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# HEAVY METAL ACCUMULATION IN THE FRUITS OF TOMATO AND OKRA IRRIGATED WITH INDUSTRIAL WASTE EFFLUENTS

**P.O. FATOBA *, A.O. ADEPOJU AND GRACE A.OKEWOLE**

** Department of Plant Biology, University of Ilorin, Ilorin, Kwara State, Nigeria

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## ABSTRACT

**Effects of industrial waste effluents on the fruits of Tomato (*Lycoperscon esculentum* and Okra (*Abelmoschus esculentus*) irrigated with wastes from Global Soaps and Detergents Factory (GSD), Ilorin and Dangote Cement Factory (DCF), Ilorin were investigated so as to assess the safety of their consumption. The used wastes were collected before their discharge into the water bodies. Top soils were collected from unpolluted environment homogenously mixed together and stocked into plastic pots perforated at their bases. The collected wastes and soils were subjected to heavy metal: Pb; Zn; Cu; Cd; Fe and Hg determination with the aid of Atomic Absorption Spectrophotometer. The pH of the wastes and soil were determined electrometrically. The wastes were serially diluted with borehole water to give 100%, 75%, 50%, 25%, 20% ,10% ,5% and 1% concentrations with borehole water used for the control. Seeds of tomato and okra were sown differently into these pots and the prepared waste water was used to irrigate these plants twice a week and the stands per pot were reduced to 2. The fruits produced by these plants were appropriately digested and subjected to Pb, Zn, Fe, Cd, Cu and Hg determination with the aid of Atomic Absorption Spectrophotometer. The experiment was replicated twice. It was found that only the okra and tomato plants irrigated with only borehole water(Control), 1% and 5% GSD and 1% DCF wastewater fruited. The pH of the soil before irrigation was acidic (pH= 4.09), GSD waste, alkaline ( pH= 10.65) and DCF waste, highly alkaline (pH=13.65). The soil had 0.06 mg/g Pb, 0.21mg/g Zn, 4.94mg/g Fe, 0.00mg/g, Cd and Hg and 0.17mg/g Cu. The GSD waste contains 0.58mg/g Pb, 0.82mg/L Zn, 6.65mg/L Fe, 1.42mg/L Cd, 152mg/L Cu and 0.03mg/L Hg. The DCF waste has 0.37mg/L, 0.57mg/L, 5.24mg/L, 0.19mg/L, 1.04mg/L and 0.00mg/L Pb, Zn Fe, Cd, Cu and Hg respectively. Results of the analyses of the okra fruits gave a range of 0.15 – 0.35mg/L Zn, 0.44 – 0.92mg/L Fe, 0.00 – 0.03mg/L Pb, 0.02 -0.04mg/L Cd, 0.11-0.34mg/L Cu and 0.01-0.02mg/L Hg for both crops irrigated with GSD wastes .For crops irrigated with DCF waste water, 0.01 – 0.31mg/L Zn, 0.03 – 0.66mg/L Fe, 0.00 - 0.05mg/L Pb, 0.00 - 0.01 mg/L Cd, 0.02 - 0.52mg/L Cu and no Hg. However, the presence and accumulation of Pb, Hg and Cd in the fruits raised with GSD waste water pose a serious threat to life. It is therefore possible to recommend these wastes for the raising of okra and tomato at very low concentration less than 1% for GSD and less 10% for DCF to avoid accumulation of Pb, Cd and Hg.**

## INTRODUCTION

Wastes are generated to the environment through agricultural mechanical, industrial discharges, poor waste management and domestic activities. All these contain harmful pollutants, leading to the pollution

***Corresponding author's - Email :** pofatoba@unilorin.edu.ng

of the environment. The industrial wastes are usually discharged with or without pretreatment to the environment and are carried away through the drains or by surface flow. The waste water should be adequately treated in Wastewater Treatment Plant (WTP) to remove harmful pollutants, minimized adverse effects to the environment , preventing pollution and bring about good health (Fernandez *et al*. 1995; Rasak *et al*. 1996). It has been identified that plant nutrients such as phosphates and nitrates are pollutants present in large quantities in industrial waste and they enter the hydrosphere in runoff from fertilized fields, municipal sewage and industrial effluents (Epstein *et al*.1976). Nitrogen and phosphorous are the major causes of eutrophication which affects the aesthetic in lakes, rivers and result in odour and appearance problems (Mulkerrins *et al*. 2004).

The soaps/detergents are made up of a variety of ingredients that are added to give them specific properties and characteristics (Charles and Walter 2007). Important ingredients are fats, alkalis, detergent fillers. surfactants, detergent builders and boosters, rinse agents, lime, rust removal, ammonia, conditioning agent etc. (Charles and Walter 2007). All these generate a waste which are discharged into the water bodies or surface where water washes them into water bodies. The cement has a variable composition depending on the cementitious products produced in the cement kiln. Cement is made up of tri-calcium silicate (20-70%) D1-calcium silicate (10-60%), tetra-calcium alumino-ferrite (5-15%), calcium sulfate (2-10%), tri-calcium alummate (1-15%), magnesium oxide (0-4%), nuisance dusts, crystalline silica (Quartz) (0-1%), hexavalent chromium (chromic acid and chromates) (Anonymous 2006). Other are potassium and sodium compounds, heavy metals such as cadmium, chromium, nickel and lead (Anonymous 2006).

Okra and tomato are popular fruit vegetables produced and consumed in Nigeria. Tomato seems to be more popular than okra as many people eat it in different forms in the preparation of stew, soup, food etc. In Nigeria, some people specialize in the production of these vegetable hence they make large plantation of these two crops. These crops are consumed throughout the year and water is very important for their growth and productivity .The availability of these crops during dry season is hindered by the poor preservative methods and non availability of rainfall during dry season. In order to solve this problem, dry season/Fadama farming is being practised. Since these plants or crops require water hence the need to make use of available water not minding the quality. In line with these, many farmers make use of rivers in which the industrial wastes are discharged like what happens in Global Soaps and Detergents Factory and Dangote Cement Factory .

Although, WHO (2004) recommended that crops eaten raw should be irrigated with only biologically treated effluent that has been disinfected to achieve a coliform level of not more than 100 coliform per 100mL in 80% of the sample. This recommendation is being disregarded by local and Fadama farmers as many make use of untreated wastewater in the raising of their vegetables. It is therefore necessary to put some steps in place to checkmate the consumption of heavily polluted vegetables so as to prevent poisoning resulting into mass death due to the consumption of contaminated/polluted vegetables. This study was undertaken to investigate the safety of and heavy metal accumulation in okra and tomato raised with wastewater from Soaps or/and Detergents and Cement factories.

## MATERIALS AND METHODS

Viable seeds of 40 day- okra (*Abelmoschus esculentus*) and tomato (*Lycopersicon esculentum*) bought from Kwara State Ministry of Agriculture were sown into top soil that was homogeneously mixed together and packed into plastic pots perforated at the bases. Wastes were collected from Global Soaps and Detergent Factory (GSD) and Dangote Cement Factory (DCF) before their discharge into water bodies. The soil and the wastes were subjected to heavy metal: Pb; Cd; Fe; Cu; Zn and Hg analyses with the aid of Atomic Absorption Spectrophotometer (AAS) so as to know the pollution status of the materials used.

The pH of these three materials were also determined electrometrically. Each of the two wastes was serially diluted with borehole water to give 100%, 75%, 50%, 25%, 20%, 10%, 5%, and 1% concentrated solutions which were appropriately used to irrigate the sown seeds, the seedlings and the plants twice a week. The borehole water served as Control. The number of plant per pot was thinned to two. The experiment was carried out in the Green house in the Biological Garden of University of Ilorin, Ilorin, Nigeria. The experiment was replicated twice. The fruits of these plants were collected, digested and subjected to Pb, Cd, Fe, Cu, Zn and Hg analyses with the aid of AAS.

## RESULTS

Table 1 shows the pH and heavy metal contents (mg/L) of the soil and wastes from Global Soaps and Detergent Factory (GSD) and Dangote Cement Factory (DCF).

**Table 1.** The pH and heavy metal contents of the soil, GSD and DCF wastes

| | Heavy metal concentration(mg/L) | | | | | | |
|---|---|---|---|---|---|---|---|
| Sample | pH | Pb | Zn | Fe | Cd | Cu | Hg |
| Soil | 4.09 | 0.06 | 0.21 | 4.94 | 0.00 | 0.17 | 0.00 |
| GSD wastes (100%) | 10.65 | 0.58 | 0.82 | 6.65 | 1.42 | 1.52 | 0.03 |
| DCF wastes (100%) | 13.65 | 0..37 | 0.57 | 5.24 | 0.19 | 1.04 | 0.00 |

Table 1 shows that the soil used was acidic and GSD and DCF wastes alkaline but the latter was more alkaline. Preliminary analyses showed that the soil is free of Cd and Hg but contained > 0.1mg/L of Pb, about 0.2mg/L of Zn, > 0.2mg/L of Cu and > 5mg/L of Fe. This result showed that the soil is not polluted. However, the wastes had higher concentrations of the heavy metals than the soil. However, only the GSD wastes contained Hg suggesting its pollution and hazardous status (Table 1). Moreover, the presence of Pb and Cd also point to the danger in these wastes. GSD waste had higher concentrations of all the analyzed heavy metals than DCF (Table 1). This shows that GSD waste was more polluted then the DCF waste. Only the okra plants irrigated with 25%, 20%, 10%, 5% and 1% GSD wastewater and tomato plants irrigated with 20%, 10%, 5% and 1% germinated like the Control. Moreover, only 1% and 5% regimes of GSD waste water supported flowering and fruiting. Okra and tomato plants irrigated with all the DCF wastewater concentrations germinated except the 100% regime. Also all the treatments with DCF irrigants that supported germination except the 75% waste water brought about flowering and fruiting while 50% and lesser concentrations of GSD supported growth, flowering and fruiting.

Table 2 shows the concentration of accumulated heavy metals in the fruits of okra and tomato. Fruit harvested from plants irrigated with GSD waste water had more of the heavy metals accumulated than those irrigated with DCF waste water . Okra fruits harvested from regimes irrigated with GSD waste water contained 0.00-0.01mg/L Pb, 0.02-0.03mg/L Cd and 0.01mg/L Hg while tomato fruits had 0.00-0.03mg/L Pb, 0.03-0.04mh/L Cd and 0.01-0.02mg/L Hg. This shows that more heavy metals accumulated in plants irrigated with more concentrated GSD waste water (Table 2).



All the fruits produced by okra and tomato plants with DCF wastewater were free of Pb except for 25% and 50% regimes which had 0.01-0.03mg/L for okra and 0.03-0.05mg/L for tomato (Table 2). All fruits of okra and tomato plants irrigated with DCF waste water were free of Hg and those irrigated with 1% and 5% gave a free Cd while other treatments had just 0.01mg/L. The results showed that GSD waste water and more toxic than the DCF, such that only concentrations less than 1% would produce fruits free of Pb, Cd and Hg. Moreover, DCF waste tends to be safer as plants treated with 1% and 5% were free of Pb, Cd and Hg but , 20% could equally be regarded as being safe other than the presence of 0.01mg/L Cd.

It was also observed that the concentration of each of the heavy metals in the plants treated will the waste water was much higher than those of the Control. The Control had no Pb, Cd and Hg and the concentration of Zn, Fe and Cu were less than 0.03mgl/L in the analyzed okra and 0.8mgl/L in tomato fruits. The higher concentrations of these heavy metals in the treated than the Control confirmed that the metals accumulated in the fruits. It was also observed that the plants accumulated these heavy metals in their fruits and could reach a toxic level within a short time. The accumulation trends of these heavy metals in the fruits produced are as follow:

Fe > Zn, Cu > >>Pb, Cd, Hg (Okra Control)
Fe > Cu > Zn > >> Pb, Cd, Hg (Tomato Control)
Fe > Zn > Cu > Cd > Hg>> Pb (Tomato and Okra treated with GSD)
Fe > Cu > Zn > Pb > Cd>>>Hg (DCF-treated okra and Tomato)

## DISCUSSION

The presence and accumulation of the analyzed heavy metals in the fruits of okra and tomato plants could be traced to their presence in the wastes used. Goldman *et al.* (1990) opined that the soil type, root stock, mulching, irrigation, fertilization, and other cultural practices influence the water and nutrient supply to plant and affect the composition and quality attributes of the harvested parts. Although, Fe, Cu and Zn are normal nutrients required for the normal growth of plants though not required in large quantities hence their presence in the fruits could be justified . The presence of Pb, Cd and /or Hg in these fruits pose serious concern as these metals are toxic to plants

**Table 2.** Heavy metal contents (mg/L) of the fruits of Okra and Tomato irrigated with industrial wastewater.

| Sample | Heavy metal content (mg/L) | | | | | |
|---|---|---|---|---|---|---|
| | Pb | Zn | Fe | Cd | Cu | Hg |
| Control (Okra) | 0.00 | 0.01 | 0.02 | 0.00 | 0.01 | 0.00 |
| Control (Tomato) | 0.00 | 0.03 | 0.07 | 0.00 | 0.04 | 0.00 |
| GSD (1%) | | | | | | |
| Okra | 0.00 | 0.15 | 0.44 | 0.02 | 0.14 | 0.01 |
| Tomato | 0.00 | 0.27 | 0.71 | 0.03 | 0.24 | 0.01 |
| GSD (5%) | | | | | | |
| Okra | 0.01 | 0.15 | 0.86 | 0.03 | 0.11 | 0.01 |
| Tomato | 0.03 | 0.35 | 0.92 | 0.04 | 0.34 | 0.02 |
| DCF (1%) | | | | | | |
| Okra | 0.00 | 0.01 | 0.03 | 0.00 | 0.02 | 0.00 |
| Tomato | 0.00 | 0.04 | 0.09 | 0.00 | 0.06 | 0.00 |
| DCF (5%) | | | | | | |
| Okra | 0.00 | 0.01 | 0.05 | 0.00 | 0.05 | 0.00 |
| Tomato | 0.00 | 0.09 | 0.15 | 0.00 | 0.09 | 0.00 |
| DCF (10%) | | | | | | |
| Okra | 0.00 | 0.05 | 0.23 | 0.01 | 0.26 | 0.00 |
| Tomato | 0.00 | 0.13 | 0.53 | 0.01 | 0.42 | 0.00 |
| DCF (20%) | | | | | | |
| Okra | 0.00 | 0.15 | 0.34 | 0.01 | 0.32 | 0.00 |
| Tomato | 0.00 | 0.15 | 0.55 | 0.01 | 0.51 | 0.00 |
| DCF (25%) | | | | | | |
| Okra | 0.01 | 0.12 | 0.41 | 0.01 | 0.31 | 0.00 |
| Tomato | 0.03 | 0.18 | 0.64 | 0.01 | 0.52 | 0.00 |
| DCF (50%) | | | | | | |
| Okra | 0.03 | 0.24 | 0.31 | 0.01 | 0.21 | 0.00 |
| Tomato | 0.05 | 0.31 | 0.66 | 0.01 | 0.52 | 0.00 |

and animals including man. The presence of these metals also suggest that they could be raw materials used in the production of soaps/detergents and cements. The presence of these metals in higher concentrations than what the plant could tolerate might have led to the non germination of seeds, no flower setting or fruit production.

The high pH (alkaline) of the waste water would certainly increase the pH of the soil, thereby rendering it unsuitable for the growth of okra and tomato .The tolerance of these plants to DCF waste than the GSD waste showed that the latter was more toxic than the former. This could be supported by the presence of Pb, Cd and Hg even at low concentrations of 1% and 5%. Abd. EL-Hady *et al*. ( 2001) reported the relative toxicity of 3 metals that Zn was the least toxic, Cu was thrice and Pb was eight times as toxic as Zn. Moreover, Ibrahim *et al.* (1992) found that total Cu, Cd, Pb and Hg contents were lower than Zn equivalent levels in all soils in EL Gabal Elasfer area irrigated with sewage water for different years. The result of this study showed that the Cu, Cd, Pb and Hg content were greater than Zn, hence the toxicity of the wastes on the plants. The accumulation of these heavy metals in the fruits was a manifestation of the presence of the metals in the soil due to their irrigation with waste water. This idea was supported by the submission of Dahdoh *et al*. (1996) who opined that the extractable Pb in both cultivated and uncultivated soils increased by increasing Pb addition to the soil. Badawy and EL-Motaium (2003) showed that the concentrations of exhaustible metals (Cu, Zn, Cd, Pb) in the soil increased with increase in sludge application rate.

Accumulation of these metals in the fruits was due to the irrigation of the plants and soils with polluted water. This was supported by the submission of Kandil *et al.* (2003) who find a highly significant correlation between the chemical composition of irrigation water used and the soil chemical properties. This shows that the level of these metals in the fruits was the reflection of their concentration in the soil. This fact was be supported by the findings of Abd-EL-Fattah *et al*. (2002) that the Zn content of the leaves of corn increased with increasing levels of extractable Zn in



the soils. They also reported that plants irrigated with municipal sewage water had higher concentration and uptake of elements than those irrigated with river water. The results obtained in this study compared favourably with these findings.

Abdel-Sabour and Rabie (2003) reported that irrigation with different waste water significantly increased the heavy metal contents (Zn, Cu, Ni ,Pb, Cd and Co) in vegetable plants, Spinach, Rochel and Jew's mellow especially in leafy species. Although, okra and tomato are fruit vegetables but the result gotten in this study compared favourably with this submission. Prolonged irrigation periods was associated with significant increases in the total and available forms of Pb, Cd and Zn. It could be inferred that prolonged irrigation of the soils may lead to these heavy metals reaching toxic levels.

Peters *et al.* (2000) reported that most heavy metals are toxic to plants and that the first result of toxicity is reduction in plant growth, which later leads to reduction in yield due to resulting adverse effects on its reproductive capabilities. It is therefore reasonable to say that the level of these heavy metals may be responsible for the non germination of seeds, flowering and fruiting of the okra and tomato irrigated with higher concentrations of GSD specifically and DCF to a lesser extent.

However, less than 1% of GSD waste water and up to 20% DCF waste water may be used in raising these vegetables as these are likely to exclude Pb, Cd and Hg in the fruits. This can be accomplished by not farming around or near these industries where these pollutants/ wastes would be of higher concentrations that is, waste water from a far distance from the point of discharge of these wastes would likely have these pollutants in very less concentration. This means that the more the distance from the source, the less the effects.

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