates during year 2019.

The data in Table 4. show the chemical analysis, heavy metals and nutritional elements content of wheat samples irrigation water in the Nile Delta region and its governorates during year 2019. The data showed that the average pH of wheat samples irrigation water was 7.23. The lowest value was 6.60 for the Nile river irrigation water in Menofia governorate (NileMe1); the peak value was 7.76 in a sample collected by Gharbia governorate in irrigated Nile water (NileGh1). The average of total dissolved solids (TDS) of the irrigation water was398.26 ppm; the lowest level was 233.26 ppm in samples collected from Dakahlia governorate of the Nile and human sewage irrigation water (NilHuDk1); the peak value for the Nile River and human sewage irrigation water (NiHuDm1) in Damietta governorate was 813.86 ppm. The average chloride value was 93.05 ppm; the lowest level in Nile irrigated water (NileGh2) taken by Gharbia governorate was 68.50ppm; a peak value of 156.82 ppm was observed in the Nile River irrigation water (NileGh1) in Gharbia governorate. The average sulfate was 62.28 ppm; the lowest level was 42.70 ppm in the Nile irrigation water (NileKr2) in Kafr Al- Sheikh Governorate; the maximum value was121.08 ppm in the Nile irrigated water (NileGh1) from Gharbia governorate. Average total carbon was 142.87ppm; the lowest value was 115.19 ppm in the Nile and articulated irrigation water samples (NilArtKr) collected from Kafr Al Sheikh governorate, the peak value was 227.30 ppm in the Nile river irrigation water (NileGh1) in Gharbia governorate. Chromium (Cr) had an average value of 0.033 ppm; the lowest value was0.007 ppm for the Nile and artesin irrigation water (NilArtKr) from Kafr Al-Sheikh province; the maximum value was 0.079 ppm in a sample of artesinirrigation water (ArtesDa1) collected from Damietta province. Cadmium (Cd) averaged 0.002 ppm; the lowest value was 0.000ppm in the Nile and self-flowing irrigation water (NilArtKr) collected from Kafr al-Sheikh governorate; the maximum level was 0.006 ppm in the Nile river irrigation water (NileGh1) fromGharbiaprovince. Average nickel (Ni) was 0.013 ppm; the lowest value was 0.000ppm in the Nile and artesein irrigation water (NilArtKr) collected from Kafr al-Sheikh governorate; the maximum value was 0.034 ppm in the Nile irrigation water (NileGh1) in Gharbia province. The average value for lead (Pb) was 0.016 ppm; the lowest value was 0.006 ppm in the Nile and self-pressurized irrigation (NilArtKr) samples collected from Kafr al-Sheikh governorate; the maximum value was 0.043 ppm in Nile irrigation water (NileGh1) in Gharbia province. The average value for iron (Fe) was 0.222 ppm; the lowest value was 0.139 ppm in the Nile and and self-flowing irrigation water (NilArtKr)for samples collected in Kafr Sheikh; the maximum value was 0.358 ppm in the Nile and human sewage irrigation water (NilHuDm1) in Damietta province. The average value for zinc (Zn) was 1.178 ppm; the minimum value was 0.189 ppm in the in Nile irrigation water (NileMe1) samples collected by Monufia governorate; the maximum value was 2.358 ppm in a sample taken in the Nile irrigation water (NileGh1) in Gahrbia governorate, with chemical analyzes (pH, TDS, chlorides, sulfates) and total carbon content and metal content (values of Cr, Cd, Ni, Pb, Fe, and Zn). The results obtained are consistent with those of Abdelrazek, (2019), who found that heavy metals, pH, and salinity in all canals, some drains and canals in northern Egypt were polluted and reached critical levels. Limits were exceeded and are used for irrigation as recorded by Jatav *et al.,* (2022) who stated that the application of sewage and treated wastewater from municipal sewage treatment plants to cultivated land can change soil physical and nutrational properties. Wastewater irrigation supports phosphorus and nitrogen and provides organic matter to the soil. However, accumulation of toxic elements (Mn, Cu, Pb, and Cd) and nutritional elements (Fe and Zn) is a concern, which feed crops and contain high levels of macro- and micronutrients.

Chemical analysis, heavy metals and nutritional elements content of wheat samples irrigation water in the Nile Delta region and its governorates during year 2020.Data in table 5. indicated the chemical analysis, heavy metals and nutritional elements content of wheat samples irrigation water in the Nile Delta region and its governorates during year 2020. Data showed that the mean value of pH of irrigation water was 7.23; the minimum value was 6.10 in the samples collected from Damietta governorate in the Nile and artesian irrigated water (Art RanDa); the maximum value was 7.52in the Nile irrigated water (NileKr) in the samples collected from Kafr Al-sheikh governorate. The mean value of the total dissolved solids (TDS) was 433.12 ppm; the minimum value was 182.68 ppm in the Nile and rain irrigation water (Ni RanMe2) in the samples collected from Monufia governorate; the maximum value was 960.48 ppm in the Nile irrigation water (NileKr2) in the samples collected from Kafr Al-sheikh governorate.

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Table 4: Chemical analysis and metals content of irrigated water in Nile Delta region and its governorates during year 2019.

Years	Region	Governorate	Irrigated water	Chemical analysis (ppm)					Metals content (mg/kg)				Nutritional elements (mg/kg)	
				pH	TDS	Chlorids	Sulfate	Total Carbons	Cr	Cd	Ni	Pb	Fe	Zn
2019	Nile Delta	Dakahlia	NilArtDk	7.40ab	312.66g	77.42f	61.52def	119.10g	0.008i	0.001f	0.001k	0.006i	0.141j	1.131g
			NilHuDk1	7.31b	233.26i	74.46f	63.52de	122.10fg	0.016g	0.003c	0.017f	0.009j	0.244f	1.143g
			NileDk1	7.34b	260.02h	92.32d	43.68hi	129.02ef	0.053c	0.001e	0.004i	0.021d	0.165i	0.209j
		Damietta	ArtsDa1	7.20bc	604.44d	90.34de	60.56ef	155.84c	0.079b	0.003c	0.019e	0.024c	0.278d	1.299f
			NilHuDm1	7.25b	813.86b	122.10b	81.38b	209.44b	0.026e	0.004b	0.025c	0.013h	0.358a	1.676d
			NileDm1	7.39ab	243.20hi	86.36e	64.54d	131.00e	0.019f	0.002d	0.013g	0.007k	0.190h	0.886h
		Gharbia	NileGh1	7.76a	730.38a	156.82a	121.08a	227.30a	0.046d	0.006a	0.034a	0.043a	0.307c	2.358a
			NileGh2	7.20bc	238.20hi	68.50g	64.54d	124.10efg	0.011h	0.004b	0.028b	0.015f	0.209g	1.904c
			NileGh3	7.45ab	258.06hi	77.42f	70.50c	123.08efg	0.016g	0.003c	0.017f	0.009j	0.244f	1.143g
		Kafr El-Sheikh	NilArtKr	7.36ab	308.69g	75.48f	60.56def	115.19g	0.007i	0.000f	0.000k	0.006i	0.139j	1.129g
			NileKr1	6.67d	256.08hi	91.30de	46.66gh	123.08efg	0.048d	0.001e	0.004i	0.019e	0.150j	0.190j
			NileKr2	6.85cd	349.36f	98.28c	42.70i	129.02ef	0.047d	0.002d	0.011h	0.014g	0.163i	0.760i
		Monufia	ArtesMe1	7.45bc	468.46e	101.22c	48.64g	143.94d	0.066a	0.004b	0.022d	0.028b	0.332b	1.554e
			NilRanMe	7.20bc	645.12c	93.30d	59.56f	148.88cd	0.013h	0.002d	0.003j	0.011i	0.262e	2.101b
			NileMe1	6.60d	252.18hi	90.38de	44.79gh	121.19efg	0.045d	0.001e	0.004i	0.017e	0.148j	0.189j
		LSD	--------	0.35	22.97	4.59	3.14	6.98	0.002	0.000	0.001	0.001	0.011	0.065

The mean value of the chloride was 63.72 ppm; the minimum value was 22.87 ppm in the Nile and rain irrigation water (NiRanMe2) in the samples collected from Monufia governorate; the maximum value was 123.08 ppm in the Nile irrigation water (NileKr2) in the samples collected from Kafr Al-Sheikh governorate. The mean value of the Sulfate was 37.72 ppm; the minimum value was 8.76 ppm in the Nile and rain irrigation water (Ni RanMe2) in the samples collected from Monufia governorate; the maximum value was 78.42 ppm in the artesian and rain irrigation water (Art RanDa) in the samples collected from Damietta governorate. The mean value of the total carbon was 81.01 ppm; the minimum value was 14.96 ppm in the Nile and rain irrigation water (Ni RanMe2) in the samples collected from Monufia governorate; the maximum value was 161.80 ppm in the artesian and rain irrigated water (Art RanDa) in the samples collected from Damietta governorate. The mean value of the Chromium (Cr) was 0.006 ppm; the minimum value was 0.001 ppm in the Nile and rain irrigation water (NiRanMe2) in the samples collected from Monufia governorate; the maximum value was 0.020 ppm in the artesian and rain irrigation water (Art RanDa) in the samples collected from Damietta governorate. The mean value of the Cadmium (Cd) was 0.005 ppm; the minimum value was 0.001 ppm in the Nile and rain irrigation water (Ni RanMe2) in the samples collected from Monufia governorate; the maximum value of was 0.030 ppm in the Nile irrigation water (NileDa1) in the samples collected from Damietta governorate. The mean value of the Nickel (Ni) was 0.006 ppm; the minimum value was 0.002 ppm in the Nile and rain irrigation water (Ni RanMe2) in the samples collected from Monufia governorate. the maximum value was 0.018 ppm in the Nile irrigation water (Nile Da1) in the samples collected from Damietta governorate. The mean value of the Lead (Pb) was 0.006 ppm; the minimum value was 0.001 ppm in the Nile and rain irrigation water (Ni RanMe2) in the samples collected from Monufia governorate; the maximum value was 0.017 ppm in the artesian and rain irrigation water (Art RanDa) in the samples collected from Damietta governorate. The mean value of the Iron (Fe) was 0.516 ppm; the minimum value was 0.129 ppm in the artesian and rain irrigation water (ArtRnGh3) in the samples collected from Gharbia governorate; the maximum value was 2.321 ppm in the Nile irrigation water (NileKr2) in the samples collected from Kafr-AlSheikh governorate. The mean value of the Zinc (Zn) was 1.011 ppm; the minimum value was 0.249 ppm in the Nile irrigated water (NileMe1) in the samples collected from Monufia governorate; the maximum value was 3.250 ppm.

Table 5: Chemical analysis and metals content of irrigated water in Nile Delta region and its governorates during year 2020.

Years	Region	Governorate	Irrigated water	Chemical analysis (ppm)					Metals content (mg/kg)				Nutritional elements (mg/kg)	
				pH	TDS	Chlorid	Sulfate	Total Carbons	Cr	Cd	Ni	Pb	Fe	Zn
2020	Nile Delta	Dakahlia	NilArtDk	7.40^{abcd}	312.66^{e}	77.42^{d}	61.52^{b}	119.10^{c}	0.007^{d}	0.003^{c}	0.004^{d}	0.006^{d}	0.141^{i}	1.131^{c}
			NileDk1	7.41^{abc}	184.60^{g}	23.82^{h}	8.94^{f}	15.88^{i}	0.001^{h}	0.004^{c}	0.003^{d}	0.004^{h}	0.323^{g}	0.304^{i}
			NlArtDk1	7.40^{abcd}	310.69^{e}	75.48^{d}	60.57^{b}	117.19^{c}	0.007^{d}	0.004^{c}	0.003^{d}	0.006^{d}	0.140^{i}	1.131^{c}
		Damietta	ArtRanDa	6.10^{de}	918.10^{b}	91.30^{c}	78.42^{a}	161.80^{a}	0.020^{a}	0.003^{a}	0.008^{a}	0.017^{a}	0.405^{e}	3.250^{a}
			NileDa1	7.23^{abcde}	341.42^{e}	61.52^{e}	38.72^{c}	98.28^{e}	0.007^{d}	0.030^{a}	0.018^{a}	0.006^{d}	0.131^{i}	1.052^{d}
			NileDa2	7.62^{a}	779.14^{c}	100.26^{b}	37.72^{c}	68.50^{f}	0.003^{f}	0.005^{c}	0.008^{c}	0.004^{e}	0.925^{c}	0.597^{g}
		Gharbia	ArtRnGh1	7.23^{abcde}	338.48^{e}	60.56^{e}	36.79^{c}	96.26^{e}	0.006^{d}	0.005^{a}	0.009^{a}	0.005^{d}	0.130^{i}	1.051^{d}
			ArtRnGh2	7.23^{abcde}	334.45^{e}	58.57^{e}	36.77^{c}	95.39^{e}	0.006^{d}	0.002^{a}	0.009^{a}	0.005^{d}	0.129^{i}	1.049^{d}
			ArtRnGh3	7.23^{abcde}	330.42^{e}	55.52^{e}	34.78^{c}	93.29^{e}	0.006^{d}	0.002^{a}	0.009^{a}	0.005^{d}	0.129^{i}	1.048^{d}
		Kafr El-Sheikh	NileKr1	6.93^{e}	327.52^{e}	42.70^{f}	15.88^{d}	28.80^{g}	0.002^{g}	0.004^{c}	0.009^{c}	0.003^{f}	0.576^{d}	0.683^{f}
			NileKr2	7.52^{ab}	960.48^{a}	123.08^{a}	61.52^{b}	110.20^{d}	0.008^{c}	0.003^{c}	0.003^{a}	0.010^{c}	2.321^{a}	0.753^{e}
			NileKr3	7.47^{abc}	272.96^{f}	35.72^{g}	12.92^{e}	23.82^{h}	0.005^{e}	0.002^{c}	0.004^{b}	0.006^{d}	1.449^{b}	0.469^{h}
		Monufia	NiRanMe1	7.20^{bcde}	645.12^{d}	93.30^{c}	59.56^{b}	148.88^{b}	0.013^{b}	0.002^{b}	0.003^{a}	0.011^{b}	0.262^{h}	2.101^{b}
			NiRanMe2	7.41^{abc}	182.68^{g}	22.87^{h}	8.76^{f}	14.96^{i}	0.001^{h}	0.001^{c}	0.002^{d}	0.001^{h}	0.319^{g}	0.303^{i}
			NileMe1	7.08^{cde}	258.06^{f}	33.74^{g}	12.92^{e}	22.84^{h}	0.002^{g}	0.002^{c}	0.003^{c}	0.002^{g}	0.363^{f}	0.249^{i}
		LSD	---------	0.35	26.10	3.39	2.13	4.55	0.000	0.000	0.000	0.000	0.038	0.061

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

The artesian and rain irrigation water (Art RanDa) in the samples collected from Damiettagovernorate, and indicted that there were significant differences at ($p \leq 0.05$) in the chemical analysis (PH, TDS, chloride, sulfate and total carbons values) and metals content (Cr, Cd, Ni, Pb, Fe and Zn values) in all governorates in the Nile Delta region. Similar results were obtained by Balkhair and Ashraf, (2016) who indicated that Waste water is a source of toxic metals, while wastewater application to crop lands can improve the physical properties and nutrient content of soils as referred by Jatav *et al.* (2022). In many countries, farmers irrigate crops with industrial wastewater because of the lack of alternative water sources. Treated wastewater from municipal sewage treatment plants can become a water supply for crops, containing high levels of macro- and micro-nutrients and heavy metals as concluded by Patil *et al.* (2014) and Nyika, (2022).

4. Conclusion

The study has revealed that excessive application of chemical fertilizer has significantly affected agricultural soil health. It is important to use the fertilizers, within the recommended doses according to the local, international agricultural standards. Excessive application of chemical fertilizer in the soil acts as a potential risk factor for human health, either the plant nutrients are consumed directly or indirectly via the food chain. The study also revealed that Cd, Pb and Zn came up with moderately contaminated factors and chemical based fields have been identified as the most contaminated site in the study area. On the other hand, using low quality water in agriculture has bad effects on both soil properties and cultivating crop by either increasing their contents of heavy metals which affects severely on the human health or by increasing salinity levels, where increasing water salinity level decreased the production of dry matter. Heavy metal toxicity is one of major current environmental health problems and potentially dangerous due to bioaccumulation. Therefore, heavy metals contamination of soils and plants has become an increasing problem and using of contaminated water for irrigation and overuses of agrochemicals led to accumulation of heavy metals in soils and their uptake by the crops grown over there. The target hazard quotient showed health risk to local population associated with Cd, Cr and Ni contamination in wheat crops. Good agricultural practices and regular monitoring of soil, crop and water quality with prevention of metals entering into agricultural products are a way to decrease the potential health hazards for inhabitants. Based on the obtained results, the following recommendations could be given for the best management of soil quality by further investigations from the national Egyptian authorities:

1. Treatment of wastewater source is important to limit its content of toxic heavy-metal.
2. Carefully management of fertilizers and pesticides usage and educate farmers about the good agricultural practices.
3. Using the applicable method for remediation and cleaning the contaminated soil.
4. Selection of new wheat species with heavy-metals tolerance or heavy metals-free wheat.
5. Monitoring and measuring the contaminated soil periodically in order to control the contaminants.
6. Commitment of the industrial factories for the environmental considerations to reduce their liquid, aerial and solid contaminants to the acceptable limits.

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