

Biochemical Characterization of Cassava Processing Waste Water and its Effect on the Growth of Maize Seedlings

*¹S. M. Sam, ²G. J. Esenowo and ³I. R. Udosen

¹Department of Biological Sciences, Akwalbom State University, IkotAkpaden

²Department of Botany and Ecological Studies, University of Uyo

³Department of Biology, Akwa Ibom State College of Education, Afaha Nsit

[*Corresponding Author: E-mail: sundaysam@aksu.edu.ng, eosamviek@yahoo.com]

ABSTRACT

The effect of cassava processing wastewater from four hybrid varieties of cassava (TMS 92/0057, NR 8082, TMS 92/0326 and TMS 30572), on the germination and early seedling growth of maize was studied in the laboratory. The physicochemical properties of the effluents and elements were analyzed using standard methods. The wastewater from these cassava varieties were highly acidic 4.0, 4.0, 4.10 and 4.20 in contrast to WHO allowable limit of 6.5-8.5 had a low BOD ranging from 1.6 – 2.45, while their HCN ranged from 12.96 – 16.86 mg/l which was observed to be very high as against FAO/WHO admissible maximum limit of less than 10mg/kg. The germination percentage, growth parameters and biomass were significantly ($P= 0.05$) reduced with increase in the acidic level of the effluents. Higher concentrations of the wastewater were inhibitory to the germination and early seedling growth of maize. The waste water from the four hybrid varieties of cassava increased the level of trace metal elements in *Zea mays*. Hybrid TMS 92/0326 was less toxic and is recommended to farmers. This study suggests that higher concentrations of cassava processing effluent could be detrimental to the germination and early seedling growth of *Zea mays*.

Keywords: Biochemical, Characterization, Cassava. Wastewater, Maize

INTRODUCTION

Maize is a crop belonging to the family of grasses, Poaceae, having the botanical name *Zea mays* (L.), and cultivated globally being one of the most important cereal crops worldwide. It is a tall, determinate annual C_4 plant varying in height from 1 to 4 meters producing large, narrow, opposing leaves (about a tenth as wide as they are long), borne alternately along the length of a solid stem. Maize is wind pollinated and both self and cross pollination is usually possible. Shed pollen usually remains viable for 10 to 30 minutes, but can remain viable for longer durations under favorable conditions (Coe *et al.*, 1988).

Maize crop is primarily a warm weather crop and it is grown in wide range of climatic conditions (ICAR, 2006). Maize can successfully be grown in areas receiving an annual rainfall of 60 cm, which should be well distributed throughout its growing stage. It needs more than 50% of its total

water requirements in about 30 to 35 days after tasseling and inadequate soil moisture at grain filling stage results in a poor yield and shriveled grains.

Waste water from cassava processing released directly into the environment before proper treatment serve as a source of pollution. In many areas where traditional processing is practiced, it's normally discharged beyond 'factory' walls into road side ditches or fields and allowed to flow freely, settling into depressions. Eventually, this will percolate into the subsoil or flow into streams. High concentrations of cyanide have been shown to contaminate ground water supply during rainfall causing a foul environment, and may kill plants and aquatic life in the nearby water bodies (Cereoda and Takahashi, 1996). Ehiagbonare *et al.* (2009) investigated the effect of cassava effluent on the environment and found out that the effluent had negative effect on plants, air, domestic animals, soil and water from the

results of the various parameters investigated. In spite of all these findings, the treatment and disposal of cassava wastewater from industrial sources is still a major problem in Nigeria.

Compounds that are generally toxic to living organisms will also prevent the germination as well as inhibit growth of plants at toxic concentrations. The growth of various crops has been reported to be influenced by different types of effluents. Orhue *et al.* (2008) observed that soil treated with brewery effluent showed increased K, CO₂, C/N ratio and pH and enhanced the growth of maize. Napu grass productions have been shown to increase significantly with rubber effluent application (Tan *et al.*, 1979). Sugar factory effluents have been shown to increase soil organic matter by 1.5%. Palm oil processing effluent has been reported to retard the germination of *Zea mays* at high concentrations (Essien and Odoemena, 2005). There are reports on the effect of tannery effluent on seed germination (Karunya *et al.*, 1994), contaminating effect of spent engine oil on plant growth (Anoliefo and Edegai, 2001) and heavy metal accumulation in vegetables grown in mine wastes (Cobb *et al.*, 2005) etc. However, there's not much literature on the effects of cassava effluent on plant growth. At present, the effect of cassava processing effluent from these hybrid varieties newly introduced into Akwa Ibom State, on the germination and early seedling growth is not clearly documented as such this studies aim to determine the physico-chemical properties of cassava processing waste water and its effect on germination and early seedling growth of maize.

MATERIALS AND METHODS

The different hybrid varieties of cassava namely TMS 92/0057, TMS 92/0326, NR 8082 and TMS 30572 were collected from Akwa Ibom Agricultural Development Program (AKADEP), Uyo, while the maize seeds were obtained from a local cultivar. The waste water was generated from the traditional production method for *gari* production, following the procedure of Okafor (1997) and was obtained from a local cassava

processing factory located at Abak, Akwa Ibom State. Ten (10) litres of wastewater was collected from each variety with a sterile rubber container and stored in a refrigerator at 20°C until needed. The physical and chemical parameters of the cassava waste effluent were determined using standard procedures for examination of water and waste water (APHA, 1989). The physical parameters analyzed were temperature at the time of collection, pH, conductivity, suspended solids (SS), while the chemical parameters were Biochemical Oxygen Demand (BOD) (mg/L), total cyanide content (mg/L), Chemical Oxygen Demand (COD) and the elements analyzed for were: phosphate (Po₄²⁻), sodium (Na⁺), calcium (Ca²⁺) and potassium (K⁺). These analyses were carried out using the Atomic Absorption Spectrometer (AAS) method as described in APHA (1989). The above parameters were analyzed at the Chemistry laboratory, Akwa Ibom State University.

Determination of Sodium, Potassium, Calcium

One thousand parts per million stock solution of sodium (Na⁺), potassium (K⁺), calcium (Ca²⁺) were prepared. The standard (Na, K, Ca) and sample solutions as well as the blank solutions were aspirated using a flame photometer (GallenKamp BKL – 210) with the filter of Na⁺, K⁺, Ca²⁺ in place and the readings of elements in the sample solutions recorded as described by Salami and Egwin (1997).

The effluent was prepared in various concentrations of 0%, 25%, 50%, 75% and 100% respectively using a simple serial dilution with sterile deionized water. Sterile distilled water was used as 0%. After sterilization with bleach, seeds were then spread on sterile Whatman's No. 2 filter paper moistened with 10 ml of the various concentrations of the cassava liquor. Three replicates were used following the methods of (Esenowo, 1991). The effluents were replenished as need arose and the criterion for seed germination was taken as protrusion of the radical up to 2 mm at the time of observation

Sam et al: Biochemical Characterization of Cassava Processing Waste Water and its Effect on.....

(Singh and Mishra, 1987) and the experiments were made to stay for 14 days.

The growth parameters (height of seedlings, root length, leaf length and width) were measured in centimeters after 14 days. The dry weights of the seedlings were determined by oven drying at 80°C for 48 hours. The difference between fresh weight and the dry weight of the seedlings were regarded as moisture contents.

Data on germination percentage and growth parameters of the seedlings were subjected to Analysis of Variance (ANOVA), following the methods of Little and Hills (1972). The levels of five trace metal elements viz. Pb (Lead), Ni (Nickel), V (Vanadium), Cr (Chromium) and Cd (Cadmium) were analyzed in cassava varieties using UNICAM 939 spectrometer. The trace elements and distilled water were analyzed with UNICAM 939 Atomic Absorption Spectrometer.

RESULTS

Table 1 shows the physical and chemical properties of the different samples of the cassava processing effluent from the four varieties of cassava that were used. The pH of the four samples were 4.20, 4.0, 4.10, and 4.20 respectively and was acidic which is in contrast to the admissible limits of 6.5-8.5 for pH value in effluent water as stated by WHO (2004). The conductivity ranged from 11.28 to 22.28 dS/m which were low compared to WHO (2004) standard of 750.5 with TMS 92/0057 being the highest, while suspended solids ranged from 44 to 241mg/L. The suspended solid of TMS 90/0326 and TMS 30572 were higher than TMS 92/0057 and NR 8082. The phosphate ranged from 8.81 – 11.65 mg/L, calcium ranged from 1200 to 1800 mg/L with NR 8082 being the highest, sodium ranged from 24 – 30 mg/L, potassium ranged from 6000 – 6600 mg/L with TMS 92/0057 being the highest, HCN was 15.12, 12.96, 16.86 and 16.11 mg/L which was observed to be very high as against FAO/WHO

(1991a) admissible maximum limit of less than 10mg/kg. However, the BOD was quite low.

Figures 1 to 10 show the growth parameters of maize seedlings using the wastewater samples from the four varieties of cassava. At the highest concentration of the effluents (100%), germination and overall growth of the plant were inhibited except with variety TMS 93/0326, which had poor germination and growth. In all the varieties tested, the germination percentage and growth parameters were significantly ($p < 0.05$) reduced with increased effluent concentration. There were also significant ($p < 0.05$) reduction in fresh weight, dry weight and moisture content with increased effluent concentration (Figures 8, 9 and 10) respectively.

The lead content of all the varieties was very high as compared to the control. It ranged from 171.15 – 229.0 (mg/L) while the control was 10.80 mg/L. Other trace metals significantly ($p < 0.05$) increased above the control (Table 2).

DISCUSSION

The physical and chemical of properties of cassava processing wastewater showed that the pH is acidic which is in contrast to the admissible limits of 6.5-8.5 for pH value in effluent water as stated by WHO (2004). The high values of pH may be attributable to the presence of prussic acid (Gibbson and Pain, 1985). Therefore, the effluent if untreated before discharge into the environment is a potential source of water pollution within the vicinity. Also the level of cyanide content was observed to be very high as against FAO/WHO (1991a) admissible maximum limit of less than 10 mg/kg. However, the high level of cyanide level can cause ill-health and ultimately death in human and aquatic biota (Ademoroti, 1996b). The electrical conductivity of the four effluent samples was low indicating low presence of conducting ions.

Table 1: Physicochemical Analysis of the Cassava Processing Effluent of varieties A-D

Parameters	Sample A	Sample B	Sample C	Sample D	WHO Standard (2004)
pH	4.20	4.00	4.10	4.00	6.5-8.5
Conductivity (dS/m)	22.28	11.28	16.78	15.32	750.5
Suspended Solid (mg/L)	44.00	46.00	230.00	241.0	25
Phosphate (mg/L)	8.81	10.00	10.00	11.65	-
Sodium (mg/L)	24.00	25.00	26.00	30.00	-
Calcium (mg/L)	1200.0	1800.0	1560.0	1440.0	-
Potassium (mg/L)	6600.0	6400.0	6000.0	6100.0	-
HCN (mg/L)	15.12	12.96	16.86	16.11	10
BOD	1.633	2.45	2.36	2.08	10

Table 2: Trace Metal Levels from the Effluents of varieties A-D

Samples	Pb (Mg/L)	Ni (Mg/L)	V (Mg/L)	Cr (Mg/L)	Cd (Mg/L)
Control	10.80	2.44	0.60	0.08	0.10
A	171.15	8.430	1.114	0.180	0.451
B	194.6	3.716	1.632	0.131	0.226
C	229.0	8.441	1.422	0.103	0.238
D	227.6	8.436	1.220	0.101	0.218

Key: A=TMS 92/0057; B = NR-8082; C =TMS 92/0326; D = TMS 30572

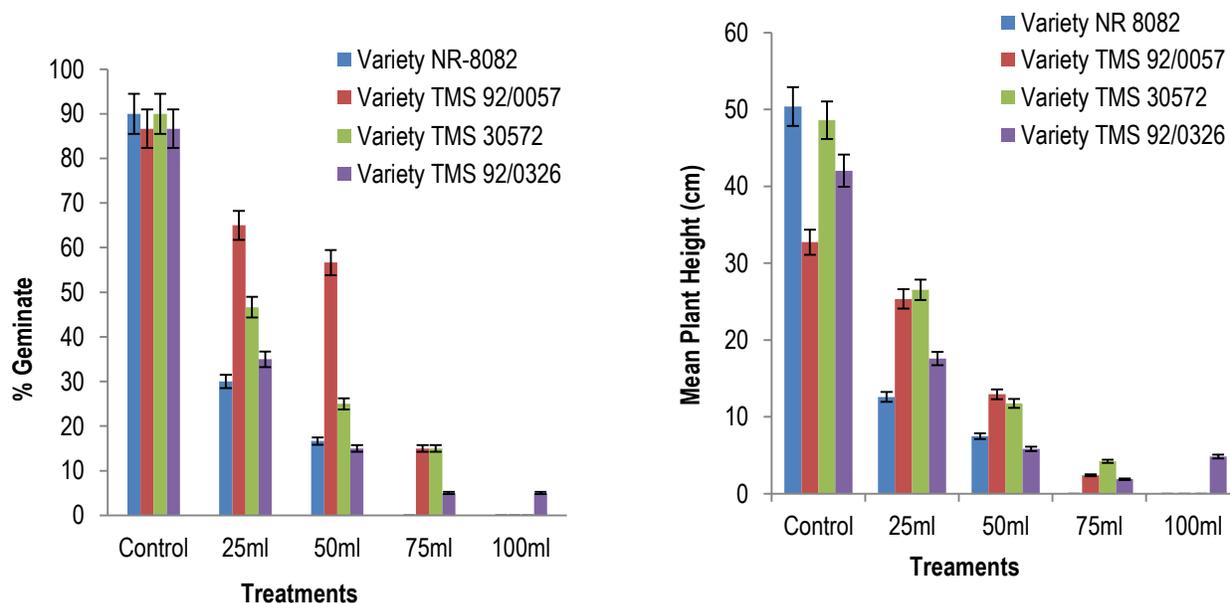


Figure 1: The effect of cassava processing waste water on % Germination of *Zea mays* varieties

Figure 2: The effect of cassava processing wastewater on Plant height of *Zea mays* varieties

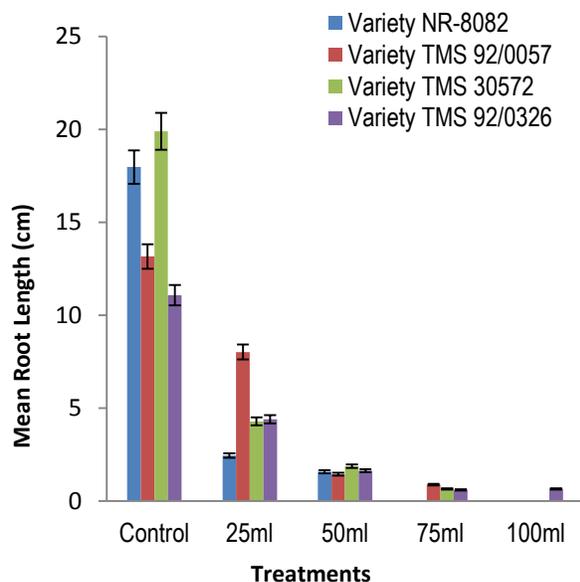


Figure 3: The effect of cassava processing waste water on root length of *Zea mays* varieties

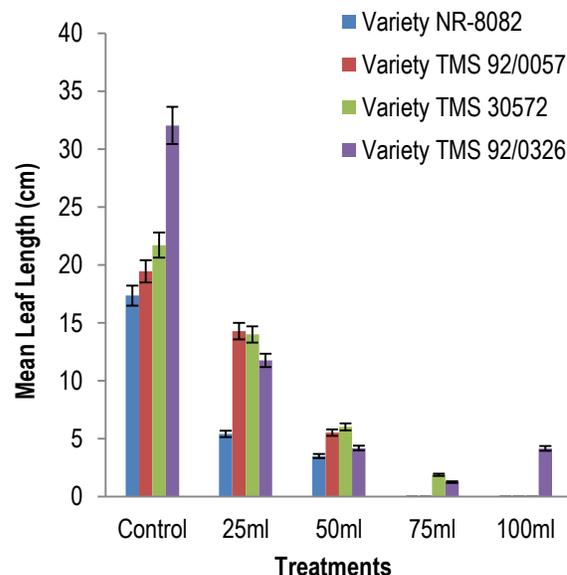


Figure 5: The effect of cassava Processing Waste Water on Leaf Length of *Zea mays* varieties

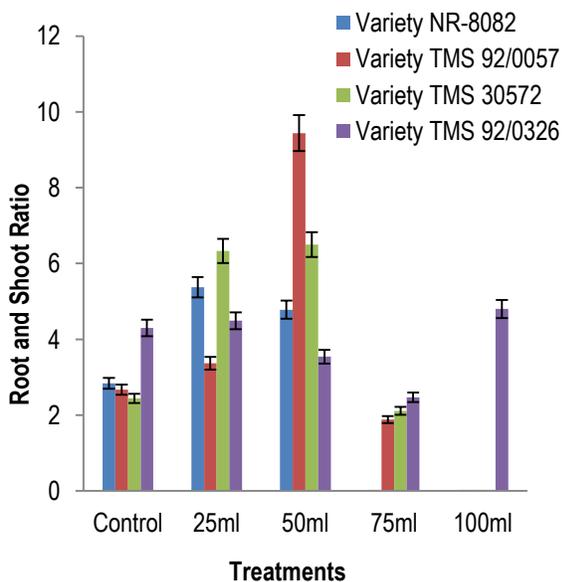


Figure 4: The effect of cassava processing waste water on Root and Shoot Ratio of *Zea mays* Varieties

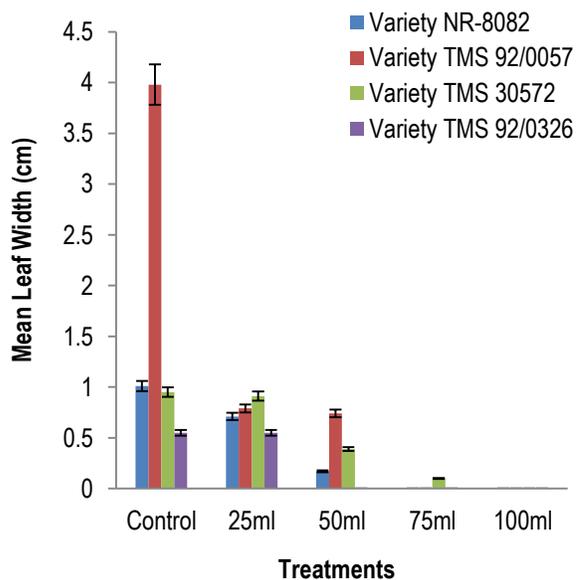


Figure 6: The effect cassava processing Waste Water on Leaf Width of *Zea mays* varieties

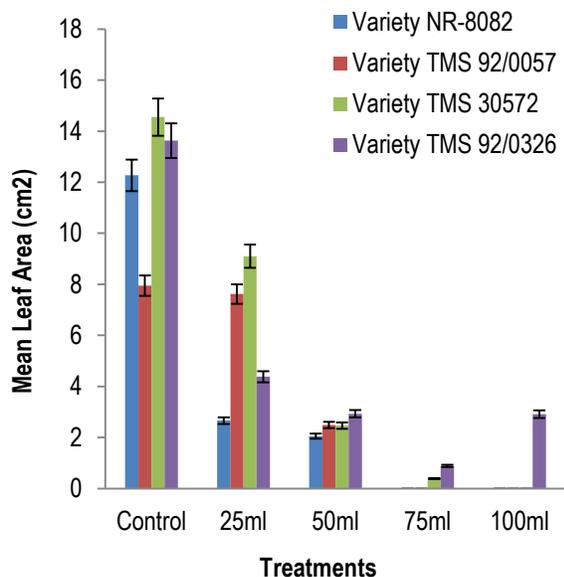


Figure 7: The effect of cassava processing waste water on Leaf Area of *Zea mays* varieties

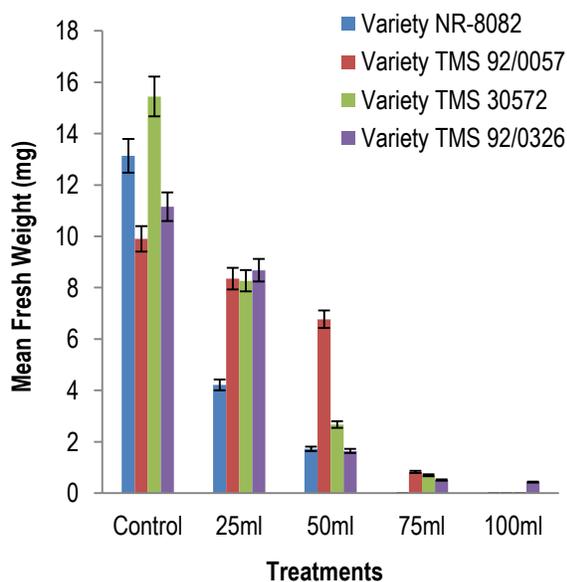


Figure 8: The effect of cassava processing waste water on Mean Fresh Weight of *Zea mays* varieties

Generally, all the effluents have slightly irritating odour and this goes to explain the odious smell that is normally associated with garri processing industry and its surrounding. These are indexes of highly polluted cassava processing waste water

that may be very detrimental to plant growth. The presence of these properties may affect seed germination and growth.

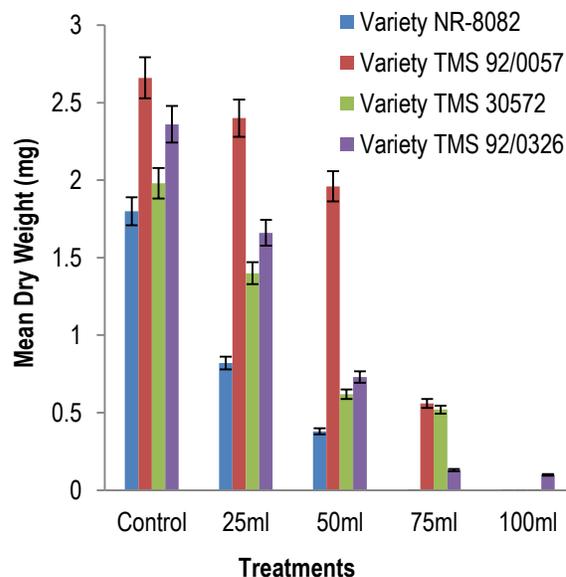


Figure 9: The effect of cassava processing Waste Water on the Mean Dry Weight of *Zea mays* varieties

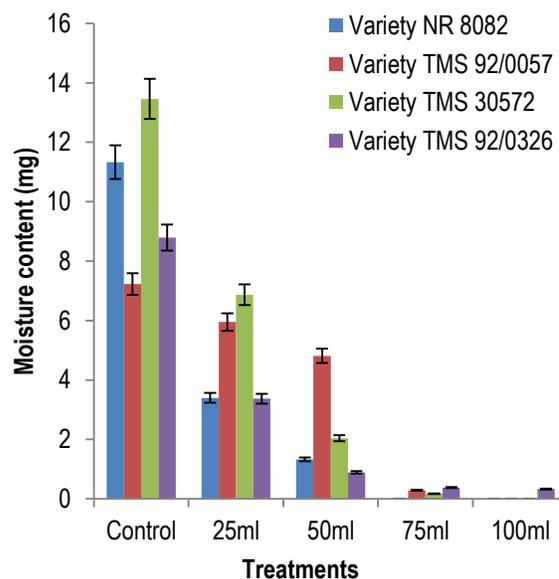


Figure 10: The Effect of Cassava Processing Waste Water on Moisture Content of *Zea mays* varieties

These pollutant indicators as shown on Table 1 can therefore be reduced in their units when the effluents are treated with suitable active carbons as documented by Okafor and Egwin (2004) in which it was reported that treatment of cassava effluent with locally developed adsorbents reduced BOD and COD by up to 50 and 75% respectively. High values for calcium and potassium were also observed. Potassium is very important in plant growth; its deficiency affects the growth of the plant severely because it stimulates early plant growth, increases protein production, improves the efficiency of water use and improves resistance to diseases and insects. There were significant ($p < 0.05$) reductions in the percentage germination and growth parameters of maize seedlings with increased levels of wastewater tested. The low rate in germination was probably due to toxicity resulting from effluent contamination around the seeds. This agrees with the findings of Dutta and Biossyna (1997) that worked on the effect of paper mill effluent on germination of rice seed and growth behavior of its seedlings and discovered that effluents particularly at higher concentration inhibit germination. Rajni and Chauchan (1996) discovered in their investigation that the effect of tannery effluent on seed values of *Hordeum vulgare* L. showed that the effluents caused a significant reduction in germination percentage. Ogunwenmo et al. (2010) also found out that paints effluents generally inhibited the germination of Leafy vegetables-*Amaranthus hybridus* and *C. argentea*. The reduction in growth parameters may also be due to heavy metal poisoning, as a result of high concentration of heavy metals like lead. The reduction in BOD observed showed that the oxygen available in the waste water is not completely consumed by the bacteria and the dissolved oxygen (DO) levels increased, indicating a small amount of organic pollution. When the BOD increases, there is an increase in the organic pollution and consequent decrease in DO. When all DO in the waste water is used up, anaerobic conditions set in resulting in offensive odours. Most fish and aquatic organisms hardly survive in water polluted with

waste water (Henry and Howeler, 1996). The fresh and dry weights significantly ($p < 0.05$) decreased with increase in cassava processing waste water. This reduction may be due to a reduction in the proportionate amount of nutrients and biomass at the elongation phase of seedlings (Mayer et al., 1973), or due to low water potential of the cassava processing effluents which weakened nutrient absorption in combination with the acidic nature of the cassava processing waste water. This result is in line with the study of Pandey et al (1994), who showed that there was significant reduction in the fresh weight of seedlings. The cassava processing wastewater had high levels of Pb, Ni, V, Cr and Cd as compared to the control. Lead was found to be a major heavy metal constituent in cassava effluents. This result is in line with the study of Heidari et al. (2005) reported that *Zea mays* is a Pb tolerant plant and that Pb metal ions accumulate mostly in their roots and shoots (Malkowski et al., 1996). Heavy metals disrupt the metabolic processes of living organism by inducing anatomical changes in primary leaves (Chaudhry and Qurat-ul-Ain, 2003). It could have been that the high rate of pollution enhanced the production of trace elements. Similar observations were made by Lowei (1968), who showed that increased levels of trace elements were indicative of extensive pollution. Therefore, these results should be a source of major concern not only to farmers with garri processing industries within their surroundings but to all others who discharge such effluents indiscriminately without adequate prior treatment.

CONCLUSION

The cassava waste water characteristics showed some values of the physicochemical parameters exceeded the World Health Organization Standard for industrial wastewaters therefore not safe for direct discharge in farmlands. The electrical conductivity of the four effluent samples was low indicating low presence of conducting ions while the pH values showed the effluent was acidic. This study also revealed the bio-

concentration of heavy metals in plants and its attendant toxicity and continued discharge industrial cassava waste water effluent could lead to further deterioration of the ecosystem.

REFERENCES

- Ademoroti, C.M.A. (1996b). *Environmental Chemistry and Toxicology*, Foludex Press Ltd., Ibadan, Nigeria.
- Anoliefo, G. O. and Edegbai, B. O. (2001). Effect of spent engine oil as a soil contaminant on the growth of two egg Nant species, *Solanum melongena* (L.) and *S. incanum* (L.). *Journal of Agriculture, Forestry and Fisheries*, **1**:21-25
- APHA (1989). Standard methods for the examination of water and wastewater. *American Public Health Association*, 17th edition pp. 110 -200.
- Chaudhry, N.Y. and Qurat-ul-Ain, (2003). Effect of growth hormones i.e., IAA, Kinetin and heavy metal i.e., lead nitrate on the internal morphology of leaf of *Phaseolus vulgaris* L. *Pakistan Journal of Biological Sciences*, **6**: 157-163.
- Cereda, M. P. and Takahashi, M. (1966). *Cassava wastes*. Their characterization; uses and treatment in Brazil pp. 16 -25.
- Cobb, G. P., Sands, K., Waters, M., Wixson, B. G. and Dorward-King, E. (2005). Accumulation of heavy metals by vegetables grown in mine wastes. *Environmental Toxicology and Chemistry*, **19**:600-609
- Coe, E. H. Jr., Nueffer, M. G. and D. A. Hoisington (1988).The genetics of maize. In G.F Sprague and J.W. Dudley, Eds. *Corn and corn improvement*. Agronomy Monographs American Society of Agronomy: Madison, Wisconsin, **18**; 220-236.
- Dutta, S.K. and Boissya, C. L. (1997). Effect of paper mill effluent on germination of rice (*Oryza sativa* L.) and growth behaviour of its seedlings. *Journal of Industrial Pollution Control*, **13**:41-47.
- Ehiagbonare, J. E., Enabulele, S. A., Babatunde, B. B. and Adjarhore, R. (2009). Effect of Cassava Effluent on Okada denizens. *Scientific Research and Essay*, **4**(4): 310-313.
- Esenowo, G. J. (1991). *Developmental Biology and Plant Physiology*. Abaam Publishing co. Kaduna, Nigeria, pp. 221-250
- Essien E. P. and Odoemena, C. S. (2005). The effect of palm oil processing effluent on germination and early seedling growth of *Zea mays* L. *Journal of Sustainable Tropical Agricultural Research*, **16**:72 - 76.
- FAO/WHO (1991a). Joint FAO/WHO food standard programme. Codex Alimentarius Commission. XII Suppl. 4Ed. Rome: FAO pp1-42
- Gibbon, D and Pain, A. (1985). *Crops of the Drier Region of the Tropics*, England Longman Group, U.K.
- Heidari, R., M. Khayami and T. Farboodnia, (2005). Effect of pH and EDTA on Pb accumulation in *Zea mays* seedlings. *Journal of Agronomy*, **4**: 49-54.
- Henry, G., Howeler, R. (1996). *Cassava in China in an era of change*. A CBN case study with farmers and processors. Working Document No. 155. CIAT, Cali, Columbia p. 18.
- ICAR, (2006). ICAR Guidelines for Intellectual Property Management and Technology Transfer/Commercialization. Indian Council of Agricultural Research, New Delhi.
- Little T. M. and Hills, G. D. (1972). *Statistical Methods in Agricultural Research, Cooperative and Extension work in Agricultural and Home Economic*, California, U.S.A. pp. 40 -47.
- Lowe, B. (1986). Effect of Bowl Sludge on growth of two pasture legumes, *Brachia mutica* and *Axonopus compressus*. *Malaysia Journal of Agriculture* **25**:19 - 31.
- Malkowski, E., Stolarek, J. and Karcz, W. (1996). Toxic effect of Pb²⁺ ions on extension

- growth of cereal plants. *Polish Journal of Environmental Studies*, **5**: 41-45.
- Mayer, B. S., Anderson, D. B., Bohning, R. H. and Friatiana D. G. (1973). *Introduction to Plant Physiology* 2nd edition, D. Van Nostrand Company – New York. pp. 431 – 463.
- Ogunwenmo, K. O., Oyelana, O. A. Ibidunmoye, O. Anyaso, G. and Ogunnowo, A. A. (2010). Effects of brewery, textile and paint effluent on seed germination of leafy vegetables-*Amaranthushybridus* and *Celosia argentea* (Amaranthaceae). *Journal of Biological Sciences.*, **10**:151-156.
- Okafor, G. E. (1997). Effect of Effluent Quality and Application Method of Agricultural Productivity and Environment Control. *Water Science and Technology* **26**: 1593 – 1601.
- Okafor, J.O. and Egwim E. (2004). Effect of Chemically and Physically treated Adsorbents on wastewater from Garri Processing Industry, 27th Annual International Conference of Chemical Society of Nigeria, Benin City, Nigeria. 21st to 22nd August.
- Orhue, E. H., Ulaamen, C. and Emuejevoke, V. D. (2005). Growth of maize and changes in some chemical properties of an utisol amended with brewery effluent. *African Journal of biotechnology* **12**:973-978.
- Pandey, D. K., Soni, P. and Dhiman R. C. (1994). Utilization Potential of Distillery effluent VOSANA **38**:12 – 13.
- Rajni, A. and S.V.S. Chauchan (1996). Effect of tannery effluent on seed germination and total biomass in some varieties of *Hordeum vulgare* L. *Acta Ecol.*, **18**: 112-115.
- Salami, S.J. and Egwin I.N. (1997). Impact of Tannery Effluents on the Quality of Receiving Stream, *African Journal of Natural Sciences*, **2**(1) pp 17-20.
- Singh, K. K. and Mishra, R. (1987). Effect of Fertilizer Factory on Soil and Crop Productivity. *Journal of Water, Air and Soil Pollution* **33**:309 – 320.
- Tan, H., Pillai, K. P. and Bary, D. J. (1979). Possible Utilization of Rubber Factory Effluent on Cropland. Proceeding of Rubber Research Institute of Malaysia, Kuaba Lumpur, pp.154.
- World Health Organization (WHO), (2004). Maximum Allowable Concentration of Selected Water Quality Variables.