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SUMMARY

El-Fayoum is agricultural as well as industrial province contains several industries such as cement, chemicals ceramics and plastics industries. Heavy metal contamination is a major problem of our environment and they are also one of the major contaminating agents of our food supply. Uncontrolled pollution levels particularly in developing countries have drawn more attention to the heavy metal problem.

Poultry could take up heavy metal compounds from different sources; metal residues may concentrate in their meat, and eggs. The presence of heavy metals in chicken meat may result from natural occurrence in the soil, from where they are taken up by the plants that feed the chicken, or due to the use of contaminated fish powder as a source of animal protein feed, or from the remnants of vehicle ex- hausts, which are hit by air to the source of fodder and water to drink used in poultry.

Eggs are one of nature's most nutritious and economical foods in the daily diet. Eggs are included in several food products for various functions**.** Global environmental pollution with trace elements are leading to increase the investigations concerning metal contamination of food-stuffs including eggs, which represent an important part of humans' diet, especially children.

The following study was conducted to determine the heavy metal residues in different poultry farms in El-Fayoum Governorate. Layer tissues, eggs, Drinking water and layer feed samples were collected from six layer farms (A, B and C) at different industrial areas (Kom-Oshim in Tammiyah district, Itsa district and Sinnuris district and (D, E and F) at non industrial areas (Integrated poultry project in El-Azab village, El-Lahoun village and El-Nasereya village at (El-Fayoum district) in El-Fayoum Governorate, Egypt. Samples were collected during a period between 2014 and 2015. And results were compared with the maximum permissible limits.

All samples were examined for estimation of lead, cadmium, copper, zinc, iron and manganese using Atomic Absorption spectrometer model **(UNICAM 969)** with hydride system of Animal Health Research Institute, Dokki, Giza, Egypt.

Our results were revealed that:

1- Lead concentrations (ppm) in different samples:

A-Layer tissues (muscle, kidney, liver and gizzard) samples:

It is evident from the results that (Pb) was the toxic metal which may be constituting a hazardous effect in human through repeated consumption of layer tissues especially for tissues collected from industrial areas farms A and C (Kom-Oshim in Tammiyah district and Sinnuris district) and from non industrial areas farm (F) at El-Nasereya village at (El-Fayoum district).

-Estimated daily intake of lead from layer´s tissue consumption:

The mean concentrations of pb in examined layer tissue samples collected from industrial and non industrial areas which give a daily intake from consumption of 250 gram layer tissue samples that contributed about (60.64, 13.7, 47.8, 57.17, Nd and 40.9), (43.72, 13.3, 98.91, 39.39, 1.2 and 61.2), (34.49, 33.6, 59.4, 3.24, 16.5 and 37.1) and (51.29, 1, 38, 16.24, Nd and 32.6 %) of ADI recommended by **FAO/WHO Codex, (2011)** in farms A, B, C, D, E & F respectively.

-Estimated Health risk of lead from layer´s tissue consumption:

The estimated Target Hazard Quotients (THQ) was less than 1. For lead in examined layer´s tissue samples collected from industrial and non industrial areas farms A, B, C, D, E & F from consumption of 100 gm muscle and 20 gm of each kidney, liver and gizzard samples

-Lead concentrations in hen´s egg

It is evident from the results that (Pb) was the toxic metal which may be constituting a hazardous effect in human through repeated consumption of egg especially for eggs collected from industrial areas farms A, B & C (Kom-Oshim in Tammiyah district, Itsa district and Sinnuris district) and from non- industrial areas farms D & F which present at El-Azab village and El-Nasereya village at (El-Fayoum district). The differences was not statistically significant at ($p>0.05$) in examined egg samples collected from industrial and non industrial regions.

-Estimated daily intake of lead from Hen´s eggs consumption:

The average concentrations of pb in examined hen´s egg samples collected from industrial and non industrial areas which give a daily intake from consumption of 100 gram hen´s egg samples that contributed about (10.8, 1.6, 19.88, 8.958, 0.4 and 12.68 %) of ADI recommended by **(FAO/WHO), (2011)** in farms A, B, C, D, E & F respectively.

-Estimated Health risk of lead from Hen´s egg consumption:

The estimated Target Hazard Quotients (THQ) were less than 1 for lead in examined Hen´s egg samples collected from industrial and non industrial areas from consumption of 37.2 gm of egg samples respectively.

-Lead concentrations in drinking water of layer farms:

lead levels detected in the water samples were in mean of 0.099± 0.027, 0.0014±0.00054, 0.0724±0.027, 0.072±0.021, 0.0006±0.00028 and 0.015 ±0.0028 ppm in farm A, B, C, D, E and F respectively.

The recorded limits of lead were exceeding permissible limit recorded by **(WHO)** and **(E.O.S.Q.C.),** in water samples of all farms except for farms (B and E) were within permissible limits.

B. Lead concentrations in layer feed:

- lead levels detected in the layer feed samples were in average of 3.38±0.1843, 0.318±0.0174, 2.79±0.132, 2.833±0.131, 0.203±0.036 and 2.776±0.06 ppm in farm A, B, C, D, E and F respectively. The recorded limits of lead were within permissible limits, in all layer feed samples which were collected from all layer farms.

It is important to take into account that farm (C) is the highest farm in lead levels in its samples of egg, kidney and liver, also farm (A) is the highest farm in lead levels in its samples of gizzard, muscle, water and feed, but farm (E) is the lowest farm in lead levels in its samples of kidney, muscle, gizzard, egg, water and feed.

In all examined samples for lead it is worth mentioning that the kidney of farm (C) seemed to be the organ which accumulated the highest value of lead but on contrast the lowest lead levels were recorded in water samples of farm (E)**.** While lead cannot be detected in gizzard and muscle samples of farm (E).

2- Cadmium concentrations in different samples (ppm):

A-Layer tissues (muscle, kidney, liver and gizzard) samples:

The results revealed that farm (B) which present at Itsa district is recorded the highest Cd levels in the examined samples and on contrast farm (F) which present at El-Nasereya village at (El-Fayoum district) recorded the lowest Cd levels in the examined sample of layer tissues.

-Estimated daily intake of cadmium from layer´s tissue consumption:

The average concentrations of cd in examined layer tissue samples collected from industrial and non industrial areas which give a daily intake from consumption of 250 gm layer tissue samples (muscle, kidney liver and gizzard) that contributed about (161.21, 74.286, Nd, 149.5, 61.429 and Nd), (125.82, 350, 225.7, 119.36, 150.7 and 32.14), (127.39, 133.57, 79.3, 120.29, 115.7 and 6.43), (110.61, 76.43, 7.86, 102.9, 45.71 and 1.429 %) of ADI recommended by **FAO/WHO Codex, (2011)** of farms A, B, C, D, E & F respectively.

-Estimated Health risk of cadmium from layer´s tissue consumption:

The estimated Target Hazard Quotients (THQ) were less than 1 for cadmium in examined layer´s tissue samples collected from industrial and non industrial areas farms A, B, C, D, E & F from consumption of 100 gm muscle and 20 gm of each kidney, liver and gizzard samples of farms A, B, C, D, E & F respectively.

B. Cadmium concentrations in hen´s egg

The highest concentrations of Cd in hen's egg were recorded in the samples which were collected from farm A & B at great industrial areas (Kom-Oshim in Tammiyah district and Itsa district) but the lowest concentrations of Cd in hen's egg samples were recorded in the samples collected from farm D which present at non industrial area (El-Azab village at (El-Fayoum district) on contrast Cd could not be detected from any of examined samples which were collected from farm C & F.

-Estimated daily intake of cadmium from Hen´s egg consumption:

The average concentrations of Cd in examined hen´s egg samples collected from industrial and non industrial areas which give a daily intake from consumption of 100 gm hen´s egg samples that contributed about (56.27%, 56%, Nd, 41.66%, 52%, Nd) of ADI recommended by **(FAO/WHO), Codex, (2011).**

-Estimated Health risk of cadmium from hen´s egg consumption:

The estimated Target Hazard Quotients (THQ) were less than 1 for cadmium in examined Hen´s egg samples collected from industrial and non industrial areas farms A, B, C, D, E & F from consumption of 37.2 gm of egg samples respectively.

C. Cadmium concentrations in drinking water of layer farms:

Cadmium were exceed permissible limit recorded by **(WHO),** and **(E.O.S.Q.C.)** respectively in water samples of farms A, B & D. and were within permissible limit in water samples of farms C, E & F.

D. Cadmium concentrations in layer feeds:

.The recorded limits of cadmium were within permissible limits, in all layer feed samples which were collected from all layer farms.

It is worth mentioning that kidney of farm (B) seemed to be the organ which accumulated the highest values of cadmium. In contrast gizzard of farm (F) accumulated the lowest values of cadmium**.** While cadmium cannot be detected in muscle and egg samples of farms (C and F) and water samples of farms (C, E and F).

3- Copper concentrations in different samples (ppm):

A-Layer tissues (muscle, kidney, liver and gizzard) samples:

Copper levels in layer tissues samples collected from six layer farms (A, B, C, D, E and F) which are present at three industrial areas and three non industrial areas in El-Fayoum Governorate during years of 2014 and 2015 were within permissible limit in layer tissue samples which were collected from all layer farms. It is of interest to note that farm (D) is recorded the highest Cu levels in the examined samples and on contrast farm (F) recorded the lowest Cu levels in the examined sample of layer tissues. It is worth mentioning that liver seemed to be the organ which accumulated the highest values of copper. While, muscle organ of farm (F) showed the lowest value of copper.

-Estimated daily intake of copper from layer´s tissue consumption:

The average concentrations of cu in examined layer tissue samples collected from industrial and non industrial areas which give a daily intake from consumption of 250 gm layer tissue samples that contributed about (0.8997, 0.48, 0.57, 4.223, 0.763 and 0.309), (2.184 , 2.32, 1.20, 3.60, 2.54 and 1.026), (3.18, 2.796, 2.62 , 3.92, 3.6 and 2.45) and (1.33 ,0.87, 1.93, 2.68, 2.05 and 0.64 %) of ADI recommended by **(FAO/WHO), Codex, (2011)** in farms A, B, C, D, E & F in muscle, kidney, liver and gizzard respectively.

-Estimated Health risk of copper from layer´s tissue consumption:

The estimated Target Hazard Quotients (THQ) were less than 1 for copper in examined layer´s tissue samples collected from industrial and non industrial areas farms A, B, C, D, E & F from consumption of 100 gm muscle and 20 gm of each kidney, liver and gizzard samples of farms A, B, C, D, E & F respectively.

B. Copper concentrations in hen´s egg

The copper levels were within the permissible limits in the egg samples which were collected from farms A, B, C, D, E & F.

-Estimated daily intake of copper from Hen´s egg consumption:

The average concentrations of Cu in examined hen´s egg samples collected from industrial and non industrial areas which give a daily intake from consumption of 100 gm hen´s egg samples that contributed about (1.186, 0.453, 1.04,1.341, 0.689 and 0.86 %) of ADI recommended by **(FAO/WHO), Codex, (2011)** in egg samples of farms A, B, C, D, E & F respectively.

-Estimated Health risk of copper from Hen´s egg consumption:

The estimated Target Hazard Quotients (THQ) were less than 1 for copper in examined Hen´s egg samples collected from industrial and non industrial areas farms from consumption of 37.2 gm of egg samples of farms A, B, C, D, E & F respectively.

C. Copper concentrations in drinking water of layer farms:

The recorded limits of copper were within permissible limit recorded by **(WHO),** and **(E.O.S.Q.C.),** respectively in examined water samples of all layer farms.

D. Copper concentrations in layer feeds:

The recorded limits of copper were exceed permissible limit recorded by **(WHO),** in the layer feed samples collected from farm A, B, D & E. on contrast the Cu levels recorded in layer feed samples collected from farm C & F were within permissible limit recorded by **(WHO).** In all examined samples for copper layer feed samples of farm (D) accumulate the highest values of copper. While, water samples of farm (C) showed the lowest value of copper. And copper cannot be detected in water samples of farm (F).

4- Zinc concentrations in different samples (ppm):

A-Layer tissues (muscle, kidney, liver and gizzard) samples:

The recorded limits of zinc were within the permissible limit in layer tissue samples which were collected from all layer farms except liver samples which were collected from layers of farm D were exceed the permissible limits. It is of interest to note that farm (D) is recorded the highest Zn levels in the examined samples except in gizzard of farm (C) is recorded the highest Zn levels and on contrast farm (F) recorded the lowest Zn levels in the examined sample of kidney and gizzard while, farm (B) showed the lowest Zn levels in the examined sample of muscle and liver.

-Estimated daily intake of zinc from layer´s tissue consumption:

The average concentrations of zinc in examined layer tissue samples collected from industrial and non industrial areas which give a daily intake from consumption of 250 gm layer tissue samples that contributed about (4.882, 0.145, 5.029, 5.191, 0.175 and 1.411), (10.425, 0.286, 0.488, 10.997, 0.231 and 0.172), (12.35, 0.47, 2.57, 18.812, 0.56 and 1.143) and (11.458, 7.439, 12.673, 12.33, 5.32 and 4.95 %) of ADI recommended by **(FAO/WHO), Codex, (2011)** in farms A, B, C, D, E & F respectively.

-Estimated Health risk of zinc from layer´s tissue consumption:

The estimated Target Hazard Quotients (THQ) were less than 1 for zinc in examined layer´s tissue samples collected from industrial and non industrial areas from consumption of 100 gm muscle and 20 gm of each kidney, liver and gizzard samples of farms A, B, C, D, E & F respectively.

B. Zinc concentrations in hen´s egg

The recorded limits of zinc were exceeding the permissible limits in the egg samples which were collected from all layer farms.

-Estimated daily intake of zinc from Hen´s egg consumption:

The average concentrations of zinc in examined hen´s egg samples collected from industrial and non industrial areas which give a daily intake from consumption of 100 gm hen´s egg samples that contributed about (7.891, 4.009, 9.027, 8.25, 3.594 and 6.318 %) of ADI recommended by **(FAO/WHO), Codex, (2011)** in egg samples of farms A, B, C, D, E & F respectively.

-Estimated Health risk of zinc from Hen´s egg consumption:

The estimated Target Hazard Quotients (THQ) were less than 1 for zinc in examined Hen´s egg samples collected from industrial and non industrial areas from consumption of 37.2 gm of egg samples of farms A, B, C, D, E & F respectively.

C. Zinc concentrations in drinking water of layer farms:

The recorded limits of zinc in examined water samples of all layer farms were within permissible limit recorded by **(E.O.S.Q.C.).**

D. Zinc concentrations in layer feeds:

- The recorded limits of zinc were within permissible limit recorded by **(WHO),** in case of the layer feed samples of all layer farms except for layer feed samples which were collected from farm A, B and D the recorded limits of zinc were exceed permissible limit recorded by **(WHO).** In all examined samples for zinc, eggs of farm (C) accumulate the highest values of zinc, while water samples of farm (A) accumulate the lowest values of zinc and zinc cannot be detected in water samples of farms (B & E).

5- Iron concentrations in different samples (ppm):

A- Layer tissues (muscle, kidney, liver and gizzard) samples:

It is worth mentioning that muscles which were collected from farm (E) seemed to be the organ which accumulated the highest values of iron while, muscle organs which were collected from farm (F) showed the lowest value of iron.

-Estimated daily intake of iron from layer´s tissue consumption:

The average concentrations of iron in examined layer tissue samples collected from industrial and non industrial areas which give a daily intake from consumption of 250 gm layer tissue samples that contributed about (83.37, 557.85, 983.2, 76.35, 1524.4 and18.07 %), (187.8, 749.1, 422.6, 82.8, 1503.3 and 46.47%), (280.9, 1478.5, 557.2, 118.04, 1225.6 and101.6%) and (121.09, 411.46, 705.8, 56.18,1507.9 and 352.5%) of ADI recommended by **FAO/WHO Codex, (2011)** in farms A, B, C, D, E & F in muscle, kidney, liver and gizzard respectively.

-Estimated Health risk of iron from layer´s tissue consumption:

The estimated Target Hazard Quotients (THQ) The THQ of Fe through the consumption of layer tissues (muscle, Kidney, liver and gizzard from layer farms (A, B, C, D & E), were higher than 1, indicating that there is a potential significant health risk associated with the consumption of these layer tissues from layer farms (A, B, C, D & E) El- Fayoum, Governorate, Egypt.

B. Iron concentrations in hen´s egg:

Iron levels detected in the egg samples were in average of (309.5±30.297, 231.75±61.412, 2386±395.8, 291.554±15.649, 627.3±265.9 and 1612±374.9 ppm) in farms A, B, C, D, E & F respectively.

-Estimated daily intake of iron from Hen´s egg consumption:

The average concentrations of iron in examined hen´s egg samples collected from industrial and non industrial areas which give a daily intake from consumption of 100 gm hen´s egg samples that contributed about (55.27, 41.38, 426.03, 52.06, 112.02 and 287.9%) of ADI recommended by **FAO/WHO Codex, (2011)** in egg samples of farms A, B, C, D, E & F respectively.

-Estimated Health risk of iron from Hen´s egg consumption:

The estimated Target Hazard Quotients (THQ) for iron in examined Hen´s egg samples collected from industrial and non industrial areas farms A, B, C, D, E & F were (0.235, 0.176, 1.811, 0.221, 0.476 and 1.224 mg/kg/day) from consumption of 37.2 gm of egg samples of farms A, B, C, D, E & F respectively.

C. Iron concentrations in drinking water of layer farms:

The recorded limits of iron were within permissible limit recorded by **(E.O.S.Q.C.)** and **(WHO)** respectively in examined water samples of all layer farms.

D. Iron concentrations in layer feeds:

- . The recorded limits of iron were within permissible limit recorded by **(WHO)** in the layer feed samples collected from farm B and F. on contrast the iron levels recorded in layer feed samples collected from farm A, C, D & E were exceed permissible limit.

The obtained results indicated that the metal found mostly abundant in layer tissues, eggs and layer feed was the iron also, Fe has the highest concentrations among the studied metals, and its health risk was the highest (6.969 mg/kg/day) in muscle samples which were collected from farm (E).

It is worth mentioning that in all examined samples for iron muscle samples accumulate the highest values of iron, while water samples accumulate the lowest values of iron and iron cannot be detected in water samples of farms (B & E).

6- Manganese concentrations in different samples (ppm):

A|-Layer tissues (muscle, kidney, liver and gizzard) samples:

Manganese levels in layer tissues were exceed the permissible limit recorded by **ATSDR and WHO** in samples which were collected from farm (E) but samples which were collected from layers of farm D & F were within the permissible limit.

-Estimated daily intake of manganese from layer´s tissue consumption:

The average concentrations of manganese in examined layer tissue samples collected from industrial and non industrial areas which give a daily intake from consumption of 250 gm layer tissue samples that contributed about (7.968, 18.395, 20.385, 3.496, 85.59 and 0.75%), (16.097, 47.18, 3.99, 6.08, 135.43And 3.258%), (55.94, 127.26, 47.39, 7.392, 86.71 and 2.58%) and (9.024, 38.755, 19.3, 1.858, 108.57 and 6.305 %) of ADI recommended by **USEPA, (2001).** in farms A, B, C, D, E & F respectively.

-Estimated Health risk manganese of from layer´s tissue consumption:

The estimated Target Hazard Quotients (THQ) were less than 1 for manganese in examined layer´s tissue samples collected from industrial and non industrial areas from consumption of 100 gm muscle and 20 gm of each kidney, liver and gizzard samples of farms A, B, C, D, E & F respectively.

B. Manganese concentrations in hen´s egg

Manganese levels in egg samples were exceeding the permissible limits recorded by **ATSDR,** in the egg samples which were collected from farms C, E & F. while, concentrations of manganese in hen´s egg samples collected from farm A, B and D were within the permissible limits.

-Estimated daily intake of manganese from Hen´s egg consumption:

The average concentrations of manganese in examined hen´s egg samples collected from industrial and non industrial areas which give a daily intake from consumption of 100 gm hen´s egg samples that contributed about (2.625, 1.33, 35.85, 2.178, 7.11and 30.74 %) of ADI recommended by **USEPA, (2001)** in egg samples of farms A, B, C, D, E & F respectively.

-Estimated Health risk of manganese from Hen´s egg consumption:

The estimated Target Hazard Quotients (THQ) were less than 1 for manganese in examined Hen´s egg samples collected from industrial and non industrial areas from consumption of 37.2 gm of egg samples of farms A, B, C, D, E & F respectively.

C. Manganese concentrations in drinking water of layer farms:

The recorded limits of manganese were within permissible limit recorded by **(E.O.S.Q.C.)** and **(WHO),** in examined water samples of all layer farms.

D. Manganese concentrations in layer feeds:

The recorded limits of manganese were within permissible limit recorded by **(WHO)** in the layer feed samples collected from farm B, C and F. on contrast the manganese levels recorded in layer feed samples collected from farm A, D & E were exceed permissible limit recorded by **(WHO).** In all examined samples for manganese layer feed of farm (A) accumulate the highest values of manganese, while water samples of farm (E) accumulate the lowest values of manganese and manganese cannot be detected in water samples of farms (B, D & F).

7. Estimated potential health risks for Pb and Cd via consumption of layer tissues (muscle, kidney, liver and gizzard) and eggs:

The analysis of layer parts and eggs revealed that the health risk index (HI) for heavy metals (lead and cadmium) were more than 1 for layer muscles only in farms (A and D) in El-Fayoum Governorate and among them the highest value was found in muscles of farm (A), (1.078) indicating potential risk to the Egyptian consumers.When the hazard index exceeds 1.0, there is concern for potential health effect as exposure to more than one contaminant may produce an additive effect on the consumer.