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Research Article

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Assessment of Heavy Metal Levels in Selected Vegetables Obtained from Irrigated Farmlands in North Central Geo-Political Zone of Nigeria

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Abstract The sustainability of human health depends on the intake of foods with essential nutritional composition. As the world population grow, the demand for various type vegetables increases. The methods of cultivating vegetables are versatile which mostly depends on the cultural background. Most farmers cultivate vegetables either at their backyard or through mixed farming system. The demand for more resources prompt some farmers instead of resting after rainy season enter into the practice of irrigation system to produce large volumes of vegetables to boost the daily needs. In this practice, they tend to use available water source which may be polluted couple with fertilizer in their production. The aim of this research is to assess the heavy metal levels in selected vegetables obtained from irrigated farmlands in North Central Geo-Political Zone of Nigeria**.** A random sampling design experiment was used to select and collected vegetable samples from kwara, Niger, Kogi, Benue and Nasarrawa states all in North central geo – political zone of Nigeria. After digestion of the sample powders, the filtrates obtained were analyzed using Atomic Absorption Spectrometry. The results of the analysis revealed that there were substantial amount of heavy metals (Cu, Mn, Fe, Cd, Ni, Zn, Pb) presence in the samples from kwara, Niger, Kogi, Benue and Nasarrawa states. As a result of this research, recommendations were made among others that, the farmers who practice irrigation system of farming should always be educated to guide against cultivation near existing industries or factories. Also, that there should be policy to guide and check the way and manners heavy metals and industrial wastes are being disposed in our major cities / towns

Keywords Atomic Absorption Spectroscopy, heavy metals, industrial waste, irrigation, Vegetables

1. Introduction

Vegetables are tender edible shoots, leaves, fruits and root of plants and spices that are consumed whole or in part, raw or cooked as a supplement to starch foods and meat [1]. Vegetables constitute essential diet components by its ability to contribute carbohydrate, proteins, vitamins, minerals that may be in short supply to human body [2]. Vegetables generally can serve as food sources and can help to provide adequate vitamins, minerals, trace essential elements and fibre [3].

Vegetables apart from their essential diet components, contains toxic elements (heavy metals) at diversified range of concentrations. The presence of these heavy metals in vegetables poses a serious threat to human health. Most plants and vegetables take up heavy metals through adsorption from contaminated soils, waste water used for irrigation, and some deposit through air on the exposed parts of the plants to the polluted environment [4]. Vegetables grown on soil contaminated with effluents containing heavy metals are prone to accumulate higher amounts of metals because they tend to absorb these metals through their roots [2]. Although, the absorption capacity of heavy metals by vegetables depends on their nature, hence some plants have higher ability to absorb heavy metals than others [5].

Many researchers had investigated the accumulation of heavy metals on some vegetables. A notable research work was done by [6], they investigated heavy metal contamination levelsof amaranthus grown along major highways in Lagos, Nigeria. [7] also investigated heavy metal levels in vegetables from selected markets in Lagos, Nigeria. [2] studied heavy metal levels in selected green leafy vegetables obtained from Katsina central market, Katsina, North-Western Nigeria. [7] stated that green leafy vegetables are used by many homes in Nigeria and other parts of West Africa in the preparation of soup. Since the intake of contaminated vegetables contribute to accumulation of heavy metals in human body and consumption of vegetables cannot be avoided, this study was carried out to assess the cumulative levels of copper, manganese, iron, cadmium, nickel, zinc and lead in selected vegetables that are consumed regularly by inhabitants of the chosen states in the North central geo-political zone of Nigeria.

2. Materials and Methods

2.1 Materials and reagents

Chemicals used were of analytical grade. All glass wares and plastic containers used were washed with detergent solution, then with 20% (v/v) nitric acid and then rinsed with tap water and finally with distilled water. The standard solutions of the metal salts and other needed reagents were adequately prepared.

2.2 Study Area

The area covered in this research work was randomly selected in North Central Zone of Nigeria. The randomly sampled towns were, in Kwara (Ilorin and Offa), Niger (Minna and Bida), Kogi (Lokoja and Okene), Benue (Makurdi and Katsina Ala), Nasarawa (Lafiya and Keffi).

2.3 Sample and Sampling

A total of 50 samples of five different vegetables that is, spinach, tomato fruits, pepper, pumpkin, okro fruits were purchased from the towns in the states as stated above in North Central geo- political zone of Nigeria.

2.4 Sample Treatment

The vegetables purchased were washed with 20% (v/v) nitric acid and then rinsed with ordinary water then further rinsed with distilled water. The samples were cut into pieces with knife and were air dried in the laboratory for 5 days before oven dried at 105 ^{o}C for about 24 h. The samples were crushed into powder in a mortar with a pestle. The samples were then sieved through a 2 mm colander and were kept in polyethylene leather for further analysis.

2.5 Sample Digestion

[8] digestion procedure was used for the vegetable samples. 0.5g of sieved samples was weighed into 100 cm^3 beaker. A mixture of 5 cm^3 concentrated HNO_3 and 2 cm^3 $HClO_4$ were added to dissolve the sample. The beaker was heated at moderate temperature of 110^{o}C on a hot plate for 1 h in a fume hood until the content was about 2 cm^3. The digest was cooled, filtered into 50 cm^3 standard volumetric flask and made up to the mark with distilled water.

2.6 Sample Analysis

A serial dilution method was used to prepared the working standards and the concentrations of the metals in each sample digest were determined using Atomic Spectrophotometer (Buck Model 210 VGP) equipped with a digital readout system.

2.7 Data Analysis

The data obtained were analyzed using Microsoft Excel and results were expressed as mean $\pm$ standard deviation.

3. Presentation and Discussion of Result

3.1 Presentation of Results

The concentrations of heavy metals of the sampled vegetables were presented in the following tables; table 1, 2, 3, 4 and 5 respectively.

Table 1: Concentration of Metals in Spinach Samples (mg/kg)

Elements	S (Ilorin)	S. (Offa)	S. (Minna)	S (Bida)	S. (Lokoja)	S. (Okene)	S (Makurdi)	S. (K.Ala)	S. (Lafia))	S. (Keffi)	RMLV
Cu	24.23±4.78	20.33 ± 3.79	25.32 ±4.97	24.24 ±4.79	26.10 ±5.26	24.23 ±4.78	20.24 ±3.78	25.33 ±4.98	24.23 ±4.78	26.10± 5.26	73.30
Mn	221.55±32.34	212.45 ± 31.28	202.45 ±30.27	223.54 ±32.35	223.54 ±32.35	221.54±32.34	222.53±32.34	202.43±30.28	223.55±32.35	202.44±30.28	500.00
Fe	104.00±9.34	100.00 ±6.32	103.00 ±9.12	105.00 ±9.35	105.00 ±9.35	104.00±9.34	105.00 ±9.35	104.00 ±9.34	105.00± 9.35	104.00± 9.34	425.50
Cd	3.05± 0.13	2.15 ±0.11	3.15± 0.14	3.04 ±0.13	ND	ND	ND	ND	ND	3.05 ±0.13	0.20
Ni	12.90 ±0.13	11.30± 0.12	12.10 ±0.12	12.90 ±0.13	11.30 ±0.12	12.30± 0.12	ND	ND	ND	11.30 ±0.12	67.90
Zn	54.68 ±23.10	51.36± 21.10	53.78 ±23.18	55.23 ±23.12	55.23 ±23.12	53.68 ±23.18	54.78 ±23.10	53.77 ±23.10	53.78 ±23.10	53.77 ±23.10	99.40
Pb	3.15 ± 0.04	2.13± 0.02	3.13 ±0.03	2.14 ±0.02	3.13± 0.03	2.14 ±0.02	2.14 ±0.02	2.13 ±0.02	2.13 ±0.02	2.14 ±0.02	0.30

*ND=Not detected

Table 2: Concentration of Metals in Tomato Samples (mg/kg)

Elements	T. (Ilorin)	T. (Offa)	T. (Minna)	T. (Bida)	T. (Lokoja)	T. (Okene)	T. (Makurdi)	T.(K.Ala)	T.(Lafia)	T.(Keffi)	RMLV
Cu	18.55 ±6.45	19.56± 7.35	18.54 ±6.45	19.55 ±7.35	18.53 ±6.45	19.55 ±7.35	18.54 ±6.45	19.55 ±7.35	18.55 ±6.45	18.53± 7.35	73.30
Mn	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	500.00
Fe	76.62 ±5.13	78.63 6.13	80.33 ±7.12	76.63 ± 5.13	78.64 ±6.13	77.62 ±5.14	76.63 ±5.13	78.64 ±6.13	80.33 ±7.12	19.55 ±7.35	425.50
Cd	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.20
Ni	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	67.90
Zn	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	99.40
Pb	ND	3.15 ±0.04	2.13 ±0.02	2.14 ±0.02	3.13 ±0.03	2.13 ±0.02	ND	ND	2.13 ±0.02	N	0.30

*ND=Not detected

Table 3: Concentration of Metals in Ugwu Samples (mg/kg)

Elements	U. (Ilorin)	U. (Offa)	U. (Minna)	U. (Bida)	U. (Lokoja)	U. (Okene)	U. (Makurdi)	U.(K.Ala)	U.(Lafia)	U.(Keffi)	RMLV
Cu	18.54 ± 6.45	19.55 ±7.35	19.56 ±7.35	18.53± 6.45	19.56 ±7.35	18.54± 6.45	21.23 ±3.79	25.32 ±4.97	25.33 ±4.97	25.32 ±4.97	73.30
Mn	224.99±32.49	223.55 ±32.36	225.56 ±32.51	223.54 ±32.36	223.53 ±32.36	224.99 ±32.49	212.45±31.28	225.56 ±32.51	225.56 ±32.51	223.54±32.35	500.00
Fe	105.05±1.35	104.33 ±9.34	105.00± 1.35	104.00± 9.34	105.54± 32.36	105.00 ±9.35	106.00 ±9.36	105.00± 9.35	105.00 ±9.35	103.00± 9.12	425.50
Cd	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.20
Ni	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	67.90
Zn	54.35 ±23.27	53.68± 23.18	54.68 ±23.10	51.36 ±21.10	54.67 ±23.10	53.68 ±23.18	54.35 ±23.27	53.68 ±23.18	54.78 ±23.11	53.78± 23.18	99.40
Pb	0.006 ± 0.005	0.071 ±0.025	0.004 ±0.009	0.071 ±0.025	0.006 ±0.005	0.044 ±0.026	0.071 ±0.025	0.006 ±0.002	2.13 ±0.02	0.004 ±0.009	0.30

*ND=Not detected

Table 4: Concentration of Metals in Okro Samples (mg/kg)

Elements	O (Ilorin)	O. (Offa)	O. (Minna)	O. (Bida)	O. (Lokoja)	O. (Okene)	O. (Makurdi)	O.(K.Ala)	O.(Lafia)	O.(Keffi)	RMLV
Cu	31.33 ±4.01	33.33± 4.07	30.33 ±4.00	31.33 ±4.01	51.10 ±4.12	50.10± 4.11	30.33 ±4.00	31.33± 4.01	33.33± 4.07	31.33 ±4.01	73.30
Mn	191.75 ±5.14	192.75± 5.16	190.75 ±5.13	190.75 ±5.13	190.74 ±5.14	191.74± 5.14	45.20± 9.55	191.75± 5.14	190.75± 5.13	92.10± 22.36	500.00
Fe	86.00 ±3.11	93.55 ±3.56	85.00 ±3.11	86.00 ±3.12	86.00± 3.11	85.00 ±3.11	74.18 ±2.22	86.00 ±3.11	85.00 ±3.11	85.00 ±3.11	425.50
Cd	0.72 ±0.02	0.71 ±0.02	ND	ND	0.72 ±0.02	5.70 ±0.55	ND	ND	ND	ND	0.20
Ni	ND	ND	ND	ND	ND	13.00 ±0.15	ND	ND	ND	ND	67.90
Zn	33.54 ±4.02	33.53 ±4.02	33.53± 4.02	21.22 ±5.98	33.53 ±4.02	53.25 ±12.50	21.22 ±5.98	33.54 ±4.02	33.53 ±4.02	33.56± 4.02	99.40
Pb	3.21 ±0.05	3.20 ±0.05	ND	ND	3.20 ±0.05	3.20 ±0.06	ND	ND	ND	ND	0.30

*ND=Not detected

Table 5: Concentration of Metals in Pepper Samples (mg/kg)

Elements	P. (Ilorin)	P. (Offa)	P. (Minna)	P. (Bida)	P. (Lokoja)	P. (Okene)	P. (Makurdi)	P.(K.Ala)	P.(Lafia)	P.(Keffi)	RMLV
Cu	53.25 ±12.50	52.15± 11.23	51.25 ±10.97	51.10 ±4.12	25.26 ±5.87	18.45 ±6.44	53.25 ±12.50	52.15 ±11.23	51.10 ±4.12	25.25 ±5.87	73.30
Mn	29.86 ±8.36	29.86 ±8.36	31.33 ±4.01	92.10± 22.36	91.75± 5.14	ND	29.85 ±8.35	31.33 ±4.01	25.26 ±5.87	29.84 ±8.35	500.00
Fe	80.67± 8.76	80.53 ±8.66	85.00 ±3.11	93.55 ±3.68	85.00 ±3.11	77.63 ±5.22	80.69 ±8.77	85.01 ±3.11	93.55 ±3.56	77.63 ±5.22	425.50
Cd	ND	ND	0.700 ±0.02	5.70 ±0.55	13.00 ±0.15	0.71 ±0.02	ND	ND	5.70 ±0.56	0.71 ±0.02	0.20
Ni	ND	ND	ND	ND	12.90 ±0.13	11.30 ±0.12	ND	ND	ND	ND	67.90
Zn	21.21 ±5.97	22.21 ±6.01	33.54 ±4.02	0.89 ±0.05	33.54 ±4.02	21.22 ±5.98	21.22± 5.98	22.21 6.01	0.89 ±0.05	53.77 ±22.11	99.40
Pb	3.15 ±0.04	3.13± 0.03	ND	ND	3.21 ±0.05	2.14± 0.02	ND	ND	ND	ND	0.30

*ND=Not detected

Discussion of Results

The result of the analysis shows clear differences in the concentrations of the heavy metals. The observed concentrations of Cu, Mn, Fe, Cd, Ni, Zn, and Pb in spinach samples from all sampled areas were 20.33 – 26.10 mg/kg, 202.43 – 223.55 mg/kg, 100.00 – 105.00 mg/kg, 2.15 – 3.15 mg/kg, 11.30 – 12.90 mg/kg, 51.36 – 55.23 mg/kg, and 2.13 – 3.15 mg/kg respectively. In all 10 sampled spinach from various markets, the Cu concentrations in the 10 sampled spinach, the Mn concentrations in all 10 spinach samples, the Fe concentrations in all 10 samples, the Cd concentrations in 5 samples, the Ni concentration in 7 samples, the Zn concentration in all 10 samples, and the Pb concentrations in 10 samples were lower than the recommended maximum levels of contaminants in foods as set by the [9], except Cd and Pb which are higher. However, the lowest concentration of Cu was found in spinach sold in Offa Kwara state of Nigeria. The lowest concentration of Mn was found in spinach sold at Katsina Ala in Benue state. The lowest Fe, Cd, Ni, Zn, Pb concentrations was found in spinach sold at Offa Kwara state. This result has shown that the spinach grown and sold in Offa market is one of the best to be consumed except it prevailing Cd and Pb whose presence is above the threshold level of tolerance.

The concentration metals in okro fruits across the selected markets is that, the Cu concentrations were between 30.33- 51.10, Mn concentrations was 45.20 – 192.75, the Fe concentrations were between 74.18- 93.55, the Cd concentrations were 0.71 -5.70, the presence of Ni was only detected in the okro sold at Okene market, the Zn concentration was 21.22 – 53.25, and finally, the Pb concentration was between 3.20 – 3.21 respectively. These results have indicated that among the sampled okro fruits across the markets, only Cd and Pb were above the tolerance level among the heavy metals investigated. The best of okro fruit is obtained in Minna, Bida, Markurdi, katsina Ala, Lafia and Keffi.

The concentration of heavy metals in pepper samples in all selected markets were, Cu concentrations were 18.45 – 53.25, the Mn concentration were between 25.26 – 92.10, the Fe concentrations were 77.63 – 93.55, Cd concentration was found to be between 0.700 – 13.00, the Ni concentration was 11.30 – 12.90, while Zn concentrations was 0.89 – 53.77, and finally the Pb concentrations was 2.14 – 3.21 respectively. Minna, Bida, Makurdi, Katsina Ala, Lafia and Keffi have the best pepper to be freely consumed without any problem.

The concentrations of heavy metals in tomato samples from various selected markets were, the Cu concentration in tomatoes was found to be between 18.55 – 19.55, while the Mn was absent in all tomatoes sampled from all markets. The concentrations of Fe was 19.55 – 80.33, Cd, Ni and Zn were not detected in all sampled tomatoes from various market. The concentration of Pb was 2.13 – 3.15. Tomatoes fruits from Ilorin, Makurdi, Katsina Ala and Keffi are free to be consumed.

The last sample was fluted pumpkin (ugwu) with various heavy metal concentrations. From the analysis, it was also discovered that fluted pumpkin sampled from various markets contain significance amount of heavy metals which differs from market to market. The Cu concentrations in fluted pumpkin were 18. 54 – 25. 33, Mn concentrations was 212.45 – 225.56, the Fe concentrations was 103.00 – 106.00. The Cd and Ni were not detected in all fluted pumpkin sampled from all markets. The presence of Zn was 51.36 – 54.78, while Pb concentrations were 0.004 – 2.13 respectively.

However, it could be observed that all vegetables have retention capacities for essential metals (Cu, Zn, and Fe) than the toxic ones (Pb, Cd, Ni and Mn). Lead is a toxic element that can be harmful to plants, although plants usually show ability to accumulate large amounts of lead without visible changes in their appearance or yield. In many plants, Pb accumulation can exceed several hundred times the threshold of maximum level permissible for human consumption (Muhammad *et al*., 2008). The high levels of Pb in some plants may probably be attributed to pollutants in irrigation water, farm soil or due to pollution from the highways traffic [10]. [11] reported that Chinese cabbage picks up Pb more readily compared to other heavy metal such as Cd, Cu, Ni, and Zn. The level of Pb in this study is found highest in the spinach, okro, peppers, tomatoes, and lowest in fluted pumpkin (0.004 mg/kg). The Pb contents in the sampled vegetables are higher (2.13 – 3.15 mg/kg) when compared with the [9] safe limit of 0.3 mg/kg. Thus, the Pb level in the vegetables examined seems too high (2.13 – 3.15) except in okro from Minna, Bida, Makurdi, Katsina Ala, Lafia, Keffi, and in peppers from Minna, Bida, Makurdi, Katsina Ala, Lafia, Keffi, in tomatoes from Ilorin, Makurdi, Katsina Ala and Keffi where Pb was not detected. Lead from road traffic still remains the key source with non-ferrous metal manufacturing, stationary fuel combustion as well as iron and steel production as additional significant source categories [12].

The major sources of cadmium originate from atmosphere. They are significantly obtained from various combustion processes based on fossil fuels (in particular coal and oil), as well as various processes in the pyrometallurgical non-ferrous metal industries [12]. Cd is a non-essential in foods and natural waters and it accumulate principally in the kidney and liver [13], Various sources of environmental contamination have been reported for its presence in foods and various values have been reported for leafy vegetables which include 0.090 mg/kg for fluted pumpkin by [14], 0.049 mg/kg for lettuce by [15]. In contrast, no Cd was detected in spinach sold at Lokoja, Okene, makurdi, katsina Ala, Lafia, okro sold in minna, Bida, makurdi, katsina Ala, Lafia, keffi, in peppers sold in Ilorin, offa, makurdi, katsina Ala, in tomatoes sold in all sample markets and fluted pumpkin sold in all sampled markets respectively. Although, where their presence was detected they are within safe limit, regular monitoring is required over a long period as the vegetables are transported from different sources.

Fe is essential for the synthesis of chlorophyll and activates a number of respiratory enzymes in plants. The deficiency of Fe results in severe chlorosis of leaves in plants. High levels of exposure to iron dust may cause respiratory diseases such as chronic bronchitis and ventilation difficulties. Fe content is found highest in spinach sold in Biba, Lokoja, Makurdi,and Lafia (105.00 mg/kg) and lowest in that sold at Offa market (100.00 mg/kg). Also, highest amount was found in okro at Offa (93.55 mg/kg) while lowest at that sold at Makurdi (74. 18 mg/kg). Substantial amounts were also recorded in pepper, fluted pumpkin at various concentrations. These values are far below the recommended maximum levels by [9] safe limit of 425.00 mg/kg. These vegetables could be good supplement for Fe.

Zn is the least toxic and an essential element in human diet as it is required to maintain the functioning of the immune system [2]. Zn deficiency in the diet may be highly detrimental to human health than too much Zn in the diet. The recommended dietary allowance for Zn is 15 mg/day for men and 12 mg/day for women, Agency for Toxic Substances and Disease Registry [16], but high concentration of Zn in vegetables may cause vomiting, renal damage, cramps etc. Spinach sold in Lokoja recorded the highest level of Zn which is 55.23 mg/kg while pepper cultivated and sold in Nasarrawa has lowest (0.89 mg/kg). The tomatoes sold in all sampled markets seem not to have Zn in them even at trace level. These values are higher when compared to those reported in available literatures. [14] have reported Zn level of 0.011, 0.070 and 0.05 mg/kg in the leaves of bitter leaf, water leaf and cabbage respectively. The contents of Zn in all the sampled vegetables examined are generally lower than the permissible levels by the FAO/WHO in vegetables as shown in tables 1, 2, 3, 4, and 5 respectively. Regular consumption of these five vegetables may assist in preventing the adverse effect of zinc deficiency which results in retarded growth and delayed sexual maturation because of its role in nucleic acid metabolism and protein synthesis [17].

Cu is also an essential micronutrient which functions as a biocatalyst required for body pigmentation in addition to Fe, maintains a healthy central nervous system, prevents anaemia and interrelated with the functions of Zn and Fe in the body [18]. However, most vegetables contain the amount of Cu which is inadequate for normal growth which is usually ensured through artificial or organic fertilizers [19]. Although, among all heavy metals, Cu is the most abundant element which recorded highest concentration of 93.55mg/kg in pepper sold at Lafia. The least concentration of 19.55 mg/kg was recorded in tomato sold at Keffi. The results obtained in the study were observed to be lower compared to other published results. [20] reported values of 5.00, 5.75 and 5.32 mg/kg for the concentration of Cu in carrot, cucumber and spinach. The contents of Cu in this study and from other published works were within the permissible level of 73.00 mg/kg by the FAO/WHO in vegetables.

The exposure of consumers and the related health risks are usually expressed in terms of the provisional tolerable daily intake. The [21] have set a limit for the heavy metal intake based on the body weight for an average adult, namely, 60 kg body weight. The average diet per person per day of vegetables is 98 g [2]. The outcome of this study has clearly indicated differences between the compositions of heavy metals in the respective sampled vegetables.

Conclusion

The results reported in this study confirmed that the vegetables obtained from various sampled markets in North Central geo-political zone contain substantial amounts of heavy metals (Cu, Mn, Fe, Cd, Ni, Zn and Pb). Although, the level of some of these metals are found to be within the safe limits prescribed by the FAO/WHO. This result is therefore considered to be very important as human health is directly affected by consumption of these vegetables. The monitoring of heavy metals in vegetables needs to be a continued research work, because these vegetables are the main sources of food for humans in many parts of the world and hence were considered as bio-indicators of environmental pollution.

Recommendations

Based on the results of this analysis, the following recommendations were made:-

- It is advice that the soil samples of the farming sites should be investigated to determine the level of heavy metals.
- There should be more research on other related vegetables cultivated and consumed in the sampled areas of the geo- political zone.
- There is always the need to educate people on the menace cause to health by consuming heavy metals above recommended levels
- The farmers who practice irrigation system of farming should always be educated to guide against using water source near industrial effluents for irrigation
- The provision of public enlightenment among the populace should always be put in place to facilitate dissemination of information regard dangers associated with heavy metals
- There should be policy to guide and check the way and manners heavy metals and industrial wastes are being disposed in our major cities / towns mostly especially through water ways
- The wetland needs to be protected as they provide the best avenue for irrigation farming

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