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Levels of Heavy Metals (Cu, Zn, Pb, Fe and Cr) in Bushgreen and Roselle Irrigated with Treated and Untreated Urban Sewage Water

Chiroma T.M.[1], Ebewele R.O.[2] and Hymore F.K.[2]
[1]Department of Chemical Engineering, Modibbo Adama University of Technology Yola, Adamawa State, NIGERIA
[2]Department of Chemical Engineering, University of Benin, Benin City, NIGERIA

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Abstract

The content of Cu, Zn, Pb, Fe and Cr in Bushgreen and Roselle vegetable plants, soil irrigated with treated and untreated urban sewage water were evaluated using atomic absorption spectrophotometer. The concentration of Cu (0.078 µg/ml), Zn (1.065 µg/ml), Pb (1.034 µg/ml), Fe (2.512 µg/ml) and Cr (0.081 µg/ml) in untreated sewage water were reduced by 58%, 46%, 27%, 70% and 33% respectively, after treatment with Alum. The mean concentration of Pb, Cu and Cr in treated and untreated sewage waters are above the maximum permissible values of 0.2µg/ml, 0.01µg/ml and 0.05µg/ml respectively for irrigation waters used on all types of soils. The levels of Zn in soils irrigated with sewage water and Pb in soils irrigated with treated sewage water are above the maximum tolerable levels of 300µg/g and 100µg/g respectively. The contamination of Zn and Cr in leaves (unwashed), leaves (washed), stem and roots of Bushgreen irrigated with sewage water are 2.5, 1.7, 1.3, 3.2 and 2.1, 1.7, 1.9, 1.1 times respectively, higher than the maximum permissible level in plants sets by World Health Organization (WHO).

Key words: Heavy metals, treated, untreated, sewage water.

Introduction

In recent years there has been an increasing consumption of vegetables among the urban community. This is due to increase awareness of their nutritive value, as a result of exposure of people to proper education. However, vegetables contain both essential elements and also toxic element that may have potential for varying degrees of contamination. Heavy metal contamination in vegetables may pose a direct threat to human health, and it is one of a range of important types of contaminants that can be found on the surface and in the tissues of fresh vegetables.

The growing demand of water for irrigation has produced a marked increased in the reuse of treated and/or untreated waste water world wide[1]. In many local urban areas, lands lying along the course of urban drainage system are used for the production of agricultural products (such as vegetable) that are in high demand by urban dwellers. Several researchers have shown that a significant proportion of a city's food requirements in developing countries is supplied from within the urban boundaries, because within those areas substantial amount of waste water (mainly from homes and industries) is available in urban drains for irrigating lands along the urban drainage course[2]. The use of these waters therefore poses the greatest risk potential to this system of land use[3].

Long-term use of untreated sewage water which is mainly used for the irrigation of leafy and other vegetables, has resulted in the accumulation of heavy metals in soils and their transfer to the various crops under cultivation, with levels of contamination that exceed the maximum permissible limits[2].

The objective of the present study therefore was to analyzed the metal concentrations of Bushgreen and Roselle irrigated with treated and untreated urban sewage water, and to ascertain the effectiveness of using alum in the treatment of heavy metals (Cu, Zn, Pb, Fe and Cr) in untreated sewage water

Material and Methods

Pilot Garden: A pilot garden was prepared; soil samples were collected at a depth of 0 – 30cm from virgin area of Yola (where there is little or no agricultural activity). The soil samples are thoroughly mixed for homogeneity. Five kilograms each of the soils was weighed into plastic pot soaked with distilled water and allowed to stand for three days[4]. The seeds of Bushgreen and Roselle were obtained from Yola main market. Two grams of each seed of these vegetables were sown and subsequently germinated in green house of the Department of Crop Production Federal University of Technology Yola at an average daily temperature of 35°C. After germination the plants were allowed to grow and each irrigated with untreated sewage and treated sewage water. The sewage water was treated with Alum before using it for irrigation. The pH of the untreated sewage water was measured and raised to 8.6 using sodium hydroxide. 8.0 grams of Alum was used for treatment of every 20 liters of untreated sewage water.

Soil: Soil samples were taken from each pot at 5 cm intervals to a depth of 30 cm. Samples were collected into polyethylene bags, labeled and properly tied. In the laboratory, the soil samples were spread on glass plates and then dried in an oven at 105°C for six hours. The dried soil were ground and sieved through 0–5 cm mesh sieve. The pH values of the soils were determined with a digital pH meter (Jenway Model).

One gram each of the ground soil samples was weighed into a 125 ml beaker and digested with a mixture of 4 ml, 25 ml and 2 ml each of concentrated $HClO_4$, HNO_3 and H_2SO_4, respectively, on a hot plate in a fume cupboard. At completion of digestion, the samples were cooled and 50 ml of de – ionized distilled water was added and then the samples were filtered. The samples were made up to 100 ml with de – ionized distilled water and concentrations of the elements determined using atomic absorption spectrophotometer (AAS Model SP 9 Unicam).

Plants: One portion of the leaves samples was left unwashed. The other portion and some of the parts (stem, roots and bulb) of the plants were thoroughly cleaned and washed under a running tap water to remove dust, dirt and possible parasite or their eggs[5]. The samples were reduced to fine powder with a grinder prior to drying at 60 ^oC in an oven to a constant weight.

Half gram each of the fine powdered samples were weighed into a flask and digested in a mixture of 4 ml, 25 ml, 2 ml and 1 ml of concentrated $HClO_4$, HNO_3, H_2SO_4 and 60 % H_2O_2, respectively, at 100^{o}C on a hot plate for two hours in a fume cupboard. The resulting solution was left over night and made up to 100 ml with de – ionized distilled water and concentrations of the elements determined using AAS SP 9 Unicam.

Water Samples: One litre of the sewage water used for irrigating each farm was collected and treated with 1.5 ml of concentrated HNO_3. 50 ml of the water sample was transferred to an evaporating dish and evaporated on a steam bath to about 20 ml. 10 ml of 8 M HNO_3 of 98 % purity was added and evaporated on a hot plate to near dryness. The residue was quantitatively transferred using two aliquot of 10 and 15 ml of concentrated HNO_3 into a 250 ml flask. 20 ml of $HClO_4$ was added and boiled until the solution became clear and white fumes of $HClO_4$ appear. It was then cooled and de – ionized distilled water (about 50 ml) was added and the solution filtered. The filtrate was quantitatively transferred to a 100 ml volumetric flask with two portions of 5 ml of de – ionized distilled water. The solution was diluted to mark and mixed thoroughly by shaking. The heavy metals under study were determined as described above.

Results and Discussion

Concentration of Heavy Metals in Treated and Untreated Urban Sewage Waters Used for Irrigation: Table 1 shows the mean concentrations of heavy metals in the treated and untreated urban sewage waters. The mean concentrations are above the maximum permissible levels set by the World Health Organization WHO[6]. However, after treatment of the sewage waters with alum, the concentrations of Fe, Zn, Pb, Cu and Cr in the sewage waters were reduced by 70%, 46%, 27%, 58% and 33% respectively. This implies that effective treatment of sewage water contaminated with Fe and Cu can be achieved using alum as coagulant compared to the other heavy metals Zn, Pb and Cr.

Concentration of Heavy Metals in Farm Soils: Table 2 is a presentation of the mean concentrations of heavy metals in Bushgreen and Roselle farm soils irrigated with treated and untreated sewage waters. It can be observed that the farm soils irrigated with untreated urban sewage water have higher mean concentrations of the heavy metals compared to those irrigated with treated sewage water. This shows that the untreated urban sewage water contributes to the higher concentrations of the heavy metals in the soils. The mean concentrations of Zn in Bushgreen farm soil irrigated with treated water was marginally below the maximum permissible level of 300µg/g Zn recommended by World Health Organization (WHO). However, the mean concentrations of Zn and Pb in both the Bushgreen and Roselle farm soils irrigated with untreated water (in the case of Zn), treated and untreated water for Pb were above the maximum permissible levels of 300µg/g and 100 µg/g respectively set by World Health Organization (WHO).

However, the mean concentrations of Fe, Cu and Cr in Bushgreen and Roselle farm soils irrigated with untreated and even more with treated sewage water are below the WHO maximum permissible limits.

The obvious implication of this observation is that there is no threat of soil contaminations by Fe, Cu and Cr when these sewage waters are used for the irrigation of vegetables[7].

Table-1
Mean concentrations of heavy metals in treated and untreated urban sewage waters used for irrigating the pilot garden

Irrigation waters	Mean concentrations of metals (µg/ml)				
	Fe	Zn	Pb	Cu	Cr
Untreated urban sewage water	2.512	1.065	1.034	0.078	0.081
Treated sewage water	0.745	0.568	0.754	0.033	0.054
WHO Maximum permissible value in irrigation water	5.0	2.0	0.2	0.01	0.05

Table-2
Mean concentrations of heavy metals in Bushgreen and Roselle farm soils irrigated with treated (T.W) and untreated (S.W) urban sewage waters

	Mean concentration of heavy metals (µg/g)									
	Fe		Zn		Pb		Cu		Cr	
Water used for irrigation	**S.W**	**T.W**	**S.W**	**T.W**	**S.W**	**T.W**	**S.W**	**T.W**	**S.W**	**T.W**
Bushgreen farm soil	892	155	467	286	454	304	21	20	48	22
Roselle farm soil	1125	413	525	359	502	361	22	20	38	15
Recommended maximum level	50000		300		100		100		100	

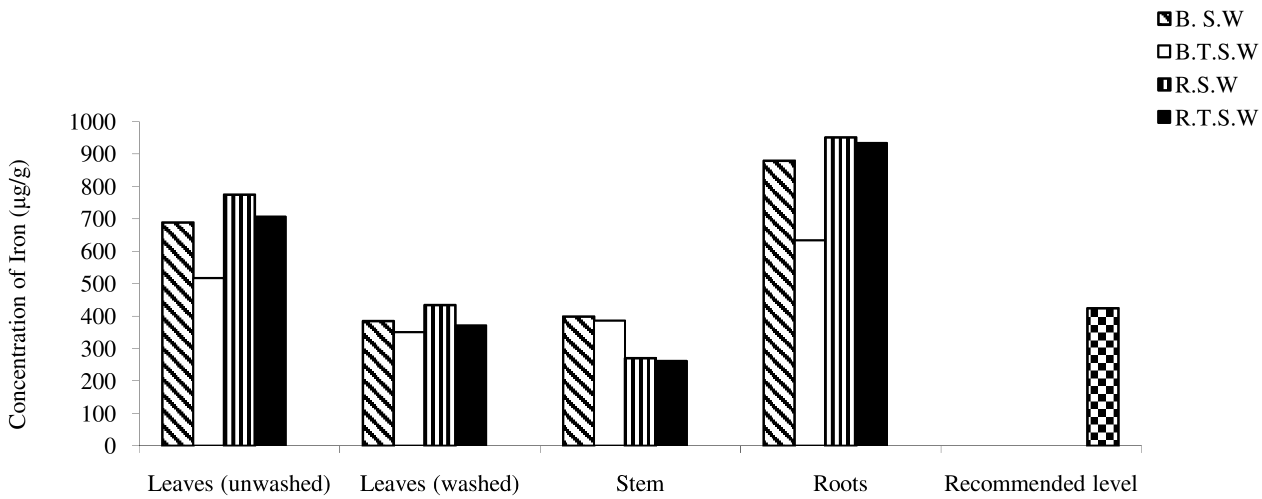

Figure-1
Fe concentration in parts of plants irrigated with treated and untreated sewage water

Figure-2
Zn concentration in parts of plants irrigated with treated and untreated sewage water

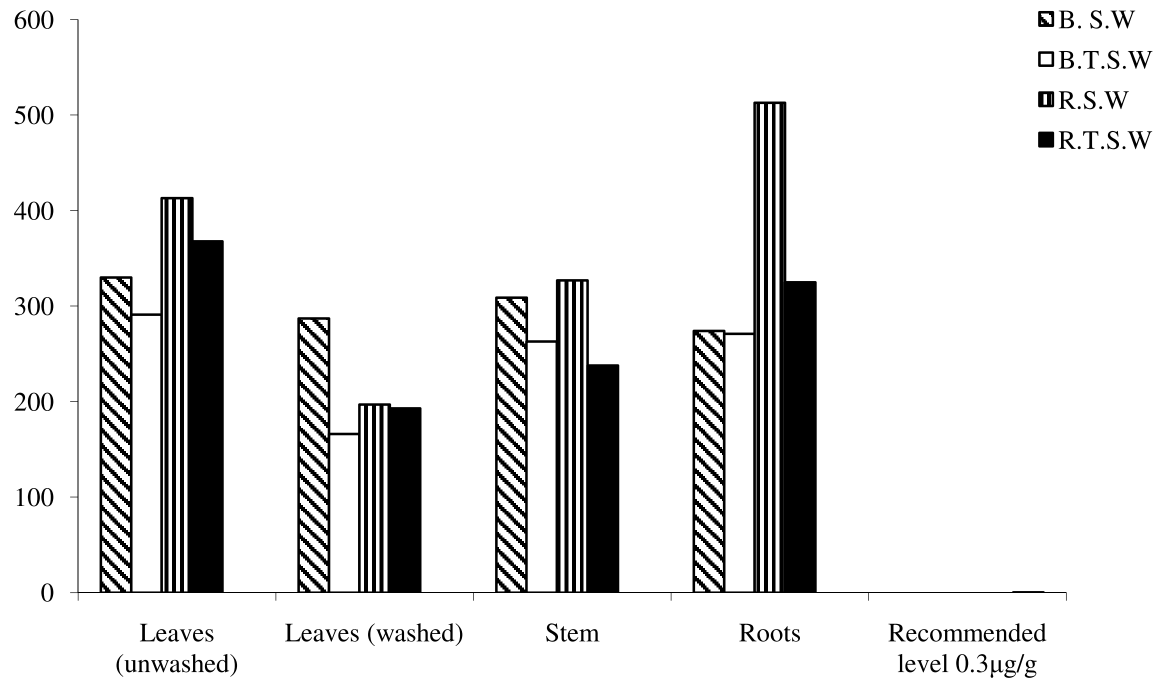

Figure-3
Pb concentration in parts of plants irrigated with treated and untreated sewage water

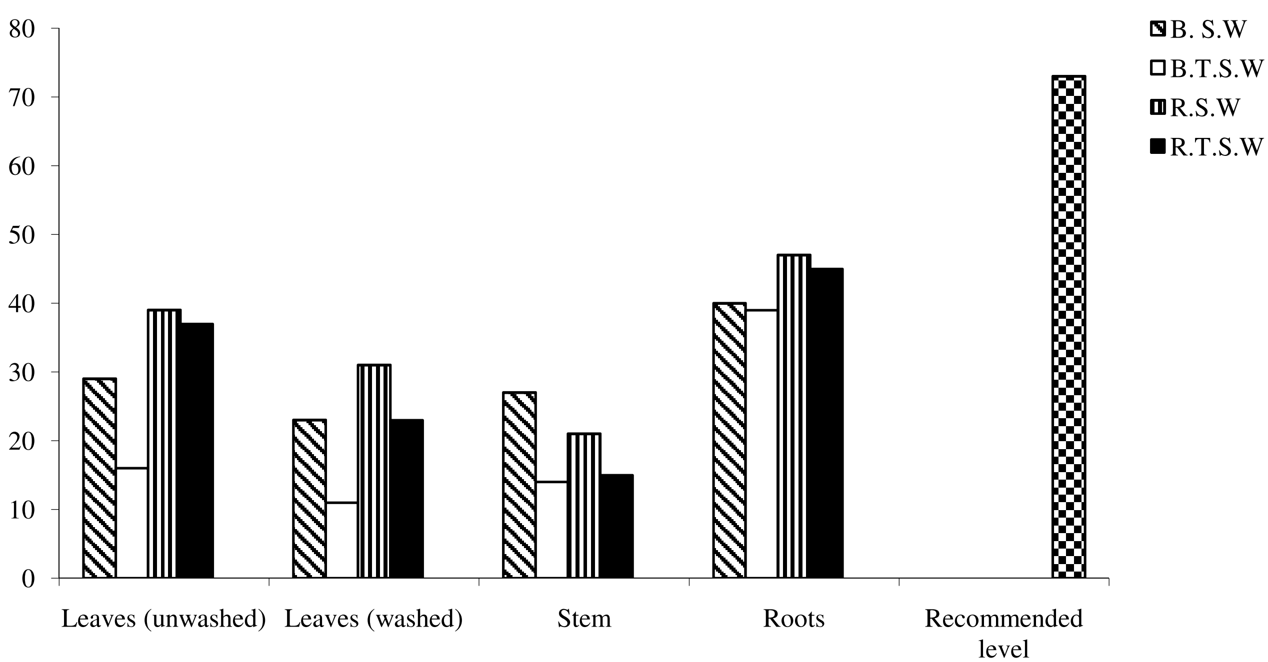

Figure-4
Cu concentration in parts of plants irrigated with treated and untreated sewage water

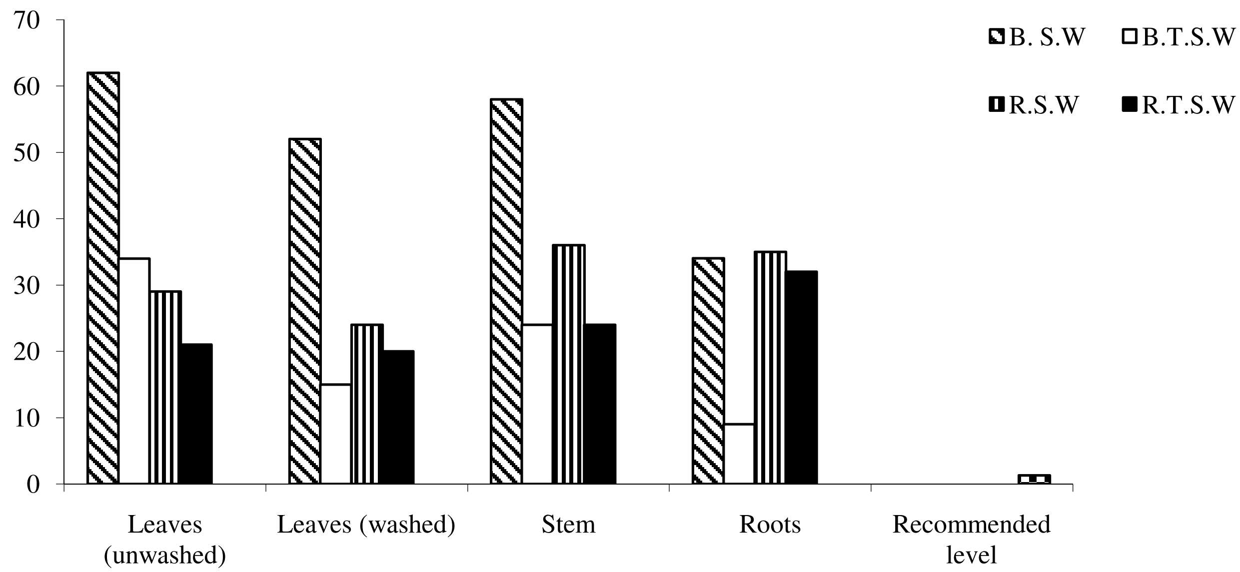

Figure-5
Cr concentration in parts of plants irrigated with treated and untreated sewage water
B.S.W. = Bushgreen plant irrigated with sewage water, B.T.S.W. =Bushgreen plant irrigated with treated sewage water, R.S.W. = Roselle plant irrigated with sewage water, R.T.S.W. = Roselle plant irrigated with treated sewage water

Concentrations of Heavy Metals in Different Parts of the Vegetable Plant: The variations of the mean concentrations of the heavy metals in different parts of the vegetables plants irrigated with treated and untreated sewage waters are shown in figures 1 to 5, the following observations are pertinent; The mean concentration of Fe in Bushgreen and Roselle leaves (unwashed) and roots in farm soils irrigated with both treated and untreated sewage waters exceeded the maximum permissible level (425µg/g) set by WHO as shown in figure-1, 2. However, for Bushgreen and Roselle leaves (washed) and stems irrigated with both treated and untreated water, the mean concentrations of Fe were below the maximum permissible level of this metal recommended by WHO[2].

The mean concentrations of Zn, Pb and Cr in all parts of the vegetable plants (leaves, washed and unwashed; stems and roots) irrigated with treated and untreated sewage waters were above the maximum levels of these metals recommended by WHO as shown in figures 2, 3 and 5 [2]. The high concentrations of these metals particularly in leaves which constitute the most edible and highly consumed part of the vegetable plant, means those humans who consume these vegetable parts are at serious health risk from the toxicity of these plants[8].

The Cu concentrations in all of the vegetables irrigated with treated and untreated sewage waters are below the maximum permissible limits of 73 µg/g set by WHO. This implies that these parts of vegetables are safe from Cu toxicity when consumed[5, 9]. Although the Cu levels found in the vegetables were within the safe limits in all parts, Cu tends to accumulate more heavily in the roots of the vegetables compared to other parts as shown in figure 4. The same observation was reported by other researchers[2] who investigated metal accumulation in some vegetables irrigated with waste water in Shahre Rey-Iran and ascribed the higher accumulation of Cu in root of the vegetables compared other parts to low translocation of the metal to the shoots. Studies have also shown that Cu has low mobility relative to other elements in plants, and a strong capability of roots tissues to hold Cu against transport to the shoots[10].

Conclusion

The treatment of the sewage water with alum reduce the concentrations of the heavy metals Fe, Zn, Pb, Cu and Cr in the sewage waters to between 27 to 70 percent. The concentrations of these heavy metals in both treated and untreated sewage waters are above the maximum permissible level in irrigation waters set by the World Health Organization WHO. The levels of Fe, Zn, Pb and Cr in leaves which is the edible parts of the vegetables are above the maximum permissible levels set by the World Health Organization (WHO), and therefore vegetables irrigated with such sewage water are not safe for animal and human consumption.

The concentration levels of Cu in all parts of vegetable plants irrigated with both treated and untreated sewage waters were lower than the maximum permissible level set by WHO.

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