Bioscience Research Communications
Vol. 14, No. 2, April 30, 2002
Printed in Nigeria

0795-8072/2002 $12.00 + 0.00

BRC 2000048/14208

Some trace elements in juice and bagasse of two varieties of sugarcane, location soil and irrigation water from Bacita Sugar Estate, Nigeria

F. A. Adekola and A. A. Akinpelu

Department of Chemistry, University of Ilorin, P. M. B. 1515, Ilorin, Nigeria

(Received May 19, 2000)

ABSTRACT: Some trace elements (Fe, Mn, Zn, Cu, Cd and Pb) have been determined in the juice and bagasse of two varieties of sugarcane (S9C0959 and S27BC0997) grown at Bacita Sugar Estate, Nigeria. These trace elements were also analysed for in the plantation soil and in the irrigation water being used for the production. All the trace elements have low concentrations in all the samples. Zn, Fe, Mn and Cu have relatively higher concentrations in the plantation soil than in other samples. Zn has relatively higher average levels of 0.311 mg/l and 0.401 mg/l in the cane juice of S9C0957 and S27BC0997 respectively. The levels of Mn and Cu are generally very low in the juice, bagasse and irrigation water, while Cd and Pb are rarely detected in most of the samples. Comparison of these levels of trace elements in irrigation water with WHO and United States Environmental Protection Agency maximum permissible levels for both drinking and irrigation purposes indicates that Bacita irrigation water is not potable but suitable for irrigation of farmlands. The linear regression analysis of the analytical results shows that stronger associations occurred between bagasse/juice ($r = 0.8744$ and 0.9039 for S9C0957 and S27BC0997 respectively), bagasse/irrigation water ($r = 0.9406$ and 0.9471 for S9CO957 and S27BC0997 respectively) and juice/irrigation water ($r = 0.7570$ and 0.9848 for S9C0957 and S27BC0997 respectively). No significant difference ($P = 0.05$) was found between the trace elements concentrations in the juice and bagasse of the two cane varieties.

Key Words: Trace elements; Sugarcane juice; Sugarcane bagasse; Irrigation water.

Introduction

Sugarcane (*Saccharum officinarum* Linn.) belongs to the grass family (*Gramminaea*) which includes about 5,000 species of plants (Phillips, 1977). Sugarcane is now grown commercially in many parts of tropical and sub-tropical regions of the World and approximately half of the sugar produced in the World is from Sugarcane (Okusanya and Ajogbasile, 1980). Sugarcane is mainly grown in Nigeria, in the alluvial valley soils of Kaduna and Kano States. The major sugar plantation estates in Nigeria are located at Numan in Adamawa State, Sunti and Mokwa in Niger State, Lafiagi and bacita in Kwara State. Sugarcane is a crop that makes a high demand on essential plant nutrients. Sugarcane production practices throughout the World vary depending on soil types, climatic factors and custom (Bello, 1999).

In most of the sugar plantation estates in Nigeria, the climate is characterized by a pronounced break between dry and wet season. The water deficit from December to March necessitates the use of irrigation during at least six months of the year. The case of Bacita sugar estate, the largest of such in Nigeria, is again peculiar in that the long dry season and poorly distributed low annual rainfall require that irrigation of plantation has to be carried out practically throughout the year. As a result of high demand of sugarcane on essential nutrients, it is not impossible that trace elements if present in the irrigation water or soil could eventually be absorbed and hence, resulting in important concentrations of these elements in the cane juice.

This study was therefore initiated in order to understand the possible effect or influence of the physico-chemical quality of the irrigation water and also of the soil on the quality of cane juice and bagasse. Furthermore, this study will provide baseline data on the trace elements levels in cane juice and bagasse and hence could serve as guide to the formulation of realistic permissible levels of trace elements in refined sugar and other sugar products by the Standard Organisation of Nigeria. Monitoring of the level of trace elements, and especially the most toxic ones such as cadmium and lead, in both juice and bagasse is important. The trace elements (cadmium, copper, lead, zinc, manganese and iron) focussed in this study are included in the list of metals considered important by the Global Environment Monitoring System (GEMS) by the United Nations Environmental Programme (UNESCO/WHO/UNEP, 1992). In the production of white sugar from cane, juice extracted from sugarcane is the major raw material. While bagasse is a by-product obtained after extraction of the juice by cane crushing and controlled leaching.

Bagasse represents about 12% of the original cane (kent, 1974; Hamilton and Longe, 1980). The various uses of bagasse including its use as an industrial fuel and as soil additives have been extensively discussed (Lucas and dada, 1980). Its use as an industrial fuel could be hazardous especially if bagasse contains high levels of some trace elements. During burning, trace elements could be emitted into the environment as flyash. Two of the main varieties of sugarcane cultivated in Bacita were considered in this study. They were S9CO959 and S27BCO997. Varietal differences with respect to the uptake of elements were also considered.

Materials and Methods

Sample Collection

Two varieties of sugarcane; S9CO959 and S27BCO997 were collected from Nigerian Sugar Company Plantation, Bacita on the 14th of April, 1998. The juice was extracted from the cane within 24 hours of collection. This was done manually by squeezing out the juice into a clean plastic container and then preserved with nitric acid. The water being used for irrigation of the plantation was also collected into a clean plastic container and appropriately preserved by adding 1ml of concentrated nitric acid. Both surface (0-15cm) and sub-surface soils of the plantation site were also samples with the aid of soil auger and for each sugarcane variety. The soils samples were collected into black polythene bags. Five samples were collected for sugarcane, topsoil, subsoils (15-30cm and 30-45cm) and irrigation water. Juice from 5 samples of each of the top varieties of cane were mixed together to form composite samples for each variety. Composite samples were then prepared for every investigated component by pulling together five samples.

Sample Preparation

The soil samples were air-dried in the laboratory for about nine days. The soil samples were then sieved and the fraction with diameter less than 2mm was retained for analysis. About 5g of the air-dried soil was then digested in a mixture of perchloric (4ml), concentrated sulphuric acid (2ml) and concentrated nitric acid (25ml) following an established procedure (IITA, 1979). Bagasse was subjected to the same digestion procedure as soil (Pearson, 1982). Both the extracted juice and the irrigation water were separately digested in a mixture of concentrated nitric and hydrochloric acids (APHA, 1993). All digestions were carried out in triplicate.

Analysis

All digested solutions of soil, bagasse, cane juice and irrigation water were analysed for zinc, manganese, copper, cadmium, iron and lead by atomic absorption spectrophotometrique technique (Pye Unicam Model PU9100X flame atomic absorption spectrophotometer).

Results and Discussion

Results of the levels of trace elements in the juice and bagasse of the two sugarcane varieties; S9CO957 and S27BCO997, collected from Bacita sugar estate are summarised in Tables 1 and 2 respectively. The trace elements concentration in both the soil and the irrigation water are also included in each Table. All the trace elements investigated exhibited low levels in all the samples. Zinc, iron, manganese and copper exhibited relatively higher levels compared with cadmium and lead in local soils. The mean concentration of zinc is also the highest out of all the elements in cane juice bagasse and irrigation water. For instance, the average level of zinc in the soil of the site of cane variety S90CO957 ranges between 0.300 and 0.380 mg/kg of dry soil, while it ranges between 0.27 and 0.33 mg/kg in the site soil of S27BCO997. Zinc has relatively higher average levels of 0.311mg/L and 0.401mg/L in the cane juice of S9CO957 and S27BCO997 respectively. The levels of manganese and copper are generally lower in the juice, baggase and irrigation water, while the levels of cadmium and lead are the lowest and at times fell below the detection limit. The levels of zinc had earlier being reported to be about three times that of manganese or even thirteen times that of copper or molasses obtained from Bacita sugar factory (Oderinde and Ngoka, 1988). A comparable trend has been observed in this work for both the cane juice and bagasse.

The results gathered in Tables 1 and 2 have been subjected to linear regression analysis in order to find associations between all possible pairs among the irrigation water, cane juice, bagasse and the location soils viz-a-viz the trace elements composition. The Perason's correlation coefficients obtained from the statistical computation for cane varieties S9CO957 and S27BCO997 were given in Tables 3 and 4 respectively. As all the components investigated had positive correlation coefficients, the statistically significant ones were extracted by making use of the critical multiple correlation coefficient, R and all values with $r \leq R$ in Tables 3 and 4 were extracted. The critical value of R with $n = 6$ and $\alpha = 0.05$ is 0.7293 (Johnson et al., 1998). The significant values, extracted from tables 3 and 4 are highlighted in Table 5. The linear regression data were obtained by calculating the Pearson's correlation coefficient, r with the aid of SPSS computer programme (Horsfall et al., 1999). Stronger associations were exhibited between the pairs bagasse/juice ($r = 0.8744$ and 0.9037 for S9CO957 and S27BCO997 respectively), bagasse/irrigation water ($r = 0.9406$ and 0.9471 for S9CO957 and S27BCO997 respectively), cane juice/irrigation water ($r = 0.7570$ and 0.9848 for S9CO957 and S27BCO997 respectively). As expected, stronger associations were also found among the three component of the soils. No significant difference ($p = 0.05$) was found between the trace elements concentrations in both the juice and bagasse of the two varieties. These results therefore show that the quality of the irrigation water could most probably influence the quality of the cane juice as well as the bagasse. Comparison of the levels of trace elements in irrigation water at Bacita sugar estate with the maximum permissible levels recommended for both human consumption and irrigation (Table 6) indicates that although the Bacita irrigation water is not potable, it is however suitable for irrigation of farmlands (UNESCO/WHO/UNEP, 1992 and USEPA, 1987).

Table 1: Mean concentration* of trace elements in extracted juice, bagasse, local soil and irrigation water for the cane variety S9CO957.

Sample	Fe	Zn	Mn	Cu	Cd	Pb
Juice	0.266±0.018	0.311±0.055	0.078±0.011	0.044±0.011	0.044±0.011	0.033±0.011
Bagasse	0.190±0.010	0.490±0.032	0.160±0.008	0.080±0.002	<0.01	<0.010
Top soil (0-15cm)	0.450±0.037	0.380±0.040	0.380±0.010	0.420±0.070	0.050±0.010	<0.010
Subsoil (15-30cm)	0.300±0.028	0.310±0.130	0.380±0.160	0.360±0.020	0.050±0.010	0.020±0.000
Subsoil (30-45cm)	0.370±0.019	0.300±0.010	0.130±0.01	0.410±0.010	0.060±0.012	0.060±0.001
Irrigation water	0.050±0.003	0.390±0.015	0.030±0.004	0.050±0.003	<0.010	<0.010

*All results are expressed in mg/kg except irrigation water and juice which are expressed in mg/L.

Table 2: Mean concentration* of trace elements in extracted juice, bagasse, local soil and irrigation water for the cane variety S27BCO997.

Sample	**Fe**	**Zn**	**Mn**	**Cu**	**Cd**	**Pb**
Juice	0.032±0.018	0.401±0.099	0.067±0.014	0.033±0.012	0.056±0.010	0.022±0.011
Bagasse	0.150±0.014	0.340±0.025	0.040±0.000	0.050±0.001	<0.010	<0.010
Top soil (0-15cm)	0.670±0.040	0.270±0.030	0.410±0.010	0.160±0.010	0.040±0.010	<0.010
Subsoil (15-30cm)	0.260±0.018	0.330±0.010	0.540±0.010	0.230±0.010	0.030±0.010	<0.010
Subsoil (30-45cm)	0.410±0.025	0.280±0.040	0.330±0.040	0.260±0.030	0.010±0.000	<0.010
Irrigation water	0.050±0.002	0.390±0.011	0.030±0.002	0.050±0.003	<0.010	<0.010

*All results are expressed in mg/kg except irrigation water and juicewhich are expressed in mg/L.

Table 3: Pearson's correlation coefficient for the investigated samples with respect to cane variety S9CO957.

Sample	Bagasse	Juice	Top soil (0-15cm)	Subsoil (15-30cm)	Subsoil (30-45cm)	Irrigation water
Bagasse	1.0000	0.8744	0.5761	0.5365	0.4504	0.9406
Juice	0.8744	1.000	0.5677	0.4106	0.5327	0.7570
Top soil (0-15cm)	0.5761	0.5677	1.000	0.9624	0.8436	0.3536
Subsoil (15-30cm)	0.5365	0.4106	0.9624	1.000	0.7200	0.3239
Subsoil (30-45cm)	0.4504	0.5327	0.8436	0.7200	1.000	0.3547
Irrigation water	0.9406	0.7570	0.3536	0.3239	0.3547	1.000

Table 4: Pearson's correlation coefficient for the investigated samples with respect to cane variety S27BCO997.

Sample	**Bagasse**	**Juice**	**Top soil (0-15cm)**	**Subsoil (15-30cm)**	**Subsoil (30-45cm)**	**Irrigation water**
Bagasse	1.000	0.9037	0.3819	0.3523	0.4917	0.9471
Juice	0.9032	1.000	0.0410	0.3015	0.2034	0.9848
Topsoil (0-15cm)	0.3819	0.0410	1.000	0.6437	0.9033	0.1039
Subsoil (15-30cm)	0.3523	0.3015	0.6437	1.000	0.8063	0.2994
Subsoil (30-45cm)	0.4917	0.2034	0.9033	0.8063	1.000	0.1039
Irrigation water	0.9471	0.9848	0.2994	0.2874	0.1039	1.000

Table 5: Number of significant correlation relationships between possible pairs of the investigated samples obtained by linear regression analysis.

Sample pairs	Significant correlation values (variety S9CO957)	Significant correlation values (variety S27BCO997)
Bagasse/Juice	0.8744	0.9037
Bagasse/Irrigation water	0.9406	0.9471
Juice/Irrigation water	0.7570	0.9848
Topsoil/Subsurface soil (15-30cm)	0.9624	0.6437
Topsoil/Subsurface soil (30-45cm)	0.836	0.9033
Subsurface soil (15-30cm)/Subsurface soil (30-45cm)	0.7200	0.8063

Table 6: Comparison of the mean concentrations (mg/L) of trace elements in Bacita irrigation water with the maximum permissible levels for both consumption and irrigation purposes.

Trace element	Consumption[1]	Irrigation[2]	Bacita irrigation water
Cd	0.005	0.010	<0.010
Cu	1.000	0.200	0.050
Pb	0.050	5.000	<0.010
Zn	5.000	2.000	0.390
Fe	0.300	-	0.050
Mn	0.100	-	0.030

[1]UNESCO/WHO/UNEP (1992) and [2]USEPA (1987).

ACKNOWLEDGEMENT: The authors are grateful to the management of Bacita Sugar Company for granting us the permission to collect the samples we used for this study.

References

American Public Health Association (APHA)(1993). Standard methods for the examination of water and wastewater. Washington, D.C., Part 3, p. 1 – 7.

Bello, O.B. (1999). Evaluation of different formulations of weak acid solution as preservatives medium for sugarcane stalks. Unpublished M.Sc. Dissertation, University of Ilorin, Ilorin, p. 1 – 4.

Hamilton, W. and Longe, T.A. (1980). Secondary products from the sugarcane industry, in the Proceedings of a National Symposium organised by the Unilorin Sugar research Institute, University of Ilorin, Nigeria, June 24 – 25, (Ed.) M.O. Fawole, 137 – 146.

Horsfall, M.; Horsfall, M.N. and Spiff, A.I. (1999). Speciation of heavy metals in intertidal sediments of the Okrika river system, Rivers State, Nigeria. Bull. Chem. Soc. Ethiop., 13: 1 – 9.

IITA (1979). Selected methods for soil and plant analysis, manual Series No. 1, p. 50, International Institute of Tropical Agriculture, Ibadan, Nigeria.

Johnson, T.L.; Shangodoyin, D.I. and Shittu, O.I. (1998). Fundamental Statistical Tables, p. 31. Department of Statistics, University of Ibadan, Ibadan, Nigeria.

Kent, J.A. (1974). Riegel's Handbook of Industrial Chemistry, 7th edition, van Nostrand Reinhold Company, New York.

Lucas, E.B. and dada, S.A. (1980). Bacita Sugar Mill residues: A potential source of raw materials for particle board manufacture and other industrial uses, in Proceedings of a national Symposium organised by the Unilorin Surgar Research Institute, University of Ilorin, Nigeria, June 24-25, (Ed.) M.O. Fawole, p. 147-160.