PRINT ISSN 1119-8362
Electronic ISSN 2659-1499

Full-text Available Online at
https://www.ajol.info/index.php/jasem
https://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 28 (7) 1993-1998 July 2024

# Assessment of Heavy Metals and Pesticide Residues in *Abelmoschus esculentus* (Okro), *Amaranthus cruentus* (Spinach), *Hibiscus sabdariffa* (Roselle) and *Cabbage* Vegetables from Agricultural Area of Boronji Jimeta, Adamawa State, Nigeria

***MICAH, MM; PEACE, Z; USAKU, R; ONYEBUCHI, PU**

*Department of Science Laboratory Technology, Faculty of Life Sciences Modibbo Adama University, Yola, P.M.B 2076 Yola, Adamawa state Nigeria*

**Corresponding Author Email: musamicahmaster@mau.edu.ng*
**ORCID: https://orcid.org/0000-0001-5547-1879*
**Tel: +2347060760188*

*Co-Authors Email: usakureuben5@gmail.com; peacezubairu@gmail.com; puonyebuchi@mau.edu.ng*

**ABSTRACT:** Although green leafy vegetables are a great source of micronutrients, they can also often include harmful heavy metals and pesticides. Hence, the objective of this paper was to assess the levels of heavy metals and pesticide residues in Abelmoschus esculentus (Okra), Amaranthus cruentus (Spinach), Hibiscus sabdariffa (Roselle) and Cabbage vegetable samples from Agricultural Area of Boronji Jimeta, Adamawa State, Nigeria usingAtomic Adsorption Spectroscopy (AAS) and gas chromatography/mass spectrometry (GC-MS) respectively. Result show that the detected heavy metals include Cd,Cr, Pb, Zn, and Cu whereas pesticide residues include Dichlorvos, Dimethoate, Chlorpyrifos Lambda.-Cyhalothrin and Imdacloprid. The concentration of Cd 0.62mg/kg, 0.47mg/kg, 0.56mg/kg and 1.93mg/kg in spinach, Roselle, okra and Cabbage. Pb 0.60mg/kg, 0.35mg/kg and 0.32mg/kg in spinach, Roselle, and okra and pesticide residues in Dimethoate in cabbage 0.202mg/kg and Lambda.-Cyhalothrin 0.067mg/kg and Chlorpyrifos 0.195mg/kg in okra were found to be above the establish permissible limit. Pesticide residues and heavy metal levels fluctuated, showing distinct patterns even though they were mostly below the established maximum permissible limit. These heavy metals and pesticide residues can be harmful to human health, especially if consumed in excess. They can come from both naturally occurring and man-made sources.

**DOI: https://dx.doi.org/10.4314/jasem.v28i7.9**



**Cite this Article as:** MICAH, M. M; PEACE, Z; USAKU, R; ONYEBUCHI, P. U. (2024). Assessment of Heavy Metals and Pesticide Residues in *Abelmoschus esculentus* (Okro), *Amaranthus cruentus* (Spinach), *Hibiscus sabdariffa* (Roselle) and *Cabbage* Vegetables from Agricultural Area of Boronji Jimeta, Adamawa State, Nigeria. *J. Appl. Sci. Environ. Manage.* 28 (7) 1993-1998

**Dates:** Received: 21 May 2024; Revised: 17 June 2024; Accepted: 23 June 2024 Published: 02 July 2024

**Keywords:** Cabbage; Heavy Metals; Okra; Residues; Roselle; Spinach

A metal is referred to as "heavy metal" if it is extremely stable, has an atomic weight greater than 5 g/cm$^3$, cannot biodegrade in the environment, and has a low risk to people, plants, and animals. (Alkas *et al.*, 2017). As, Ni, Cd, Hg, Fe, Mn, Co, Cr, Pb, Zn, and Cu are the heavy metals that should be of the utmost concern. The environment is full of heavy metals, which are often detected in trace amounts in a variety of matrices. Both anthropogenic and natural processes contribute to the spread of these metals. (Harmanescu *et al.*, 2011 and Bortey *et al.*, 2015). Vegetables are essential for human health and a balanced diet. They contain a variety of nutrients, such as carbs, minerals, dietary fiber, proteins, and vitamins. Plants take heavy metals from contaminated soil through their roots in addition to their external parts, such as leaves and fruits, which are exposed to contaminated environments. Vegetables may potentially contain a trace amount of dangerous chemicals (Pan *et al.*, 2016). Raw or cooked, vegetables are a vital part of

**Corresponding Author Email: musamicahmaster@mau.edu.ng*
**ORCID: https://orcid.org/0000-0001-5547-1879*
**Tel: +2347060760188*

human diet since they are abundant in fiber, vitamins, and minerals and low in fat and carbs. Vegetable consumption is generally encouraged by governments, with five or more servings per day being the standard recommendation. Eating vegetables gives one of the quickest and least expensive ways to acquire enough vitamins, minerals, and fiber. Included in soups or given as essential components of the main course of a meal are vegetables that are utilized as food. Although leafy greens are an essential part of the human diet, they are also one of the dietary groups that most strongly contribute to the consumption of heavy metals, nitrates, and other anions. Especially as suppliers of vitamin C, thiamine, niacin, pyridoxine, folic acid, minerals, and dietary fiber, vegetables are crucial for human nutrition and health. (Siegel *et al.,* 2014). The use of pesticides, which are chemicals used to control pests in agricultural and other settings, can be beneficial in lowering crop losses and raising yields, but it can also have detrimental effects on the environment and human health. One such issue is the possibility of pesticide residues in food, which can lead to long-term exposure and health risks. One of the biggest threats to public health is the contamination of food sources, particularly vegetables, with pesticide residues. (Khan *et al*., 2010). Pesticide use is crucial, research must be done, and frequent, frequent monitoring programs must be carried out in order to give governments and rural extension organizations the guidance they need to accurately notify the public about the negative impacts of pesticides. One significant characteristic of these pesticides is that they have always been intended for use on large crops, particularly cereals. Nevertheless, because vegetables have short growing seasons and are cultivated in relatively small areas, these pesticides have evolved to become somewhat specific to vegetable crops. Vegetables usually provide a good return on investment per unit area, especially as buyers tend to favor goods with positive attributes, believing that these would secure their quality and health (Baptista *et al* 2007). Pesticide application rates may need to change depending on the agricultural and meteorological conditions, as well as between countries and regions within a single nation. (Leena *et al*., 2011) Thus, this paper was to assess the levels of heavy metals and pesticide residues in *Abelmoschus esculentus* (Okro), *Amaranthus cruentus* (Spinach), *Hibiscus sabdariffa* (Roselle) and *Cabbage* vegetable samples from Agricultural Area of Boronji Jimeta, Adamawa State, Nigeria

## MATERIALS AND METHOD

*Sample Collection:* Four samples of the following vegetables *Abelmoschus esculentus* (Okro), *Amaranthus cruentus* (Spinach), *Hibiscus sabdariffa* (Roselle) and *Cabbage was* randomly collected on different farm land at Borongi. The samples were washed and dried at room temperature in the laboratory. It was grinded into small particle size and stored in a polytene bag prior for analysis.

*Determination of Heavy Metals***:** Determination of heavy metals method from (Ashutosh *et al.,* 2018) was adopted**.** A weighing balance was used to weigh 1 gram of the sample, which was then divided into three separate 250 ml beakers and filled with 15 ml of aqua regia (HCL and $HNO_3$ in a 3:1 ratio). At 70°C, the combination was broken down until a translucent solution was obtained. After passing through filter paper, the resultant solution was transferred to a sample bottle and diluted with distilled water to the desired strength. The sample solution was analyzed for concentrations of Cu, Zn, Cd, Cr and Pb using an atomic absorption spectrophotometer.

*Sample Extraction Of Pesticide:* Optimization of extraction procedures for pesticide residues in vegetables using QuEChERS methodology. (Matiur *et al*., 2021)

*Weighing and Preparation:* A dried representative portion of 100g of each vegetable sample was weighed. Any visible dirt or debris from the samples was removed. The samples were cut into smaller pieces to facilitate extraction.

*Homogenization:* The weighed samples were transferred into a clean blender or grinder. The samples were Blended or grinded until a homogeneous powder was obtained. This step ensures that the analytes are evenly distributed within the sample.

*Sample Extraction*: The homogenized sample was placed in a suitable extraction vessel. A volume of 150ml of the extracting solvent (a mixture of acetone, hexane, and ethyl acetate) was added to the sample. The solvent was sufficient to cover the sample adequately.

Extraction Procedure**:** The sample-solvent mixture was agitated by manual shaking for 30 minutes. This facilitates the transfer of pesticide residues from the sample matrix into the solvent.

*Centrifugation:* After the extraction period, the sample-solvent mixture was centrifuge for 5 minutes at 4000 revolutions per minute (rpm) to separate the liquid phase (extract) from the solid phase (sample

matrix). The supernatant, containing the extracted pesticide residues, was carefully collected and transferred into a clean vial.

## RESULTS AND DISCUSSION

*Levels of Heavy Metals Concentration In Vegetables*: The present study reveals that the concentration of Pb ranges from 0.60mg/kg to 0.00mg/kg. In this study, Lead was 0.60mg/kg, 0.35mg/kg, 0.32mg/kg and 0.00mg/kg in *Amaranthus caudatus* (Spinach), *Hibiscus sabdariffa* (Roselle), okro and cabbage respectively. Pb in three of the samples: *Amaranthus caudatus* (Spinach), *Hibiscus sabdariffa* (Roselle) and okro were found to be above the safe limit of 0.30mg/kg recommended by (WHO/FAO 2001), while Pb was not detected in cabbage. Even while plants typically show high levels of Pb without showing any overt changes in look or yield, lead is a hazardous element that can be harmful to plants. Lead accumulation in many plants can reach several hundred times the upper limit of what is considered safe for human use. Long-term exposure to lead may weaken the central nervous system, slow down reaction times, and reduce comprehension ability. In children, lead exposure may cause behavioral problems, difficulty focusing and learning, and delayed reaction times. (Latif *et al.*, 2018).

**Table 1**: Concentration in mg/kg of Heavy Metals in Vegetables from Boronji

| S/No. | Metals | Spinach (mg/kg) | Roselle (mg/kg) | Okra (mg/kg) | Cabbage (mg/kg) | WHO/FAO SafeLimit (mg/kg) |
|---|---|---|---|---|---|---|
| 1. | Pb | 0.60±0.01 | 0.35±0.01 | 0.32±0.02 | 0.00±0.00 | 0.30 |
| 2. | Cu | 0.17±0.00 | 0.16±0.01 | 0.22±0.03 | 0.08±0.01 | 4.0 |
| 3. | Cd | 0.62±0.02 | 0.47±0.02 | 0.56±0.03 | 1.93±0.02 | 0.2 |
| 4. | Cr | 0.10±0.03 | 1.30±0.02 | 2.42±0.02 | 0.61±0.02 | 2.3 |
| 5. | Zn | 0.91±0.02 | 0.12±0.02 | 0.41±0.03 | 0.21±0.01 | 6.0 |

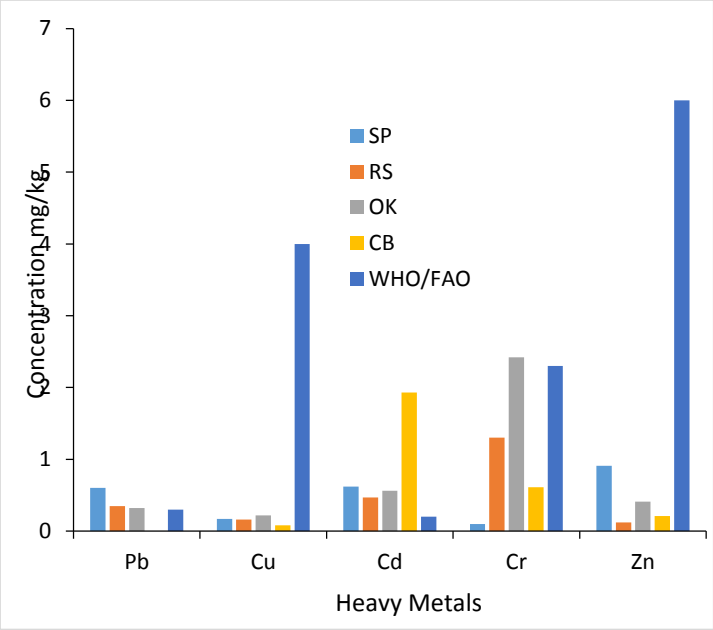


**Fig 1.** Heavy Metal Concentration in Vegetables

**Table 2** Pesticide Concentrations in Vegetable Samples (mg/kg)

| Compounds | RT(Min) | Cabbage (mg/kg) | Roselle (mg/kg) | Spinach (mg/kg) | Okora (mg/kg) | MRL (mg/kg) |
|---|---|---|---|---|---|---|
| Dichlorvos | 2.098 | ND | 0.018 | ND | ND | 0.02 |
| Dimethoate | 4.827 | 0.202 | ND | ND | 0.019 | 0.02 |
| Chlorpyrifos | 6.418 | ND | ND | ND | 0.195 | 0.05 |
| Lambda.-Cyhalothrin | 11.024 | ND | ND | ND | 0.067 | 0.03 |
| Imdacloprid | 30.599 | ND | ND | 0.016 | ND | 0.06 |

*ND: Not* Detected

The level of Cu recorded also range from 0.22mg/kg to 0.08mg/kg. The result obtained in this study also revealed that the concentration of Cu in the entire vegetable sample was lower than the recommended safe limit 4.00mg/kg (WHO/FAO, 2001). In this study the concentration of Cu. In *Hibiscus sabdariffa* (Roselle), cabbage, *Amaranthus caudatus* (Spinach), and Okoro was 0.016 mg/kg, 0.17 mg/kg, 0.22mg/kg

and 0.08mg/kg respectively. When the concentration of Cu was compared with values reported in literature, the values were found higher than 3.03 – 6.24 mg/g reported by Fisseha, (2002) in vegetable crops. (Thilini *et al.,* 2014) also reported 7.05-18.44 mg/kg which was higher than those reported in this study. Furthermore, it should be mentioned that Cu is necessary as a necessary food component. It is necessary for both enzymatic and non-enzymatic systems' cellular metabolism. A number of enzymes are significantly metallic-activated by copper. Low white blood cell counts and stunted growth are the results of Cu deficiency. Overconsumption of copper can result in neurological disorders, Wilson's illnesses, and vomiting. (Lewis *et al.,* 2015).

The level of Cd concentration ranges from 0.47mg/kg to 1.93mg/kg. In this study, Cd was 0.62mg/kg, 0.47mg/kg, 0.56mg/kg and 1.93mg/kg in Spinach, Roselle, Okro and Cabbage respectively. From this study, it is clearly revealed that the concentration of Cd in the entire vegetable sample was higher than the recommended safe limit 0.2mg/kg (WHO/FAO, 2001). It should be mentioned that cadmium is among the most hazardous elements and has been linked to human cancer. Serious health concerns are raised by the concentration of Cd absorption in plants that humans may later consume. (Dike *et al.*, 2004) stated that persons exposed to contaminated foods or water may experience mutagenic and carcinogenic effects from cadmium. It mostly builds up in the liver and kidney, and studies have shown that chronic kidney impairment can result from high concentrations of it. It interferes with biological systems' ability to regulate calcium, which results in cell damage and death. It has been discovered that fish and other aquatic life find it poisonous. Endocrine disruptive activities linked to cadmium may present significant health risks.

The present study also revealed that Zn concentration ranges from 0.91mg/kg to 0.10mg/kg. Zn was 0.91mg/kg, 0.12mg/kg, 0.41mg/kg, and 0.21mg/kg in *Amaranthus caudatus* (Spinach), *Hibiscus sabdariffa* (Roselle), okro and cabbage. However, all the vegetable samples in terms of Zn did notexceed the safe limit of 6.0mg/kg (WHO/FAO, 2001). Because zinc plays a crucial role in the metabolism of nucleic acids and the sequencing of proteins, regular consumption of vegetables may help prevent the negative effects of zinc deficiency, which include stunted growth and delayed sexual maturation. Inadequate zinc consumption can lead to deficiencies in zinc absorption, excessive zinc excretion, or genetic abnormalities in zinc metabolism. (Colak *et al.*, 2015, Narin *et al.*, 2005).

The level of Chromium ranges from 2.42mg/kg to 0.10mg/kg. The present study reveals the concentration of Chromium as 0.10 mm/kg, 1.30 mg/kg, 2.42 mg/kg and 0.61 mg/kg in *Amaranthus caudatus* (Spinach), *Hibiscus sabdariffa* (Roselle), okro and cabbage respectively. The level of chromium in three (3) samples spinach, roselle and cabbage were found to be lower than the safe limit 2.3mg/kg recommended by (WHO/FAO, 2001), with exception of okro which is above the safe limit. As a non-essential metal for plants, Cr has no known metabolic role or specialized absorption routes. According to certain theories, plants absorb certain critical ions through particular carriers, and the process varies depending on the kind of plant and Cr species. (Shahid *et al.,* 2017). The environment is highly concerned about chromium because of its fluctuating oxidation state. Cr is phytotoxic and has no metabolic use in plants. It is also not needed by plants. Whereas Cr (VI) occurs as oxyanions (such as dichromate, hydrochromate, and chromate), Cr (III) appears as a cation. In soil, the hexavalent Cr is more stable and highly mobile.

*Concentration of pesticide residues in vegetables:* The concentration of pesticide residues in cabbage is present in the table (2) above, one organophosphorus pesticide dimethoate (0.202mg/kg) was detected which exceeded the maximum residue limit (MRL) of 0.02mg/kg according to European food safety authority (EFSA). Dimethoate is commonly used to control pests in various crops (EFSA, 2021). It is concerning to find dimethoate in cabbage at levels higher than the recommended maximum residual levels. Exposure to dimethoate has been linked to a number of health problems, including neurotoxic side effects and possible carcinogenicity (EFSA, 2021). The higher concentration found in cabbage highlights the necessity of adhering more strictly to advised pesticide application procedures. The existence of dimethoate above maximum residual levels (MRLs) suggests possible health hazards and highlights the significance of pesticide usage monitoring and regulation in agriculture.

The concentration of pesticide residue in roselle is present in the table above, one organophosphorus pesticide chlorpyriphos (0.018mg/kg) was detected which was slightly below the maximum residue limit (MRL) of 0.02 mg/kg according to Codex alimentarius commission 2021 (REP21/PR). Because of its neurotoxic properties, chlorpyrifos is frequently employed in agriculture to manage a variety of pests (EFSA, 2021). Research has shown that exposure to chlorpyrifos has a negative impact on the neurological system, particularly in susceptible groups like children. (Bradman *et al*., 2011).

The concentration of pesticide residues in okra is present in the table (2) above, three organophosphorus pesticide was detected which include Lambda.-Cyhalothrin, Chlorpyrifos and. Dimethoate. Dimethoate (0.019mg/kg) was detected which was slightly below the maximum residue limit (MRL) of 0.02mg/kg according to European food safety authority (EFSA). While Lambda-Cyhalothrin (0.067mg/kg) and Chlorpyrifos (0.195mg/kg) in okra was detected which was above the established maximum residue limit MRLs is a cause for concern. The retention durations of 11.024 and 6.418 minutes line up with Lambda's anticipated retention duration Chlorpyrifos and Cyhalothrin. Lambda:Exposure to chlorpyrifos and cyclathrin has been linked to a number of health problems, including neurotoxic effects and possible carcinogenicity (EFSA, 2021). Okra's higher concentration highlights the necessity of adhering more strictly to advice pesticide application procedures. The existence of chlorpyrifos and lambda-cyhalothrin beyond maximum recommended levels (MRLs) raises concerns about possible health effects and highlights the need of controlling and observing pesticide use in agriculture.

The concentration of pesticide residues in spinach is present in the table (2) above, one organophosphorus pesticide Imdacloprid (0.06mg/kg) was detected which was below the maximum residue limit (MRL) of 0.06mg/kg according to Codex alimentarius commission 2021 (REP21/PR). The retention time of 30.5999 minutes corresponds to the expected retention time for Imdacloprid (Smith *et al*., 2018). Because of its neurotoxic properties, imidacloprid is frequently used in agriculture to manage a variety of pests (EFSA, 2021). Research has shown that exposure to imidacloprid can have negative effects on the neurological system, particularly in susceptible groups like children. (Bradman *et al*., 2011).

*Conclusion:* The findings of this study indicate that heavy metals and pesticides residues were present in the selected vegetables in Borongi Jimeta, Yola, Adamawa State, the detected heavy metals include Cd, Cr, Pb, Zn, and Cu and pesticide residues include Dichlorvos, Dimethoate, Chlorpyrifos Lambda.-Cyhalothrin and Imdacloprid. The results indicate that some of the heavy metals and pesticides residues were found to be above the safe limit while others were found to be below the safe limit. Pesticide residues and heavy metal levels fluctuated, showing distinct patterns even though they were mostly below the established maximum permissible limit. These heavy metals and pesticide residues can be harmful to human health, especially if consumed in excess. They can come from both naturally occurring and man-made sources.

*Declaration of Conflict of interest:* The authors have no conflict of interest in any form.

## REFERENCES

Alkas, F. B.; Shaban, J. A.; Sukuroglu, A. A.; Kurt, M. A.;Battal, D.; Saygi, S. (2017). Monitoring and assessment of heavy metal/metalloid concentration by inductively coupled plasma mass spectroscopy (ICP-MS) method in Gonyeli Lake, Cyprus. *Environ. Monit. Assess.* 189(10), 492.

Angelova, V. R.; Ivanova, R. V.; Todorov, J. M.; Ivanov, K. I. (2010). Lead, Cadmium, Zinc, and Copper Bioavailability in the Soil-Plant-Animal System in a Polluted Area. *Sci. World J.*, 10, 273-285. DOI: 10.1100/tsw.2010.26

.

Ashutosh, M.; Lav, K.; Munish, K. M. (2018). Analysis of Heavy Metal in Soil through Atomic Absorption Spectroscopy for Forensic Consideration. *Int. J. Res. Appl. Sci. Eng. Technol.*, 6(6), 1118-1192. DOI: 10.22214/ijraset.2018.612

Balkhair, K. S.; Ashraf, M. A. (2016). Field accumulation risks of heavy metals in soil and vegetable crop irrigated with sewage water in western region of Saudi Arabia. *Saudi J. Biol. Sci.*, 23(1), 32-44. DOI: 10.1016/j.sjbs.2015.02.009

.

Bortey-Sam, N.; Nakayama, S.; Akoto, O.; Ikenaka, Y., Fobil, J.; Baidoo, E.; Ishizuka, M. (2015). Accumulation of Heavy Metals and Metalloid in Foodstuffs from Agricultural Soils around Tarkwa Area in Ghana, and Associated Human Health Risks. *Int. J. Environ. Res. Public Health*, 12(8), 8811-8827. DOI: 10.3390/ijerph120808811

Colak, H.; Soylak, M.; Turkoglu, O. (2005). Determination of trace metal content of various herbal and fruit teas produced and marketed from Turkey. *Trace Elem. Electrolytes*, 22, 192-195. DOI: 10.1007/s10661-017-6283-1.

FAO/WHO (2001). Food additives and contaminants. Joint Codex Alimentarius Commission, FAO/WHO. Food Standards Programme, ALINORM 01/12A.

Fisseha Itanna (2002). Metals in Leafy vegetables grown in Addis Ababa and toxicological Implication, *Ethiop. J. Health Dev*. 16(3). 295-302.

Harmanescu, M.; Alda, L.; Bordean, D.; Gogoasa, I.;

Gergen, I. (2011). Heavy metals health risk assessment for population via consumption of vegetables grown in old mining area; a case study: *Banat County, Romania. Chem. Cent. J.* 5(1), 64.

Islam, E. U.; Yang, X.; He, Z.; Mahmood, Q. (2007). Assessing potential dietary toxicity of heavy metals in selected vegetables and food crops. *J. Zhejiang Univ. Sci.* 8(1), 1-13.

Khan MJ; Zia MS; Qasim M (2010) Use of pesticides and their role in environmental pollution. *World Acad Sci Eng Technol.* 48:122-128.

Latif, A.; Bilal, M.; Asghar, W.; Azeem, M.; Ahmad, M. I. (2018). Heavy metal accumulation in vegetables and assessment of their potential health risk. *J. Environ. Anal. Chem.* 5, 234-244.

Leena S; Choudhary SK; Singh Pk (2011). Organochlorine and organophosphorus pesticide residues in water of river Ganga At Bhagalpur, Bihar, *India*. *Int. J. Res. Chem. Environ.* 4(3):271-280.

Narin I; Tuzen M; Sari H; Soylak M (2005). Heavy metal content of potato and corn chips from Turkey. *Bull. Environ. Contam. Toxicol.* 74:1072-1077.

Pan, X.; Wu, P.; Jiang, X. (2016). Levels and potential health risk of heavy metals in marketed vegetables in Zhejiang, China. *Sci. Rep*. 6(1), 20317.

Shahid, M. (2017). Biogeochemical behavior of heavy metals in soil-plant system. *Higher Education Commission: Islamabad, Pakistan*, 1-196.

Siegel KR; Ali MK; Srinivasiah A; Nugent RA; Narayan KMV (2014) Do we produce enough fruits and vegetables to meet global health need? PLoS One. 2014;9

Sun, L.; Zheng, M.; Liu, H.; Peng, S.; Huang, J.; Cui, K.; Nie, L. (2014). Erratum to Water Management Practices Affect Arsenic and Cadmium Accumulation in Rice Grains. *Sci. World. J.* 1-2. DOI: **10.1155/2014/379654**