Studia Universitatis "Vasile Goldiş", Seria Ştiinţele Vieţii
Vol. 28 issue 2, 2018, pp. 63-77

HUMAN HEALTH RISK IMPLICATIONS FROM THE CONSUMPTION OF FREE RANGE CHICKEN RAISED NEAR DUMPSITES

[1,3,5]Alex Ajeh Enuneku, *[2]Osikemekha Anthony Anani, [3,4,5]Emmanuel Ogbomidia, [3]Osaro Asemota. [1]Anyanso Ibe Anyanso, [1]Stanley Ordih, Mohammed Kyari[6], [3]Lawrence Ikechukwu Ezemonye

[1]Department of Environmental Management and Toxicology, Faculty of Life Science, University of Benin, Benin City, PMB 1154, Nigeria
[*2]Department of Animal and Environmental Biology, Faculty of Life Science, University of Benin, Benin City, PMB 1154, Nigeria
[3]Ecotoxicology and Environmental Forensics Laboratory, Department of Animal and Environmental Biology, University of Benin, PMB 1154, Benin City, Nigeria.
[4]Ecotoxicology Laboratory, National Centre for Energy and Environment, Energy Commission of Nigeria, University of Benin.
[5]Laboratory of Toxicology, Graduate School of Veterinary Medicine, Hokkaido University, Kita 18, Nishi 9, Kita-ku, Sapporo 060-0818, Japan.
[6]African Union ScientificTechnical Research Commission, Abuja, Nigeria.

ABSTRACT: The objectives of this study are to determine the concentration of heavy metals in selected organs of free range chicken and ascertain the human health risk implications via consumption. Samples of free range chicken around the study areas were purchased from their owners. Heavy metal concentrations were analysed in tissues using Buck scientific atomic absorption spectrophotometer, model 210VGP. The results revealed that the heavy metal contents were not significant ($P > 0.05$ and $P > 0.01$) in all selected organs and across the locations sampled. The results of the target hazard quotient (THQ) were less than 1 for all single metals found in the each organ from all locations. The highest THQ (1.04) was in the spleen sourced from Ekweniro at January 2017. The total target hazard quotient (TTHQ) obtained in the various organ parts of the free range chicken might contribute to the potential health risk if consumed in large proportion simultaneously or differently. All the Estimated daily intake (EDI) values obtained in this study ranged from 0.00 to 0.10 mg/kg. The computed values of the %EDI to provisional tolerable daily intake (PTDI), showed that Ni in the muscles, crop and gizzard were 0.60 and 0.49%, while the liver, intestine and spleen were 0.45, 0.47 and 0.47% respectively. The findings of this study revealed that Zn, Cu and NI had great total health risk impacts (THRI) if they are consumed together. Zn and Cu had values far > 1 while the values of Ni were > 1 and < 1 respectively.

Keywords: free range chicken, total health risk impact, hazard quotient, heavy metals, risk assessment

INTRODUCTION:

The transfer of toxicants including heavy metals from contaminated sources along the food chain has been a serious threat to human health. The rapid explosion of the human population has also contributed to this where a lot of waste via anthropogenic sources; farming, domestic, industrial and municipal has contributed negatively to the ecosystem.

In Nigeria, a developing country, municipal wastes has been associated with high heavy metals residues. Heavy metal pollution is likely to reach disturbing levels when anthropogenic activities exceed normalcy without adequate control measures. The proliferation of open and unsafe dump sites containing multiple disposals of domestic, municipal, industrial and medical waste are common practice in most cities in Nigeria (Solomon *et al*., 2014). Dump site is an old traditional method of waste disposal similar to the landfill method of waste management. Dump sites contain the build-up of heavy metals in soils from anthropogenic sources which have been reported to be harmful to crops, animals and human health. Furthermore, heavy metal concentrations can transfer up to the food chain, thereby leading to accumulation in the food web (Abdus-Salam, 2009; Adewuyi and Opasina, 2010) and subsequent transfer to humans.

Correspondence: Email: osikemekha.anani@lifesci.uniben.edu

Heavy metals are normally found in foodstuffs and household and industrial wastes in various concentrations in dumpsites (Smedley *et al*., 2002). The concentrations of toxic elements in foods depend on the type of food and the route through which the food was exposed to the toxic element. These elements can enter foodstuffs from the environment in different pathways such as contaminated water with untreated municipal, industrial waste and polluted air (Islam *et al*., 2017).

Food consumption is considered to be the main pathway, the other pathways being inhalation, dermal contact contaminated water, through which humans are exposed to potentially toxic elements (Farid, *et al*., 2003; Demirezen and Uruc, 2006; Arslan *et al*., 2016). The risk of heavy metal contamination in meat is of great concern for safety of both animal and human health because of the toxic nature of heavy metals, even at relatively minute concentrations (Akan *et al*., 2010).

Metal contamination in foods, especially in meat have been broadly investigated (Sharif *et al*., 2005). Contamination with heavy metals is a serious threat because of their toxicity, bioaccumulation and biomagnifications in the food chain (Demirezen and Uruc, 2006). Concentrations of environmental contaminants in tissues of chickens can be used to evaluate chronic or acute exposure, as chickens are fed a wide variety of feed stocks from a multiplicity of sources (Scheuhammer 1987; Sileo *et al*., 2003). The metal accumulations in chickens via contaminated diets have been investigated in a few studies to assess the potential human risk from poultry consumption (Lasky *et al*., 2004). The main sources of metals in chicken meat arise from contamination of poultry feeds, contaminated materials from dumpsites, drinking water and processing methods (Mariam and Nagre, 2004). Toxic effects of the heavy metals to the chickens includes feed refusal, loss of weight, low digestibility, organ failure and death while in higher animals it include, kidney and liver damage, anemia, alteration of central nervous system and cancer (Hassan *et al*., 1998). The primary site of the accumulation of the heavy metals is the liver and the kidney (Demirezen and Uruc, 2006). The concentration of heavy metals in internal tissues of chicken has been extensively determined by several researchers (Demirbas 1999; Mariam *et al*., 2004; Iwegbue *et al*., 2008; Uluozlu *et al*., 2009). According to Duruibe *et al*., (2007), some heavy metal ions that are known to be potentially toxic includes aluminium, arsenic, cadmium and lead. Toxic elements can be harmful to birds even at low concentrations when ingested over a long period of time (Young 2005). Other metals like Cu, Zn and Ni which may be biologically essential have been known to be toxic at elevated concentrations in animal and human tissues.

In Nigeria and several African countries, there has been a long standing culture of raising free range chickens in individual households. They are allowed to roam the environment and source for feed from wastes around residential buildings. In areas where these buildings are close to dumpsites, the chickens spend more time in these areas, feeding on food wastes. Because these wastes are a heterogeneous mix and not segregated, there is a high potential on consuming items that contain heavy metal residues from homes, mechanic and furniture workshops, agricultural establishments, schools and small industries.

The purpose of this study are to determine the concentration of heavy metals in selected organs (gizzard, crop, muscles, liver, intestine and spleen) of free range chicken sourced from the environment of waste dump sites and to assess the potential health risk to humans.

MATERIALS AND METHODS:

Ethical Approval

The Animal Rights and Ethical Use Committee of University of Benin, Benin City have approved this study.

Study Location

This study was carried at specific dump sites locations in Benin City. The locations were Ekweniro, Oluku and Egor (reference point) with their geographical coordinates readings as; latitude N06 ° 19.541’’ and longitude E005° 44.851’’, N06° 27.729’’ and longitude E005o 36.060’’, longitude N06° 21.375’’ and latitude E 005° 34’’ respectively Figure 1. The Communities lie in the South-western, Western and Eastern parts of Benin City, Edo State, Nigeria. The mean monthly temperatures fluctuate between 22.3 °C in September and 33.3 °C in February. The rainfall ranges from February to late November with a mean value of 1400 mm. The areas are semi-urban and located at the fringe of the major city-Benin. Being a semi-urban environ, their lifestyle is mainly agriculture- farming and local poultry breeding of free range chickens. Most waste dumps are located within these terrains (Ekweniro and Oluku) and are active till date. While in the reference point (Egor), the main anthropogenic activity taken place there is farming.

Sampling and Pre-analysis

The dump sites were visited between the months of January-March, 2017. Three samples of free range chicken were obtained each month after proper negotiations and purchase around the study areas within the scope of this study. These chickens were usually seen to roaming around the dump sites and were caught while scavenging between the hours of 9am and 12pm. The age of the chicken in the study area ranged from 12 to 18 months. In each location, chicken of age 18 months were sampled. They were then taken to the laboratory for heavy metal analysis of organ parts.

Upon getting to the laboratory, the chickens were weighed (1.12-1.28 kg), and then disembowelled and then slaughtered to obtain the gizzard, crop, muscle, liver, intestine and spleen organ parts. The various organs were categorized and labelled for ease of identification in the course of the experiment.

The glass wares used for this study were thoroughly washed with detergent and rinsed with distilled water. The glass wares such as beakers, conical flasks, test tubes and pipettes were wrapped with aluminium foil and appropriately sterilized in the hot air oven at 160 °C for 1 hour.

Sample digestion

The chicken organ samples were oven dried for 2h in an oven at 100 °C. One (1) gram of dried sample was measured using an analytical weight balance. Then 1g was introduced into a kjeldhal flask and then 10 ml of the acid mixture was introduced. This was then transferred into a fume cupboard and was then heated.

The concentration of the respective heavy metals (Cu, Zn and Ni) present in the digested samples was determined with the aid of an Atomic absorption spectrophotometer (model 210VGP) using the modified methods of Ademoroti, (1996).

Quality control examination

The equipment was first calibrated using buck certified atomic absorption standards for the respective heavy metals to obtain calibration curves. Reagent blanks were first run at intervals of every ten sample analysis to eradicate equipment drift. All samples were analysed in duplicates for reproducibility, accuracy and precision.

Data Analysis

Studia Universitatis “Vasile Goldiş”, Seria Ştiinţele Vieţii
Vol. 28 issue 2, 2018, pp. 63-77

The heavy metal contents in the chicken parts were compared using parametric analysis of variance (ANOVA) with the IBM Statistical Package for the Social Sciences (SPSS) version 20 and Excel 2013 Software.

Health risks Assessment

The target hazard quotient (THQ) method used in this study was adopted from the United States EPA Region III Risk based concentration table, US EPA, (1989). The total THQs in this study was treated as the arithmetic sum of the individual metal THQ values, adopted from the method of Chien *et al*., (2002). Where EFr is exposure frequency (365 days/year); EDtot is the exposure duration 52 years, average lifetime); FIR is the food ingestion rate assumed as 2 g/day; C is the heavy metal concentration in the (mg/kg); RfDo is oral reference dose (mg/kg/day), ATn is average exposure time for non-carcinogens in days [365×EDtot (52)] and BWa is the average adult body weight (70 kg).

The estimated daily intake (EDI) exposure of the heavy metals to humans via ingestion of the contaminated chicken was estimated using the modified methods of Chary *et al*., (2008); Copat *et al*., (2012); Saha and Zaman, (2012); Xue *et al*., (2012). The fresh chicken ingestion rate (kg/ person/day), was assumed to be 2 for this study. Where EF is the exposure frequency (365 days/year); ED is the exposure duration, equivalent to average lifetime (52 years for Nigeria population); FIR is the fresh food ingestion rate (kg/ person/day), Cf is the conversion factor (0.208) for fresh weight (FW) to dry weight (Dw). Cm is the heavy metal concentration in foodstuffs (mg/kg Dw.); WAB is the average body weight (bw) (average adult body weight was considered to be 70 kg; and TA is the average exposure time for non-carcinogens (equal to EF × ED) (Saha and Zaman, 2012).The provisional tolerable daily intake (PTDI) values (in mg/kg body wt/day) of all the examined metals Cu (500), Zn (1000) and Ni (5) used in this study, were based on the data suggested by the Joint Expert Committee on Food Additives (JECFA), FAO/WHO (1999 and 2003).

The health risk impact (HRI) due to intake of heavy metals from the chicken parts was adopted using the method of Wang et al. (2005). The reference oral doses (RfD) of Cu (0.001), Zn (0.0006) and Ni (2.0 x 10-2) used for this study was adapted from US EPA, (2007 a, b and 2009). A total HRI was calculated for the heavy metals in all examined parts of the chicken. The equation below illustrates it:

$$THRI = \sum EDI/RDos$$

Where THRI is the total health risk impact from the intake of different chicken parts, ∑EDI is the sum of the daily intake of heavy metals in the different organ parts and RFDos is the reference dosage values assigned to each heavy found in the organ parts. A significant impact occurs when THRI > 1 and < 1 when there is no significant impact. The rational of implementing this method, is that, there might be a cumulative interactive health risk of more than one heavy metals from the different chicken body parts if they are consumed simultaneously daily.

RESULTS AND DISCUSSION:

The evaluation of the heavy metal contents in organs of free range chicken collected from the study locations in the month of January-March, 2017

The results of the heavy metal contents obtained from the organ samples (gizzard, crop, muscle, liver, intestine and spleen) in the free range chicken from the three study locations are shown in Table 1. The results showed that the heavy metal contents were not significantly different (P>0.05 and P>0.01) in all selected organs and across the locations sampled

The concentration of copper (Cu), zinc (Zn) and nickel (Ni) in the muscle, crop and gizzard of chicken samples obtained from Ekweniro for the period of January 2017 were Cu (1.90, 4.63 and 1.20 mg/kg), Zn (17.20, 7.16 and 16.60 mg/kg) and Ni (0.06 mg/kg) respectively. The concentrations of Ni in the muscle and gizzard were below detectable limits (BDL). For February 2017, the values obtained were Cu (7.15, 7.84 and 7.10 mg/kg), Zn (8.33, 9.76 and 6.50 mg/kg) and Ni (1.15, 1.24 and 2.66 mg/kg) respectively. And for March 2017, the values obtained were Cu (7.70, 12.77 and 7.83 mg/kg), Zn (9.37, 11.74 and 11.35 mg/kg) and Ni (0.44, 0.65 and 1.26 mg/kg) respectively. The concentration of copper (Cu), zinc (Zn) and nickel (Ni) in the liver, intestine and spleen of chicken samples obtained from Ekweniro for the period of January 2017 were Cu (0.96, 1.31 and 6.60 mg/kg), Zn (12.35, 3.69 and 17.80 mg/kg) and Ni (BDL) respectively. For February 2017, the values obtained were Cu (3.67, 6.27 and 5.67 mg/kg), Zn (6.90, 6.33 and 4.27 mg/kg) and Ni (1.76, 1.02 and 0.98 mg/kg) respectively. And for March 2017, the values obtained were Cu (4.19, 2.02 and 8.64 mg/kg), Zn (4.58, 8.82 and 1.44 mg/kg) and Ni (0.39, 0.52 and 0.52 mg/kg) respectively.

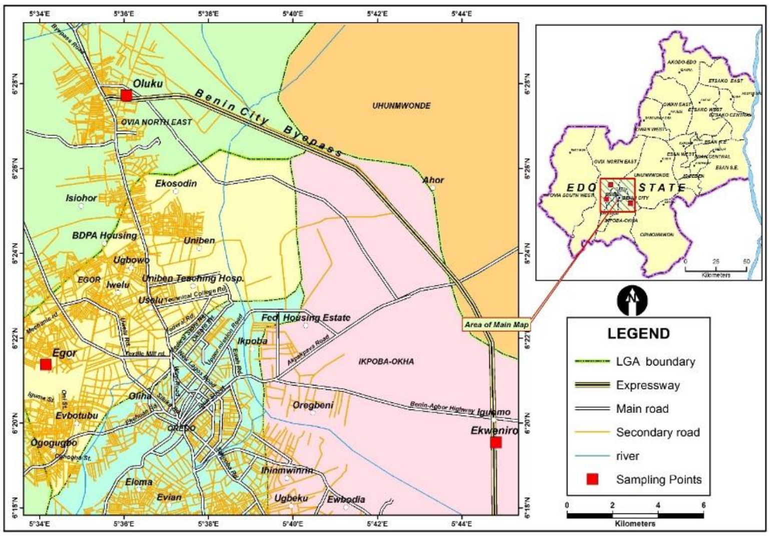

Fig. 1. Showing the map of Edo state and the study locations (Ekweniro, Oluku and Egor).

At Oluku, for the period of January the heavy metal values were Cu (3.00, 7.70 and 8.45 mg/kg), Zn (17.33, 11.32 and 9.47 mg/kg) and Ni (BDL) respectively. The concentrations of Ni in the muscle, crop and gizzard were below detectable limits (BDL). For February, the values obtained were Cu (18.54, 11.41 and 16.56 mg/kg), Zn (8.85, 9.12 and 11.17 mg/kg) and Ni (1.00, 0.91 and 2.24 mg/kg) respectively. For March, the values obtained were Cu (5.20, 10.83 and 5.20 mg/kg), Zn (11.70, 7.99 and 2.62 mg/kg) and Ni (0.82, 0.54 and 0.33 mg/kg) respectively. Contrarily, the concentration of copper (Cu), zinc (Zn) and nickel (Ni) in the liver, intestine and spleen of chicken samples obtained from Oluku for the period of January 2017 were Cu (2.05, 2.70 and 1.45 mg/kg), Zn (8.05, 8.05 and 8.70 mg/kg) and Ni (BDL) respectively. For February, the values obtained were Cu (13.24, 14.57 and 8.19 mg/kg), Zn (7.67, 8.59 and 6.24 mg/kg) and Ni (2.19, 0.59 and 1.17 mg/kg) respectively. And for March 2017, the values obtained were Cu (17.22, 8.08 and 8.48 mg/kg), Zn (15.43, 11.43 and 9.89 mg/kg) and Ni (0.61, 0.82 and 0.56 mg/kg) respectively.

In Egor, for the period of January, the heavy metal contents were Cu (2.35, 1.90 and 7.40 mg/kg), Zn (8.25, 5.20 and 3.73 mg/kg) and Ni (BDL, 0.36 and 0.27 mg/kg) mg/kg) respectively. However, the concentrations of Ni in the muscle of the chicken were below detectable limits (BDL). For February, the values obtained were Cu (13.76, 6.57 and 6.25 mg/kg), Zn (3.72, 4.45 and 6.36 mg/kg) and Ni (0.95, 0.78 and 0.48 mg/kg) respectively. In March, the values obtained were Cu (5.20, 3.49 and 2.32 mg/kg), Zn (2.62, 3.61 and 3.50 mg/kg) and Ni (0.33, 0.38 and 0.49 mg/kg) respectively. Inversely, the concentration of copper (Cu), zinc (Zn) and nickel (Ni) in the liver, intestine and spleen of chicken samples obtained from Egor for the period of January were Cu (1.55, 1.30 and 2.55 mg/kg), Zn (4.70, 2.40 and 8.70 mg/kg) and Ni (BDL, 0.05 and 0.07 mg/kg) respectively. For February, the values obtained were Cu (10.29, 2.33 and 13.43 mg/kg), Zn (0.86, 1.19 and 1.24 mg/kg) and Ni (11.28, 7.20 and 10.65 mg/kg) respectively. In March, the values obtained were Cu (11.28, 7.20 and 10.65 mg/kg), Zn (13.51, 9.70 and 10.22 mg/kg) and Ni (0.56, 0.68 and 0.72 mg/kg) respectively.

The amount of Zn obtained in Ekweniro, Oluku and Egor seem to be much higher than other metals found in the various chicken parts, followed by Copper while Ni was the least (Zn > Cu > Ni). The average values of the heavy metals in the organ parts across the months were January; Cu (4.28), Zn (10.70) and Ni (0.08), February; Cu (10.58), Zn (7.58) and Ni (1.27) and March; Cu (7.02), Zn (7.36) and Ni (0.60).

Figures 2 and 3 show the heavy metal contents in the muscle, crop, gizzard, liver, intestine and spleen of free range chicken sourced around three dump sites. The results revealed that there were fluctuations in the values of Zn and Cu in terms of dominance in the various organ parts, especially in Ekweniro an Oluku as compared with the reference point (Egor). The values of Ni were generally low across all organ parts of the chicken in reference to their locations. Although, in the months of January. The findings of this study clearly indicate that most of the heavy metals obtained in the various parts of the free range chicken in Ekweniro and Oluku were fairly lower than those obtained in the reference point (Egor) an indication of lesser environmental impact in the latter.

The values of Zn and Ni were observed to be far below the regulatory standards set by FAO, (1999 and 2011a). It was also observed that there were fluctuations in the values of Cu in the studied chicken samples across the locations. However, most of the values surpassed the set standard limits.

Mariam *et al*., (2004) reported mean levels of 28.53 ± 3.39 mgkg-1 Zn in lean meat of poultry in Lahore, while Iwegbue *et al*., (2008) reported that the concentrations of Zn for turkey meat, chicken meat and chicken gizzard in Delta State Southern Nigeria ranged between 4.9 – 48.23 mgkg-1, 6.12 – 33.21mgkg-1 and 10.19 - 37.03 mgkg-1 and by Nick *et al*., (2012) indicated in his study that chicken livers (1.8049 – 2.619 mg kg-1) contained the highest concentrations of zinc, followed by chicken gizzards (1.7697 – 2.0685 mg kg-1) and then the muscles (1.3939 – 1.7078 mg kg-1) respectively. The findings in this study revealed a lesser concentrations as compared with the above studies.

Zinc is an essential element, playing important roles as coenzymes in the body. It is also needed for the tissues repairing and growth, forming connective tissues, skin, bones, teeth, hair, and nails (Soetan *et al*., 2010; Mineral Information Institute, 2012; Donia, 2015; Khan *et al*., 2015). Donia, (2015) recorded higher results of zinc levels in quail meat in Egypt in quail organs were 18.9 and

9.82 mg/kg in liver and quail muscle respectively. Skalicka *et al*., (2008), in Slovak recorded 8.11mg/kg in quail muscle. Abduljaleel *et al*., (2012) in Malaysia reported in Japanese quails about 50.607 and 51.076 mg/kg in liver and muscle. The findings from this current study are generally far lower than the values obtained in the above studies. Conversely, the results obtained in Iraq by Reem *et al*., (2012) who found about 3.266 mg/kg Zn from poultry liver can be fairly compared with this current study. Zinc added to poultry diets to improve immunity, weight gain (Ali *et al*., 2017). Zinc toxicity leading to pneumonia mortality in children (Hala *et al*., 2009). The chicken has been recommended as the best dietary sources of Zn to the human body (Falah *et al*., 2017).

Copper functions in the utilization of iron in an early stage of haemopoiesis. Copper deficiency results in an increase in iron in the liver, whereas an excess of copper results in a decrease in the iron content of the liver, thus reflecting the role of copper in iron utilization (Soetan *et al*., 2010). Copper is present in blood plasma as a copper-carrying plasma protein called erythrocuprin. Erythrocuprin provides a link between copper and iron metabolism and mediates the release of iron from ferritin and haemosiderin (Hays and Swenson, 1985). The dietary requirement of copper is affected by the level of some other minerals in the diet, and is increased in ruminants by excessive molybdenum (Soetan *et al*., 2010). Treatment of copper poisoning is based on the rationale that excess molybdenum may cause copper deficiency and molybdenum in conjunction with the sulfate ion has been used in treating copper poisoning in ruminants (Pierson and Aenes, 1958). Cu requirement varies among animal species to some extent, but is influenced to a large degree by its relationship with and the intake of other mineral elements such as iron, molybdenum and sulfate (Soetan *et al*., 2010). The established RDA for Cu in normal healthy adults is 2 mg/day (National Research Council, Food Nutrition Board, 1980). Cu is absorbed in the gut and then transported to the liver bound to albumin. After processing in the liver, Cu is distributed to other tissues in a second phase. Cu transport in the liver involves the protein ceruloplasmin, which carries the majority of Cu in blood. Ceruloplasmin also carries Cu that is excreted in milk and is particularly well absorbed as a Cu source (Linder *et al*., 1998; Hellman and Gitlin, 2002; O'Brien and Bruce, 2009). The chicken has been recommended as the best dietary sources of Cu to human body (Roger, 2011).

Nickel on the other hand is an essential element in animals (Nielsen, 1976). It has been speculated that nickel may play a role in the maintenance of membrane structure, control of prolactin, nucleic acid metabolism or as a cofactor in enzymes. It appears that most dietary intakes would provide sufficient amounts of this element (Hurley, 1976). In a trace element-controlled environment, chicks supplemented with nickel have shorter, thicker legs, lower haematocrit and plasma cholesterol levels and higher liver cholesterol levels than control chicks. In rats, there is a slower growth rate and post-natal mortality. In swine, there is impaired reproduction, abnormal hair coats, and poor growth of offspring (Anke et al., 1974; Tejada-Jimenez *et al*., 2009). Although the biological function of nickel is still somewhat unclear in the human body, however, nickel is found in the body in highest concentrations in the nucleic acids, particularly RNA, and is thought to be somehow involved in protein structure or function. It has been speculated that nickel may play a role, as a cofactor, in the activation of certain enzymes related to the breakdown or utilization of glucose (Falah *et al*., 2017).

The evaluation of the target hazard quotient (THQ) in selected chicken parts

Tables 2 and 3 showed the THQ of the risk in consuming Cu, Zn and Ni from contaminated chicken parts. All computed values were < 1. For the results of the TTHQ of the whole tissues (muscles, crop, gizzard and liver, intestine, spleen), it was observed that the highest values were; Ekweniro January - February (2.17, 1.81, 0.04, 1.86, 1.28 and 0.02), Olukun January - February (2.36, 2.72, 1.83, 0.9, 2.11 and 2.72) and Egor January - February (1.15, 1.36, 0.94, 0.91, 1.94 and 2.43) respectively.

The evaluation of risk to human health is one founded on assumptions. According to US EPA, the acceptable value is 1 for THQ (US EPA, 1989 and 2011). This current study revealed that the THQ was less than 1 for all heavy metals found in the organ parts from all locations. On this premise, there is no health risk from the ingestion of these three metals individually from the chicken organ parts. An interaction effect had also been established by Chien *et al*., (2002) and supported by Enuneku *et al*., (2014) for organisms carrying different contaminated entities on food. The cumulative health impact of ingesting such food is risky! The findings of this study underpin this potential health risk from the residues of chemical found in the selected organs of the free range chicken. The highest TTHQ (1.04) from each heavy metals was in the spleen, sourced from Ekweniro at January 2017. This might reduce the efficacy of the spleen; for destroying old red blood cell, removing debris from the blood streams and impede lymphocytes formations. However, collectively, the total hazard for all the heavy metals quotients revealed that there might be a potential health risk if a single organ part is consumed and a serious risk if the all body parts; muscles, crop, gizzard, liver, intestine and spleen are consumed simultaneously.

Previous studies by Hough *et al*., (2003), Hang *et al*., (2009), Xu *et al*., (2013) reported that exposure to two or more pollutants may result in additive effects. The findings from the THQs in this study, therefore support the above studies be added to generate a hazard index/total target hazard quotient (TTHQ). Cu and Zn were observed to contribute to the TTHQ in the various organ parts of the free range chicken. From the findings, they might contribute to the potential health risk if consumed in large proportion. However, the study showed that standards regarding the maximum level of contaminants in food (MLCF) (SEPAC, 2005) lacked a specified limit for Cu and Zn. But in Nigeria, the safe maximum level of these elements have not yet be established in free range chicken. Even on Ni a typical carcinogen.

Copper is an essential substance to human life, but in high doses it can cause anemia, liver and kidney damage, and stomach and intestinal irritation. People with Wilson's disease are at greater risk for health effects from overexposure to copper (Thirulogachandar *et al*., 2014). Small amounts of Nickel are needed by the human body to produce red blood cells, however, in excessive amounts, can become mildly toxic. Short-term overexposure to nickel is not known to cause any health problems, but long-term exposure can cause decreased body weight, heart and liver damage, and skin irritation (Thirulogachandar *et al*., 2014).

The evaluation of the estimated daily intake (EDI) and the provisional tolerable daily intake (PTDI) of heavy metals in selected parts of free range chicken

The comparison of EDI with the respective PTDI for Cu, Zn and Ni in the various organ parts are shown in Tables 4 and 5. All the EDI values obtained in this study ranged from 0.00 to 0.10 mg/kg. The maximum daily intake was observed only in Zn for muscle, crop and gizzard with values ranging from 0.00 to 0.10 mg/kg and least in Ni (0.00-0.01 mg/kg). For the liver, intestine and spleen, the values ranged from 0.01- 0.09 from Cu daily impact and Ni (0.00-0.01 mg/kg).

The EDI for this study for Cu, Zn and Ni were above the RfDos value used in this study. The intake of these metals from the consumption of the free range chicken was far above the RfDos limits. The higher intake of Cu, Zn and Ni were found through the consumption of all organ parts, the higher intake of Ni might pose serious risk. However, from the computed values of the %EDI to PTDI, the maximum concentrations of Ni in the muscles, crop and gizzard of the free range chicken sourced from Ekweniro and Olukun at the month of February, had the values of 0.60 and 0.49% respectively. On the contrary, the maximum concentrations of Ni in the liver, intestine and spleen of the free range chicken sourced from Ekweniro and Olukun at the month of February were 0.45 and 0.47% respectively and Olukun at the month of March was 0.47%.

It is important to note that the calculated EDI in this study for Ni (which is less than PTDI) was only obtained through chicken consumption, and including Ni intake through dietary would probably increase the EDI values. Therefore, the health risks for Ni through the consumption of free range chicken could be a great concern for the population of the studied areas.

The evaluation of the health risk impact (HRI) of heavy metals in selected parts of free range chicken

The results of the of health risk impact of the heavy metals in the selected parts of the free range chicken are as shown in Tables 6 and 7. The values obtained for the THRI in this study, according to the locations and organ parts; muscles, crop and gizzard are: Ekweniro Cu (45.94), Zn (405.70) and Ni (0.02), Olokun Cu (113.81), Zn (377.57) and Ni (0.00) and Egor Cu (69.23), Zn (170.76) and Ni (0.19) for the period of January. Ekweniro Cu (131.28), Zn (243.56) and Ni (1.50), Olokun Cu (276.40), Zn (288.62) and Ni (1.23) and Egor Cu (164.80), Zn (117.87) and Ni (0.59) for the period of February. And, Ekweniro Cu (168.18), Zn (321.51) and Ni (0.70), Olokun Cu (141.92), Zn (238.31) and Ni (0.56) and Egor Cu (95.62), Zn (98.65) and Ni (0.29) for the period of March (Tables 6 and 7).

Conversely, the values obtained for the THRI in this study, according to the locations and organ parts; liver, intestine and spleen are: Ekweniro Cu (27.1), Zn (247.12) and Ni (0.00), Olokun Cu (36.85), Zn (244.15) and Ni (0.00) and Egor Cu (32.09), Zn (156.50) and Ni (0.00) for the period of January. Ekweniro Cu (92.77), Zn (173.33) and Ni (1.12), Olokun Cu (213.94), Zn (222.86) and Ni (1.17) and Egor Cu (143.88), Zn (258.02) and Ni (0.98) for the period of February. And, Ekweniro Cu (88.25), Zn (117.27) and Ni (0.43), Olokun Cu (213.94), Zn (222.94) and Ni (1.17) and Egor Cu (173.12), Zn (331.12) and Ni (0.58) for the period of March (Tables 6 and 7).

The health risk of any population is considered acceptable when HRI is equal to or higher than 1. On this premise, the population will most likely experience health problems (Khan *et al*., 2009). A total HRI (THRI) was used to ascertain the potential impacts of Cu, Zn and Ni to individuals and the same standards in measuring HRI according to Khan *et al*., (2009) was implored for this study. This was done in order to evaluate the added influence of the studied heavy metals on various organ parts of the free range chicken if consumed simultaneously.

The values of Ekweniro and Olokun obtained as compared with the reference station were fairly higher in content than the latter. The trend of THRI impact is Zn > Cu >Ni. This finding is in consonance with the results of the ANOVA, THQ, and EDI. However, the Codex Alimentarium Commission (CAC), (1995) has set the maximum permissible limit of zinc in meat as 50 mg/kg for muscle and 80 mg/kg fw for edible offals. All zinc values reported in this study were exceeded this limit. Moreover, Okoye and Ugwu, (2010) have also reported elevated zinc levels in the parts of goats bred in Nigeria. This suggests that zinc contamination likely takes place in the environment where the animals feed (Janefrances *et al*., 2010). There are no set standards for copper and nickel concentrations in meat parts of international bodies such as Codex

Alimentarium and/or the WHO/FAO as at the time of this study.

The findings of this study revealed that Zn, Cu and NI had great potential health risk impacts if they are consumed together. Zn and Cu had values far greater than l (THRI>I) while most of the values of Ni were > 1 and < 1. The study also indicated that the muscles, crop and gizzard had more heavy metal contents compared to the liver, intestine and spleen.

Tab. 1.

The results of the of the heavy metal contents in muscle, crop, gizzard, liver, intestine and spleen of free range *Gallus domesticus* around selected dumpsites

	Months	Jan-17			Feb-17			Mar-17		
		Concentration (Mean ± S.D) (mg/kg)			Concentration (Mean ± S.D) (mg/kg)			Concentration (Mean ± S.D) (mg/kg)		
Location	Organ	Cu	Zn	Ni	Cu	Zn	Ni	Cu	Zn	Ni
Ekweniro	Muscle	1.90±0.57	17.20± 1.84	BDL	7.15± 0.33	8.33 ± 3.73	1.15 ± 0.31	7.70± 2.83	9.37± 1.08	0.44±0 .06
	Crop	4.63±5.27	7.16± 9.81	0.06± 0.01	7.84± 3.06	9.76 ± 10.70	1.24 ± 0.18	12.77± 11.31	11.74±7 .33	0.65±0 .16
	Gizzard	1.20±0.14	16.60± 2.55	BDL	7.10± 4.10	6.50 ± 9.19	2.66 ± 0.66	7.83± 7.46	11.35±5 .03	1.26±0 .54
Oluku	Muscle	3.00±0.57	17.33± 8.58	BDL	18.54± 3.17	8.85 ± 0.69	1.00 ± 0.09	5.21± 4.35	11.70±1 .70	0.82±0 .01
	Crop	7.70±7.70	11.32± 14.83	BDL	11.41± 5.18	9.12 ± 6.31	0.91 ±0.29	7.84± 6.17	4.37± 0.17	0.53±0 .53
	Gizzard	8.45±8.98	9.47± 3.07	BDL	16.56± 3.27	11.17 ± 4.57	2.24 ± 0.30	10.83± 6.72	7.99± 1.32	0.54±0 .28
Egor (reference point)	Muscle	2.35±1.06	8.25± 4.31	BDL	13.76± 10.72	3.72 ± 0.95	0.95 ± 0.30	5.20± 1.12	2.62± 0.47	0.33±0 .06
	Crop	1.90±0.57	5.20± 2.69	0.36± 0.51	6.57± 2.91	4.45 ± 0.46	0.78 ± 0.78	3.49± 0.92	3.61± 0.28	0.38±0 .15
	Gizzard	7.40±0.00	3.73± 3.21	0.27± 0.37	6.25± 1.53	6.36 ± 0.99	0.48 ± 0.38	2.32± 1.24	3.50± 0.42	0.49±0 .24

	Months	Jan-17			Feb-17			Mar-17		
		Concentration (Mean ± S.D) (mg/kg)			Concentration (Mean ± S.D) (mg/kg)			Concentration (Mean ± S.D) (mg/kg)		
Location	Organs	Cu	Zn	Ni	Cu	Zn	Ni	Cu	Zn	Ni
Ekweniro	Liver	0.96± 0.65	12.35± 7.85	BDL	3.67± 1.09	6.90± 2.65	1.76± 0.25	4.19± 0.64	4.58± 0.7	0.39± 0.14
	Intestine	1.31± 0.29	3.69± 0.81	BDL	6.27± 1.61	6.33± 0.47	1.02± 0.05	2.02± 0.92	5.82± 0.88	0.52± 0.25
	Spleen	6.60± 3.50	17.80± 2.50	BDL	5.67± 2.09	4.27± 0.60	0.98± 0.19	8.64± 0.50	1.44± 0.30	0.53± 0.21
Oluku	Liver	2.05± 0.95	7.9± 4.50	BDL	13.24± 0.27	7.67± 7.43	2.19± 0.47	17.27± 6.63	15.43± 3.67	0.61± 0.20
	Intestine	2.70± 0.30	8.05± 4.35	BDL	14.57± 1.53	8.59± 0.66	0.59± 0.35	8.08± 1.27	11.43± 0.76	0.82± 0.65
	Spleen	1.45± 0.15	8.70± 2.90	BDL	8.19± 3.23	6.24± 2.90	1.17± 0.11	8.48± 0.44	9.89± 2.03	0.56± 0.24
Egor (reference point)	Liver	1.55± 0.45	4.70± 1.30	BDL	10.15± 0.59	10.29± 2.69	0.86± 0.00	11.28± 0.25	13.51± 8.56	0.56± 0.24
	Intestine	1.30± 0.20	2.40± 0.49	0.05± 0.00	4.96± 2.48	2.33± 2.05	1.19± 0.46	7.20± 4.09	9.70± 2.39	0.68± 0.14
	Spleen	2.55± 0.25	8.70± 3.50	0.07± 0.0	9.10± 6.45	13.43± 0.13	1.24± 0.20	10.65± 1.01	10.22± 2.36	0.72± 0.43
P-values		P>0.05	P>0.05	P>0.05	P>0.05	P>0.05	P>0.05	P>0.05	P>0.05	P>0.05
P-values		P>0.01	P>0.01	P>0.01	P>0.0	P>0.01	P>0.01	P>0.01	P>0.01	P>0.01
FAO (1999 and 2011a) limits		2	250	20	2	250	20	2	250	20

NB: BDL means beyond detectable limits, WHO means World Health Organization and FAO means Food and Agriculture Organization

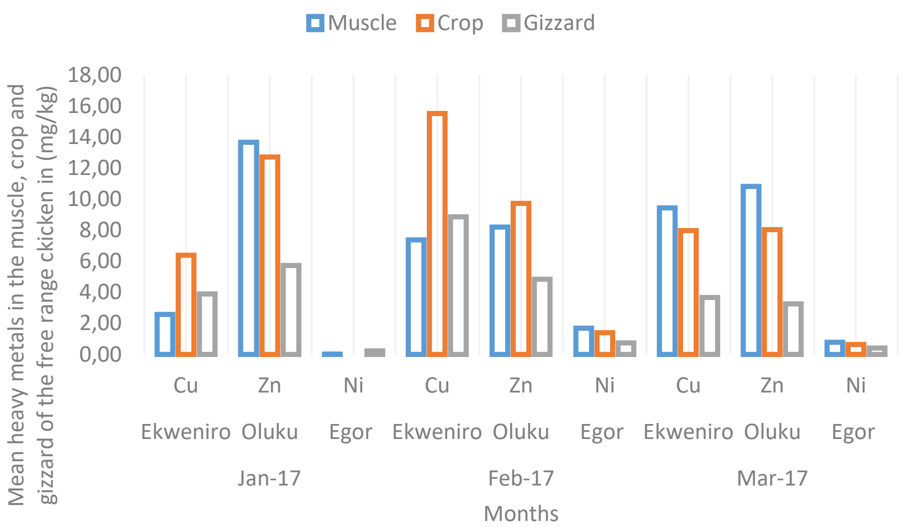

Fig. 2. Heavy metal contents in muscle, crop and gizzard of free range chicken sourced around three dump sites.

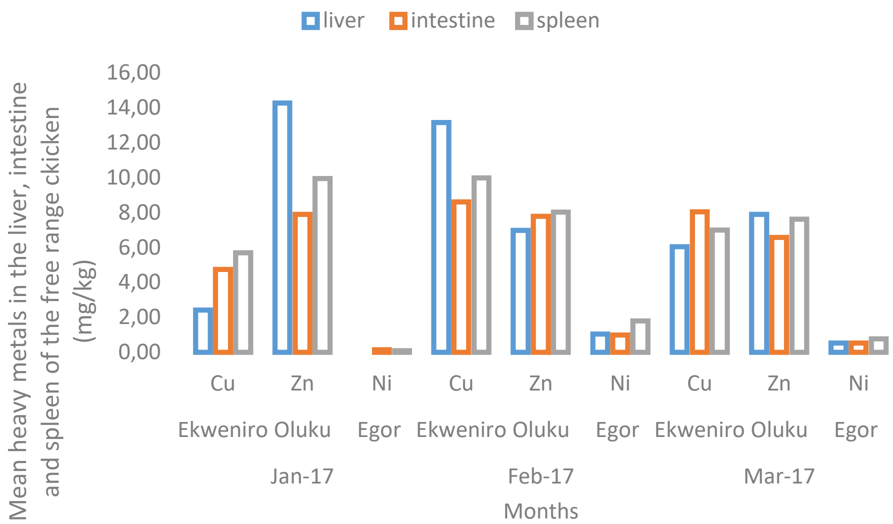

Fig. 3. Heavy metal contents in liver, intestine and spleen of free range chicken source around three dump sites.

Tab. 2.
The results of the Target Hazard Quotients (THQ) of heavy metals in muscles, crop and gizzard of free range *Gallus domesticus* around selected dumpsites

Months	**Jan-17**						**Feb-17**						**Mar-17**					
		THQ						**THQ**						**THQ**				
Location	Organs	Cu	Zn	Ni	TTHQ of each organ	TTHQ of all organs	Organ	Cu	Zn	Ni	TTHQ of each organ	TTHQ of all organs	Organ	Cu	Zn	Ni	TTHQ of each organ	TTHQ of all organs
Ekweniro	Muscle	0.05	0.82	0.00	0.87		Muscle	0.20	0.40	0.00	0.60		Muscle	0.01	0.00	0.00	0.01	
	Crop	0.13	0.34	0.00	0.47	**2.17**	Crop	0.22	0.46	0.00	0.69	**1.81**	Crop	0.01	0.00	0.01	0.02	0.04
	Gizzard	0.03	0.79	0.00	0.82		Gizzard	0.20	0.31	0.00	0.52		Gizzard	0.01	0.00	0.01	0.02	
Oluku	Muscle	0.09	0.83	0.00	0.91		Muscle	0.53	0.42	0.00	0.95		Muscle	0.15	0.56	0.00	0.71	
	Crop	0.22	0.54	0.00	0.76	**2.36**	Crop	0.33	0.43	0.00	0.76	**2.72**	Crop	0.22	0.21	0.00	0.43	**1.83**
	Gizzard	0.24	0.45	0.00	0.69		Gizzard	0.47	0.53	0.00	1.01		Gizzard	0.31	0.38	0.00	0.69	
Egor (reference point)	Muscle	0.07	0.39	0.00	0.46		Muscle	0.39	0.18	0.00	0.57		Muscle	0.15	0.12	0.00	0.27	
	Crop	0.05	0.25	0.00	0.30	**1.15**	Crop	0.19	0.21	0.00	0.40	**1.36**	Crop	0.10	0.17	0.00	0.27	**0.94**
	Gizzard	0.21	0.18	0.00	0.39		Gizzard	0.21	0.18	0.00	0.39		Gizzard	0.21	0.18	0.00	0.39	

Tab. 3.
The results of the Target Hazard Quotients (THQ) of heavy metals in liver, intestine and spleen of free range *Gallus domesticus* around selected dumpsites

Months	**Jan-17**						**Feb-17**						**Mar-17**					
			THQ					**THQ**							**THQ**			
Location	Organs	Cu	Zn	Ni	TTHQ of each organ	TTHQ of all organs	Organs	Cu	Zn	Ni	TTHQ of each organ	TTHQ of all organs	Organs	Cu	Zn	Ni	TTHQ of each organ	TTHQ of all organs
Ekweniro	Liver	0.03	0.59	0.00	0.62	**1.86**	Liver	0.1	0.33	0.00	0.44	**1.28**	Liver	0.00	0.00	0.00	0.01	0.02
	Intestine	0.04	0.18	0.00	0.21		Intestine	0.18	0.3	0.00	0.48		Intestine	0.00	0.00	0.00	0.01	
	Spleen	0.19	0.85	0.00	**1.04**		Spleen	0.16	0.2	0.00	0.37		Spleen	0.01	0.00	0.00	0.01	
				0.00														
Oluku	Liver	0.06	0.38	0.00	0.43	0.9	Liver	0.38	0.37	0.00	0.75	**2.11**	Liver	0.49	0.73	0.00	**1.23**	**2.72**
	Intestine	0.08	0.38	0.00	0.46		Intestine	0.42	0.41	0.00	0.83		Intestine	0.23	0.54	0.00	0.78	
	Spleen	0.00	0.00	0.00	0.00		Spleen	0.23	0.3	0.00	0.53		Spleen	0.24	0.47	0.00	0.71	
				0.00												0.00		
Egor (reference point)	Liver	0.04	0.22	0.00	0.27	0.91	Liver	0.29	0.49	0.00	0.78	**1.94**	Liver	0.32	0.64	0.00	0.97	**2.43**
	Intestine	0.04	0.11	0.00	0.15		Intestine	0.14	0.11	0.00	0.25		Intestine	0.21	0.46	0.00	0.67	
	Spleen	0.07	0.41	0.00	0.49		Spleen	0.26	0.64	0.00	0.9		Spleen	0.3	0.49	0.00	0.79	

NB: TTHQ means Total Target Hazard Quotients. Bolded and coloured values exceed recommended limits. While coloured values without bolded have the potentials to exceed recommended limits.

Tab. 4.
The results of the Estimated Daily Intake (EDI) of heavy metals in muscle, crop and gizzard of free range *Gallus domesticus* around selected dumpsites

	Jan-17					**Feb-17**				**Mar-17**		
			EDI				**EDI**				**EDI**	
Location	Organs	Cu	Zn	Ni	Organs	Cu	Zn	Ni	Organs	Cu	Zn	Ni
Ekweniro	Muscle	0.01	0.10	0.00	Muscle	0.04	0.05	0.01	Muscle	0.05	0.06	0.00
	Crop	0.03	0.04	0.00	Crop	0.05	0.06	0.01	Crop	0.08	0.07	0.00
	Gizzard	0.01	0.10	0.00	Gizzard	0.04	0.04	0.02	Gizzard	0.05	0.07	0.01
% PTDI of all organs		**0.01**	**0.02**	**0.01**		**0.03**	**0.01**	**0.60**		**0.03**	**0.02**	**0.28**
PTDI (FAO/WHO 1999 and 2003)		500	1000.00	5.00		500	1000.00	5.00		500	1000.00	5.00
Oluku	Muscle	0.02	0.10	0.00	Muscle	0.11	0.05	0.01	Muscle	0.03	0.07	0.00

	Crop	0.05	0.07	0.00	Crop	0.07	0.05	0.01	Crop	0.05	0.03	0.00
	Gizzard	0.05	0.06	0.00	Gizzard	0.10	0.07	0.01	Gizzard	0.06	0.05	0.00
% PTDI of all organs		**0.02**	**0.02**	**0.00**		**0.06**	**0.02**	**0.49**		**0.03**	**0.01**	**0.22**
PTDI (FAO/WHO 1999 and 2003)		500	1000.00	5.00		500	1000.00	5.00		500.00	1000.00	5.00
Egor (reference point)	Muscle	0.01	0.05	0.00	Muscle	0.08	0.02	0.01	Muscle	0.03	0.02	0.00
	Crop	0.01	0.03	0.00	Crop	0.04	0.03	0.00	Crop	0.02	0.02	0.00
	Gizzard	0.04	0.02	0.00	Gizzard	0.04	0.02	0.00	Gizzard	0.04	0.02	0.00
% PTDI of all organs		**0.01**	**0.01**	**0.07**		**0.03**	**0.01**	**0.24**		**0.02**	**0.01**	**0.12**
PTDI (FAO/WHO 1999 and 2003)		500	1000.00	5.00		500	1000.00	5.00		500	1000.00	5.00

Tab. 5.
The results of the Estimated Daily Intake (EDI) of heavy metals in liver, intestine and spleen of free range *Gallus domesticus* around selected dumpsites

	Jan-17				**Feb-17**				**Mar-17**			
		EDI				**EDI**				**EDI**		
Location	Organs	Cu	Zn	Ni	Organs	Cu	Zn	Ni	Organs	Cu	Zn	Ni
Ekweniro	Liver	0.01	0.07	0.00	Liver	0.02	0.04	0.01	Liver	0.02	0.03	0.00
	Intestine	0.01	0.05	0.00	Intestine	0.04	0.04	0.01	Intestine	0.01	0.03	0.00
	Spleen	0.01	0.03	0.00	Spleen	0.03	0.03	0.01	Spleen	0.05	0.01	0.00
% PTDI of all organs		**0.01**	**0.01**	**0.00**		**0.02**	**0.01**	**0.45**		**0.02**	**0.01**	**0.17**
PTDI (FAO/WHO 1999 and 2003)		500	1000	5		500	1000	5		500	1000	5
Oluku	Liver	0.01	0.05	0.00	Liver	0.08	0.05	0.01	Liver	0.08	0.05	0.01
	Intestine	0.02	0.05	0.00	Intestine	0.09	0.05	0.00	Intestine	0.09	0.05	0.00
	Spleen	0.01	0.05	0.00	Spleen	0.05	0.04	0.01	Spleen	0.05	0.04	0.00
% PTDI of all organs		**0.01**	**0.01**	**0.00**		**0.04**	**0.01**	**0.47**		**0.04**	**0.01**	**0.47**
PTDI (FAO/WHO 1999 and 2003)		500	1000	5		500	1000	5		500	1000	5
Egor (reference point)	liver	0.01	0.03	0.00	liver	0.06	0.06	0.01	liver	0.07	0.08	0.00
	Intestine	0.01	0.01	0.00	Intestine	0.03	0.01	0.01	Intestine	0.04	0.06	0.00
	spleen	0.02	0.05	0.00	spleen	0.05	0.08	0.01	spleen	0.06	0.06	0.00
% PTDI of all organs		**0.01**	**0.01**	**0.01**		**0.03**	**0.02**	**0.39**		**0.03**	**0.02**	**0.23**
PTDI (FAO/WHO 1999 and 2003)		500	1000	5		500	1000	5		500	1000	5

NB: PTDI means Provisional Daily Intake, FAO means Food and Agriculture Organization and WHO means World Health Organization. The coloured and bolded values have the potentials to exceed recommended limits.

Tab. 6.
The results of health risk impact (HRI) of the mean heavy metals in muscles, crop and gizzard of free range *Gallus domesticus* around selected dumpsites

	Jan-17				**Feb-17**				**Mar-17**			
			EDI				**EDI**				**EDI**	
Location	Organs	Cu	Zn	Ni	Organs	Cu	Zn	Ni	Organs	Cu	Zn	Ni
Ekweniro	Muscle	0.01	0.10	0.00	Muscle	0.04	0.05	0.01	Muscle	0.05	0.06	0.00
	Crop	0.03	0.04	0.00	Crop	0.05	0.06	0.01	Crop	0.08	0.07	0.00
	Gizzard	0.01	0.10	0.00	Gizzard	0.04	0.04	0.02	Gizzard	0.05	0.07	0.01
T_{HRI} of all organs		**45.94**	**405.70**	**0.02**		**131.28**	**243.56**	**1.50**		**168.18**	**321.51**	0.70
Rfdos		0.001	0.0006	0.02		0.001	0.0006	0.02		0.001	0.0006	0.02
Oluku	Muscle	0.02	0.10	0.00	Muscle	0.11	0.05	0.01	Muscle	0.03	0.07	0.00
	Crop	0.05	0.07	0.00	Crop	0.07	0.05	0.01	Crop	0.05	0.03	0.00

	Gizzard	0.05	0.06	0.00	Gizzard	0.10	0.07	0.01	Gizzard	0.06	0.05	0.00
T_{HRI} of all organs		**113.81**	**377.57**	**0.00**		**276.40**	**288.62**	**1.23**		**141.92**	**238.31**	**0.56**
Rfdos		0.001	0.0006	0.02		0.001	0.0006	0.02		0.001	0.0006	0.02
Egor (reference point)	Muscle	0.01	0.05	0.00	Muscle	0.08	0.02	0.01	Muscle	0.03	0.02	0.00
	Crop	0.01	0.03	0.00	Crop	0.04	0.03	0.00	Crop	0.02	0.02	0.00
	Gizzard	0.04	0.02	0.00	Gizzard	0.04	0.02	0.00	Gizzard	0.04	0.02	0.00
T_{HRI} of all organs		**69.23**	**170.16**	**0.19**		**164.80**	**117.87**	0.59		**95.62**	**98.65**	**0.29**
Rfdos		0.001	0.0006	0.02		0.001	0.0006	0.02		0.001	0.0006	0.02

Tab. 7.
The results of health risk impact (HRI) of the mean heavy metals in liver, intestine and spleen of free range *Gallus domesticus* around selected dumpsites

		Jan-17				Feb-17				Mar-17		
		EDI				EDI				EDI		
Location	Organs	Cu	Zn	Ni	Organs	Cu	Zn	Ni	Organs	Cu	Zn	Ni
Ekweniro	liver	0.01	0.07	0.00	liver	0.02	0.04	0.01	liver	0.02	0.03	0.00
	intestine	0.01	0.05	0.00	intestine	0.04	0.04	0.01	intestine	0.01	0.03	0.00
	spleen	0.01	0.03	0.00	spleen	0.03	0.03	0.01	spleen	0.05	0.01	0.00
T_{HRI} of all organs		**27.1**	**247.12**	0.00		**92.77**	**173.33**	**1.12**		**88.25**	**117.27**	0.43
Rfdos		0.001	0.0006	0.02		0.001	0.0006	0.02		0.001	0.0006	0.02
Oluku												
	liver	0.01	0.05	0.00	liver	0.08	0.05	0.01	liver	0.08	0.05	0.01
	intestine	0.02	0.05	0.00	intestine	0.09	0.05	0.00	intestine	0.09	0.05	0.00
	spleen	0.01	0.05	0.00	spleen	0.05	0.04	0.01	spleen	0.05	0.04	0.01
T_{HRI} of all organs		**36.85**	**244.15**	0.00		**213.94**	**222.86**	**1.17**		**213.94**	**222.86**	**1.17**
Rfdos		0.001	0.0006	0.02		0.001	0.0006	0.02		0.001	0.0006	0.02
Egor	liver	0.01	0.03	0.00	liver	0.06	0.06	0.01	liver	0.07	0.08	0.00
(reference point)	intestine	0.01	0.01	0.00	intestine	0.03	0.01	0.01	intestine	0.04	0.06	0.00
	spleen	0.02	0.05	0.00	spleen	0.05	0.08	0.01	spleen	0.06	0.06	0.00
T_{HRI} of all organs		**32.09**	**156.5**	0.04		**143.88**	**258.02**	0.98		**173.12**	**331.12**	**0.58**
Rfdos		0.001	0.0006	0.02		0.001	0.0006	0.02		0.001	0.0006	0.02

NB: Rfdos means reference dosages

CONCLUSION:

The findings of this study have revealed that free range chicken is susceptible to heavy metal contaminations from dump site activities and farming likewise. Higher heavy metal levels in free range chicken ascertained, using various indices, underpin the fact that man is exposed to potential health risks if he consumes additive parts of the free range chicken. The most conspicuous contaminant of concern is zinc found in high amounts followed by Cu and Ni. There might also be carcinogenic risk factor when Ni is consumed beyond the recommended threshold. The implication is that the free-range local chicken of these areas tends to accumulate the metals from the soil which pose health hazard to consumers. On this ground, we recommend a close litter system for the rearing of chicken in order to monitor what we consume. Because 'what we eat becomes part of us'. Heavy metals consumed beyond daily intake pose serious threat to human health.

ACKNOWLEDGEMENTS:

We thank the Department of Environmental Management and Toxicology for giving us the platform in conducting this research work and the Ecotoxicology and Forensic Unit of University of Benin, Benin City, for carrying out analytic analysis of the samples pro Bono.

REFERENCES:

Abduljaleel SA, Shuhaimi-Othman M, Babj, A, Assessment of trace metals contents in chicken (*Gallus gallus domesticus*) and Quail (*Coturnix coturnix japonica*) tissues from Selangor (Malaysia). Journal of Environmental Science and Technology, 5, 441-451, 2012.

Abdus-Salam N, Assessment of Heavy Metals Pollution in Dumpsites in Ilorin Metropolis. Ethiopian Journal of Environmental Studies and Management, 2, 2, 2009.

Ademoroti CMA, Standard Methods for Water and Effluent Analysis. Foludex Press. Ltd. Ibadan, 182, 1996.

Adewuyi GO, Opasina MA, Physicochemical and heavy metal Assessment of leachates from Aperin Abardoned Dumpsite in Ibadan city, Nigeria Environmental Journal of Chemistry, 7(4), 1278-1283, 2010.

Akan JC, Abdulraham FI, Sodipo OA, Choroma YA, Distribution of heavy metals in the liver, kidney and meat of beef, mutton, caprine and chicken from Kasuwan Shanu market in Maiduguri metropolis, Borno state, Nigeria. Research Journal of Applied Engineering and Technology, 2, 743-748, 2010.

Ali M, Ahmed Dalia M, Hamed N, Elsharawy T, Evaluation of some heavy metals residues in batteries and deep litter rearing systems in Japanese quail meat and offal in Egypt. Veterinary World, EISSN: 2231-0916. Available at www.veterinaryworld.org/Vol.10/February-2017/20.pdf.

Anke M, Grun M, Dittrick G, Groppel B, Hennig A, In: Trace Element Metabolism in Animals-2, WG Hoekstra, J.W., Shuttle, H.E., Ganther and Mertz, W., Editors. University Park Press, Baltimore, 715-718, 1974.

Arslan B, Djamgoz MB, Akün E, ARSENIC: A Review on Exposure Pathways, Accumulation, Mobility and Transmission into the Human Food Chain. Review on Environmental Contaminants and Toxicology, 243, 27–51, 2016.

Chary NS, Kamala CT, Raj DS, Assessing risk of heavy metals from consuming food grown on sewage irrigated soils and food chain transfer. Ecotoxicology and Environmental Safety, 69 (3), 513–524, 2008.

Chien LC, Hung TC, Choang KY, Yeh CY, Meng PJ, Shieh MJ, Han BC, Daily intake of TBT, Cu, Zn, Cd and As for fishermen in Taiwan. Science of a Total Environment, 285, 177-185, 2002.

Codex Alimentarius Commission (CAC), Food standards programme. Codex general standard for contaminants and toxins in foods. Doc. no. CX/FAC96/17. Joint FAO/WHO, 1995.

Copat C, Bella F, Castaing M, Fallico R, Sciacca S, Ferrante M, Heavy Metals Concentrations in Fish from Sicily (Mediterranean Sea) and Evaluation of Possible Health Risks to Consumers. Bulletin of Environmental Contamination and Toxicology, 88, 78–83, 2012.

Demirbas, Proximate and Heavy Metal Composition in Chicken Meat and Tissue. Food Chemistry, 67: 27-31, 1999.

Demirezen O, Uruc K, Comparative study of trace elements in certain fish meat and meat products. Journal Food of Chemistry, 32, 215–222, 2006.

Donia GR, Determination of some heavy elements residues in some organs of migratory Quail in relation to public health. International Journal of Scientific Research (IJSR), 4(10): 2048-2059, 2015.

Duruibe JO, Ogwuegbu MOC, Egwurugwu JN, Heavy metal pollution and human biotoxic effects. International Journal of Physiology and Science, 2, 112-118, 2007.

Enuneku AA, Ezemonye LI, Ainerua MO, Human health risk assessment of metal contamination through consumption of *Sesarmaangolense* and *Macrobrachium macrobrachion* from Benin River Nigeria. European International Journal of Science and Technology. 3, 6, 2014.

Falah S, Al-Fartusie, Saja N, Mohssan, Essential Trace Elements and their Vital Roles in Human Body. Indian Journal of Advance in Chemical Science, 5(3), 127-136, 2017.

FAO, The State of Food Insecurity in the World. Rome, 1999.

FAO, The State of Food Insecurity in the World. 2011, (http://www.fao.org/docrep/014/i2330e/i2330e00.htm).

FAO/WHO, Expert Committee on Food Additives, Summary and Conclusions, Fifty-third Meeting, Rome, 1999.

FAO/WHO, Summary and conclusions of the 61st meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA).JECFA/61/SC. Rome, Italy, 2003.

Farid AT, Roy KC, Hossain KM, Sen R, A study of arsenic contaminated irrigation water and it's carried over effect on vegetable. Dhaka Bangladesh University Journal of Engineering and Technology, 16, 113–121, 2003.

Hala SH, Mohamed H, Shireen MN, Estimation of some heavy metals in chicken. Egyptian Journal of Computational Pathology and Clinical Pathology, 22(3): 24-36, 2009.

Hang XS, Wang HY, Zhou JM, Ma CL, Du CW, Chen XQ, Risk assessment of potentially toxic element pollution in soils and rice (*Oryza sativa*) in a typical area of the Yangtze River Delta. Environmental Pollution, 157, 2542–2549, 2009.

Hassan AR, Saleh M, Sobih M, Wilson S, Reddy P, Effects of some heavy metals pollutants on the performance and immune system of chicks. Pollution Science, 77: 24-30, 1998.

Hays VW, Swenson MJ, Minerals and Bones. In: Dukes' Physiology of Domestic Animals, Tenth Edition 449-466, 1985, 2003.

Hellman NE, Gitlin, Ceruloplasmin metabolism and function. Annual Review of Nutrition. 22, 439-458, 2002.

Hough RL, Breward N, Young SD, Crout NMJ, Tye AM, Moir AM, Thornton I, Assessing potential risk of heavy metal exposure from consumption of home-produced vegetables by urban populations. Environ. Heal. Persp. 112, 215–221.

Hurley LS, Manganese and other Trace Elements. In: Present Knowledge in Nutrition (Nutrition Reviews'), Fourth Edition. The Nutrition Foundation, Inc. New York, Washington, 1976.

Islam MA, Romi´c D., Akber MA, Romi´c M, Trace metals accumulation in soil irrigated with polluted water and assessment of human health risk from vegetable consumption in Bangladesh. Environ. Geochem. Health. 1–27, 2017. [CrossRef] [PubMed].

Iwegbue CMA, Nwajei GE, Iyoha EN, Heavy metal residues of chicken meat and gizzard and turkey meat consumed in southern Nigeria. Bulgarian Journal Veterinary medication, 11(4), 275-280, 2008.

Janefrances N, Ihedioha Chukwuma OB, Okoye Uchenna A., Onyechi, Health risk assessment of zinc, chromium, and nickel from cow meat consumption in an urban Nigerian population. International Journal of Occupational and Environmental Health 2014 VOL. 20 NO. 4 281. W. S. Maney & Son Ltd 2014 DOI 10.1179/2049396714Y.0000000075.

Khan MZ, Perween SH, Gabol K, Khan IS, Baig N, Concentrations of heavy metals in liver, meat and blood of poultry chicken *Gallus domesticus* in three selected cities of Pakistan. Canadian Journal of Pure and Applied Science, 9(1), 3313-3324, 2015.

Khan S, Farooq R, Shahbaz S, Khan MA, Assessment of heavy metals for population via consumption of vegetables. World Applied Science and Journal, 6 (12), 1602-1606, 2009.

Lasky T, Sun WY, Kadry A, Hoffman MK, Mean total arsenic concentrations in chicken and estimated exposures for consumers of chicken. Environmental Health and Perspective, 112, 18-23, 2004.

Linder MCL, Wooten P, Cerveza S, Cotton R, Shulze N, Lomeli, Copper transport. American Journal of Clinical Nutrition. 67(5), 965S-971S, 1998.

Mariam I, Iqbal S, Nagra SA, Distribution of some trace and macro minerals in beef, mutton and poultry. Internal Journal of Agriculture and Biology, 6, 816-820, 2004.

Mineral Information Institute, The Role of Elements in Life Processes: Minerals, Elements and Nutrition. Available from: http://www.mii.org/periodic/lifeelement. html. Accessed on 15-04-2012.

National Research Council, Food Nutrition Board, 1980. Copper. In: Recommended Dietary Allowances, Washington, DC: NRC/NAS, p151-154.

Nick C, Oforka Leo C, Osuji Uche, I Onwuachu Assessment of Heavy Metal Pollution in Muscles and Internal Organs of Chickens Raised in Rivers State, Nigeria Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 3 (3): 406-411© Scholarlink Research Institute Journals, 2012 (ISSN: 2141-7016)jeteas.scholarlinkresearch.org.

Nielsen FH, In: Trace Elements in Human Health and Disease. A Prasad, Editor, Academic Press, New York, 2: 379-399, 1976.

O'Brien PJ, Bruce WR, Endogenous Toxins: Targets for Disease Treatment and Prevention, Toronto: John Wiley & Sons, 2, 405-406, 2009.

Okoye COB, Ugwu JN, Impact of Environmental cadmium, lead, copper and zinc on quality of goat meat in Nigeria. Bulletin of Chemistry Society of Ethiopian, 24(1), 133–8, 2010.

Pierson RE, Aenes WA, Treatment of chronic copper poisoning in sheep. Journal of American Veterinary Medicine Association. 133, 307-311, 1958.

Reem TH, Hussain M, Ebraheem KH, Hanady M, Assessment of heavy metals (Cd, Pb and Zn) contents in livers of chicken available in the local markets of Basrah city, IRAQ. Basrah Journal of Veterinary Research, 11(1), 43-51, 2012.

Roger M, The Minerals You Need, USA: Safe Goods Publishing. 21, 2011.

Saha N, Zaman MR, Evaluation of possible health risks of heavy metals by consumption of foodstuffs available in the central market of Rajshahi City, Bangladesh. Environmental Monitoring and Assessment, 185, 3867- 3878, 2012.

Scheuhammer, A.M., 1987. The chronic toxicity aluminium, cadmium, mercury and lead in birds: a review. Environ. Pollut. 46, 263.

Sharif LM, Dalal'eh R, Hassan M, Copper and mercury levels in Local Jordanian and Imported Sheep meat and organs. Bulgeria Journal of Veterinary Medicine, 8(4), 255-265, 2005.

Sileo L, Beyer WN, Mateo R, Pancreatitis in wild zinc poisoned waterfowl. Avian Pathology, 32, 655, 2003.

Skalicka M, Koréneková B, Nad P, Distribution of trace elements in liver and muscle of Japanese quails. Slovak Journal of Animal Science 41(4), 187-189, 2008.

Smedley PL, Kinniburgh DG, A review of the source, behavior and distribution of arsenic in natural Waters. Applied Geochemistry. 17, 517–568, 2002. [CrossRef].

Soetan KO, Olaiya CO, Oyewole OE, The importance of mineral elements for humans, domestic animals and plants: A review. African Journal of Food Science, 4(5), 200-222, 2010.

Solomon IP, Oyebadejo SA, Uyanga VA, Effect of heavy metals in feeding dumpsite forage (Calapo - *Calopogonium mucunoides*) on heamatological profile of Rabbits (*Oryctolagus cuniculus*). Asian Journal of Biomedical Pharmaceutical Science. 4(36), 35-43, 2014.

State Environment Protection Administration of China (SEPAC), Maximum level of contaminants in food (GB 2762-2005), 2005. Available from: ⟨http://www.ziq.gov.cn/portal/webfiles/web/file/12275082059288029.pdf⟩.

Tejada-Jimenez M, Galvan A, Fernandez E, Liamas A, Homeostasis of the micronutrients Ni, Mo and Cl with specific biochemical functions. Current Opinion of Plant. Biology, 12: 358-363, 2009.

Thirulogachandar AM, Rajeswari ME, Ramya S, Assessment of heavy metal impacts in Gallus and their impacts on human. International Journal of Scientific Research Publication, 4, 6. 1ISSN 2250-3153, 2014.

Uluozlu, O.D., Tuzen, M., Mendil, D., Soylak, M., 2008. Assessment of Trace Element Contents of Chicken Products from Turkey. J. Haz. Mat. (163), 2-3: 982-987.

US EPA, Risk Assessment Guidance for Superfund. Vol. I: Human Health Evaluation Manual (Part A); EPA/540/1- 89/002, 1989.

US EPA, Framework for Determining a Mutagenic Mode of Action for Carcinogenicity. Review Draft. EPA 120/R-07/002-A, Sep 2007a. http://www.epa.gov/osa/mmoaframework/pdfs/ MMOA-ERD-FINAL-83007. Pdf. US EPA, 2007b. Integrated Risk Information System. Available from: ⟨http://cfpub.epa.gov/ncea/iris/index.cfm? fuseaction=iris.showSubstanceList⟩.

US EPA, United States Environmental Protection Agency, Risk-based concentration table. Philadelphia: United States Environmental Protection Agency, Washington, DC, 2009.

US EPA, Recommended Use of BW3/4 as the Default Method in Derivation of the Oral Reference Dose. EPA/100/R11/001. Office of the Science Advisor, 2011, http://www.epa.gov/raf/publications/pdfs/recommended-use-of-bw34.pdf

Wang X, Sato T, Xing B, Tao S, Health risk of heavy metals to the general public in Tianjin, China via consumption of vegetables and fish. Science of a Total Environment, 350, 28–37, 2005.

Xu DC, Zhou P, Zhan J, Gao Y, Dou CM, Sun QY, Assessment of trace metal bioavailability in garden soils and health risks via consumption of vegetables in the vicinity of Tongling mining area, China. Ecotoxicology and Environmental Safety, 90, 103–111, 2013.

Xue ZJ, Liu SQ, Liu YL, Health risk assessment of heavy metals for edible parts of vegetables grown in sewage-irrigated soils in suburbs of Baoding City, China. Environmental Monitoring Assessment, 184, 3503–3513, 2012.

Young RA, Toxicity Profiles: Toxicity Summary for Cadmium, Risk Assessment Information System. University of Tennessee, Nashville, TN, USA, 2005.