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Assessment of Herbicide Residues in Different Varieties of Sugarcane Samples from Savannah Sugarcane Plantation, Numan L.G.A, Adamawa State, Nigeria

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ABSTRACT

The uncontrolled usage of herbicide residues in agricultural production can lead to the accumulation of chemical contamination in soil and plants. In this study, varieties of sugarcane samples were collected from three agricultural locations (Garisa, Kem and Pita 145) in savannah sugarcane plantation Numan Local government area Adamawa State. Five variaties of sugarcane samples was collected. Sugarcane samples were prepared using standard procedures. Herbicide residues, propachlor, atrazine, paraquat, propanil, alachlor, metolachlor and butachlor were determined using high performance liquid chromatography (HPLC). Results obtained from this study show that the sugarcane samples from the three agricultural locations contained some amounts of herbicides. There are significant differences in the mean concentrations of herbicides at the various sampling locations. Also, the concentrations of all the studied herbicides were significantly higher in the soil samples as compared to the sugarcane samples. Among the herbicide residues, paraquat was the most dominant in the study area, followed by butachlor. The study also revealed that most of the studied herbicide residues were significantly higher than the WHO and FAO maximum residue limits (MRLs) and acceptable daily intake values (ADIs) values.

Keywords: *Saccharum officinaru*; Herbicides; Sugarcane; Savannah

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INTRODUCTION

Sugarcane (*Saccharum officinarum* Linn.) is a tropical crop that usually takes between 8 – 12 months to reach its maturity. Matured cane may be green, yellow, purplish or reddish depending on the varieties and are considered ripe when sugar content is at its maximum [1]. Nigeria is one of the most important producers of the crop with a land potential of over 500,000 hectares of suitable cane field capable of producing over 3.0 million metric tonnes of sugarcane. When processed, will yield about 3.0 million metric tons of

sugar[2].Nigeria is noted to be abundantly blessed with human, water and environmental potentials for the production of sugarcane. Most of the areas in the northern states where water for irrigation is available can be used for sugarcane cultivation [2].

Sugarcane juice as such is highly nutritious having many minerals and also rich in enzyme and possesses many medicinal and therapeutic properties [3]. Sugarcane juice contains water (75-85%), reducing sugar (0.3-3.0%), and non-reducing sugar (10-21%) [4]. One hundred miles (100 ml) of sugarcane juice provides 40 Kcal of energy, 10 mg of iron and 6 μg of carotene[4]. Sugarcane juice is a great preventive and healing source for sore throat, cold and flu. It has a low glycemic index which keeps the body healthy and hydrates the body quickly when exposed to prolonged heat and physical activity. It refreshes and energizes the body instantly and can be an excellent substitute for aerated drinks and cola. By using sugarcane juice regularly, rapid gain in weight can be achieved, thus can be an effective remedy for thinness [5]. But the juice extracted from the canes turns dark brown and marked sedimentation appears during storage. Generally sugarcane juice is spoiled quickly by the presence of sugars [6].

The Savannah Sugar Company (SSC) was established in Numan, Adamawa State in 1980.The sugar industry is the major user of the sugarcane (its raw material) acquired from local producers through the concept of out growers scheme of cane delivery. The varieties of sugar cane grown in the study area include (B47 419: Bardabos, COC– 671: Combatin Cudda, CO 997: Combatin, CO 6809– Combatin and SP 71 – 6180: Sawa Polo). Under this concept, sugarcane farmers are organized to grow and supply sugarcane for processing by the existing sugar plants. This is to encourage the production of sugarcane to feed sugar mills through the activities of smallholder and corporate out-growers. This approach tends to minimize the overhead cost of sugarcane processors and enable them to concentrate on processing rather than growing of sugarcane [7]. In order to be able to continue production with reduction in overhead costs of any investment, many agricultural production enterprises resorted to contracting out the production of its raw materials to the farmers that live within and around their respective companies so as to concentrate only on processing. This arrangement will ensure steady supply of raw material, employment generation and economic empowerment of the rural communities as well as reduction in rural-urban migration. In the case of the Savannah Sugar Company Limited, Numan, for it to maintain the peaceful co-existence with its immediate community, it resorted to providing array of social services such as health services, education and electricity. In addition, it went further to apportion part of its estate farm and allocated to the communities so as to keep the communities employed throughout the year with generation of employment to the teeming population living around the company. This arrangement in which the company contracts out their raw material production is referred to as out grower's scheme [7].

Successful weed control is essential for economical sugarcane production. Weeds can reduce sugarcane yields by competing for moisture, nutrients, and light during the growing season [8]. Several weed species also serve as alternate hosts for disease and insect-pests. Weed control is most critical early in the season prior to sugarcane canopy closure over the interrow spaces. Heavy weed infestations can also interfere with sugarcane harvest by adding unnecessary harvesting expenses. A weed that is allowed to mature and produce seed will multiply weed control problems by being a source of seed bank replenishment and re-infestation in subsequent years [9]. The competition depends upon the crop stand and weed population as well as competition period. The critical period of weed competition is the shortest time span during the crop growth when weeding results in highest economic returns. The initial period of crop-weed competition starts with beginning of interference from weeds and ends when crop covers 80% of soil. The length of critical period of crop-weed competition depends on the nature of crops, its competitive ability, variety, growth habit, field conditions and sowing technique [10]. The use of herbicides to control weeds has become essential to prevent weed competition and losses in sugarcane production. Sugarcane is most susceptible to weed competition during the first eight to ten weeks after cane emergence [11].

Farmers within the study area use herbicides to control weeds in sugarcane cultivation in an effort to reduce or eliminate yield losses and preserve high product quality. Lack of knowledge of the use and the effects of these herbicides among small and large scale farmers within the study area has resulted in their misuse. The accumulation of the herbicides in soil and various plants, may affect humans and other species that depend on such sugarcane for food. As a result of this, analysis of herbicide residues in the study area may be of immense significance.

MATERIALS AND METHODS

Sampling Area

Sugarcane samples were collected from Savannah Sugar Company Limited in Numan, Adamawa State, Nigeria.

Sample Collection

Five varieties of sugarcane; B47-419: Bardabos, COC– 671 Combatin Cudda, CO 997 – Combatin, CO 6809–Combatin and SP 71 – 6180: Sawa Polo was collected from Savannah Sugarcane Plantation, Numan, Adamawa State, Nigeria. The juice was extracted from the cane within 24 hours of collection. This was done using milling machine by squeezing out the juice into a clean glass flask container. The sugarcane juice was stored in a glass flask with screw caps and kept frozen in a refrigerator at 18°C frozen until analyses.

Extraction of Sugarcane Juice Samples

Two hundred and fifty miles (250 ml) of sugarcane juice were measured using measuring cylinder and then transferred into separation funnel, then 25 ml of dichloromethane was added and shake for 30s and allowed to stand for 30s the mixture were separated into clean glass container pending analysis [12].

Cleaning-up of the Juice Extracts

Cleanup of the juice extract were performed according to Lehotay [13]. Four milliliter aliquot of the upper layer of the extract were transferred into a polypropylene centrifuge tube containing 600 mg anhydrous $MgSO_4$. The extract will be mixed using a vortex for 30 s and then centrifuged for 3 min at 3500 rpm. Two millilitre of the upper layer were transferred into a glass flask and the extract evaporated in a water bath at 40 ^{0}C under nitrogen flow until total dryness. The extract will be diluted in 500 l toluene. This procedure will result in an amount of sample in the final extract of 4 ml.

Determination of Herbicide Residues

The SHIMADZU GC/MS (GC - 17A), equipped with fluorescence detector were used for the chromatographic separation and was achieved by using a 35% diphenyl, 65% dimethyl polysiloxane column. The oven were programmed as follows' initial temperature 40^{0}C, 1.5 min, to 150°C, 0.0 min, S°C/min to 200°C, 7.5 mm, 25°C/min to 290°C with a final hold time of 12 min and a constant column (flow rate of 1 ml/rnin). The detection of herbicides were performed using the GC-ion trap MS with optional MSn mode. The scanning mode offer enhances selectivity over either full scan or selected ion monitoring (SIM). In SIM at the elution time of each herbicide, the ration of the intensity of matrix ions increase exponentially versus that of the herbicide ions as the concentration of the herbicide approach the detection limit, decrease the accuracy at lower levels. The GC-ion trap MS were operated in MSn mode and perform tandem MS function by injecting ions into the ion trap and destabilizing matrix ions, isolating only the herbicide. The retention time, peak area and peak height of the sample were compared with those of the standards for quantization.

Data Handling

Data collected were presented as mean and standard deviation and two-way analysis of variance (ANOVA) were used to assess whether herbicide residues varied significantly between soil, water and sugarcane samples. Probabilities less than 0.05 ($p<0.05$) were considered statistically significant. All statistical calculations were performed with SPSS 9.0 for windows.

RESULTS

Concentration of Some Herbicide Residues in Sugarcane Samples

The mean concentration of some herbicide residues in the root, juice and leaf of B47-419 sugarcane samples from savannah sugarcane plantation is as presented in Figure 1. The

concentration of glyphosate in the root, juice and leaf ranged from 0.04 to 0.07 mg/kg; 0.08to 0.11 mg/kg butachlor; 0.06 to 0.10 mg/kg paraquat; 0.07 to 0.11 mg/kg propachlor; 0.04 to 0.07 mg/kg atrazine; 0.05 to 0.09 mg/kg propanil; 0.04 to 0.07 mg/kg alachlor and 0.03 to 0.05 mg/kg metolachlor. The mean concentration of some herbicide residues in the root, juice and leaf of SP71-6180 sugarcane samples from savannah sugarcane plantation as is presented in Figure 2. The concentration of glyphosate in the root, juice and leaf ranged from 0.05 to 0.08 mg/kg; 0.04 to 0.06 mg/kg butachlor; 0.05 to 0.08 mg/kg paraquat; 0.03 to 0.08 mg/kg propachlor; 0.04 to 0.10 mg/kg atrazine; 0.03 to 0.08 mg/kg propanil; 0.03 to 0.07 mg/kg alachlor and 0.04 to 0.07 mg/kg metolachlor. For that of CO 997 sugarcane samples from savannah sugarcane plantation as presented in Figure 3. The concentration of the glyphosate in the root, juice and leaf ranged from 0.03 to 0.06 mg/kg; 0.07 to 0.11 mg/kg butachlor; 0.05 to 0.10 mg/kg paraquat; 0.05 to 0.09 mg/kg propachlor; 0.04 to 0.07 mg/kg atrazine; 0.03 to 0.07 mg/kg propanil; 0.04 to 0.07 mg/kg alachlor and 0.02 to 0.06 mg/kg metolachlor. The mean concentration of some herbicide residues in the root, juice and leaf of COC 671 sugarcane samples from savannah sugarcane plantation is as presented in Figure 4. The concentration of glyphosate in the root, juice and leaf ranged from 0.05 to 0.09 mg/kg; 0.06 to 0.10 mg/kg butachlor; 0.05 to 0.08 mg/kg paraquat; 0.03 to 0.08 mg/kg propachlor; 0.03 to 0.07 mg/kg atrazine; 0.04 to 0.08 mg/kg propanil; 0.02 to 0.05 mg/kg alachlor and 0.04 to 0.07 mg/kg metolachlor. For that of CO 6806 sugarcane samples from savannah sugarcane plantation as presented in Figure 5. The concentration of the glyphosate ranged from 0.05 to 0.07 mg/kg; 0.05 to 0.08 mg/kg butachlor; 0.05 to 0.09 mg/kg paraquat; 0.03 to 0.08 mg/kg propachlor; 0.04 to 0.07 mg/kg atrazine; 0.07 to 0.08 mg/kg propanil; 0.03 to 0.06 mg/kg alachlor and 0.05 to 0.06 mg/kg metolachlor.

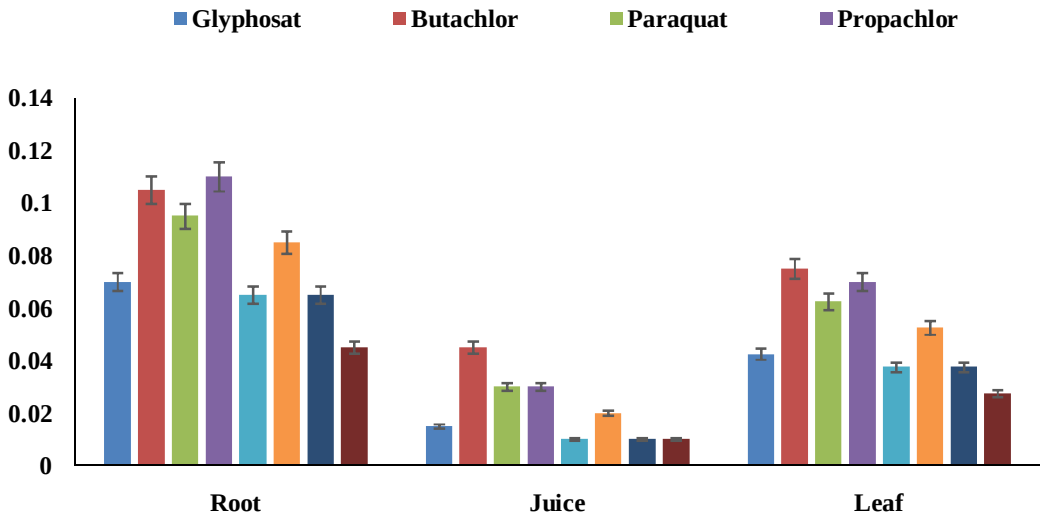


Figure 1:

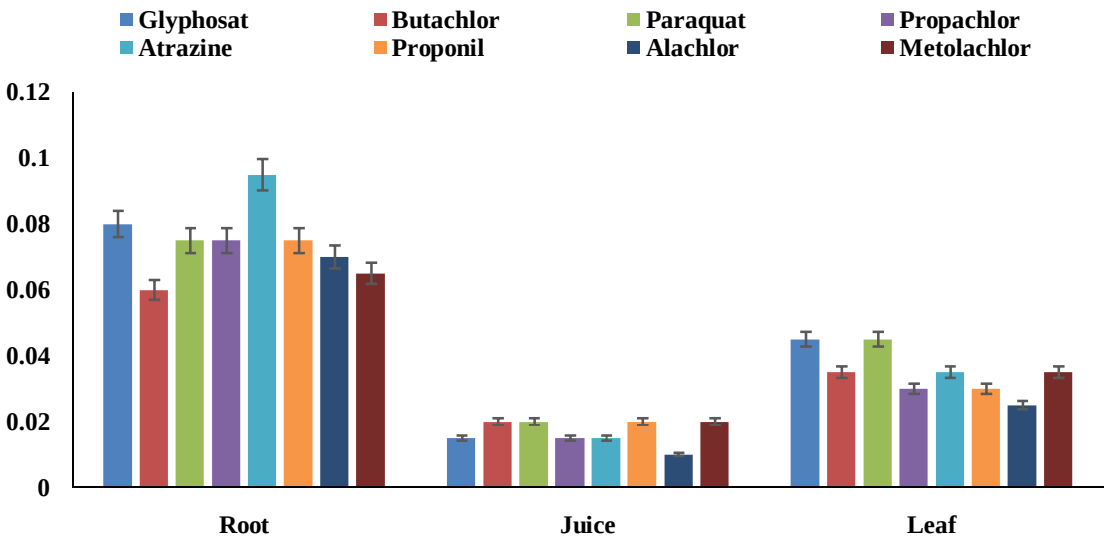
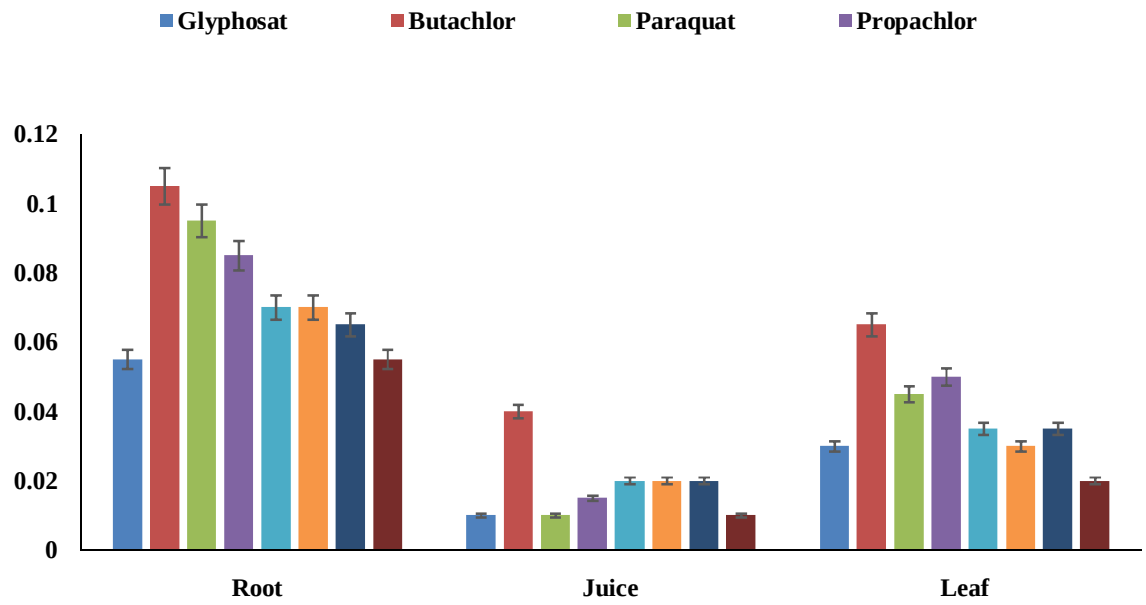


Figure 2:



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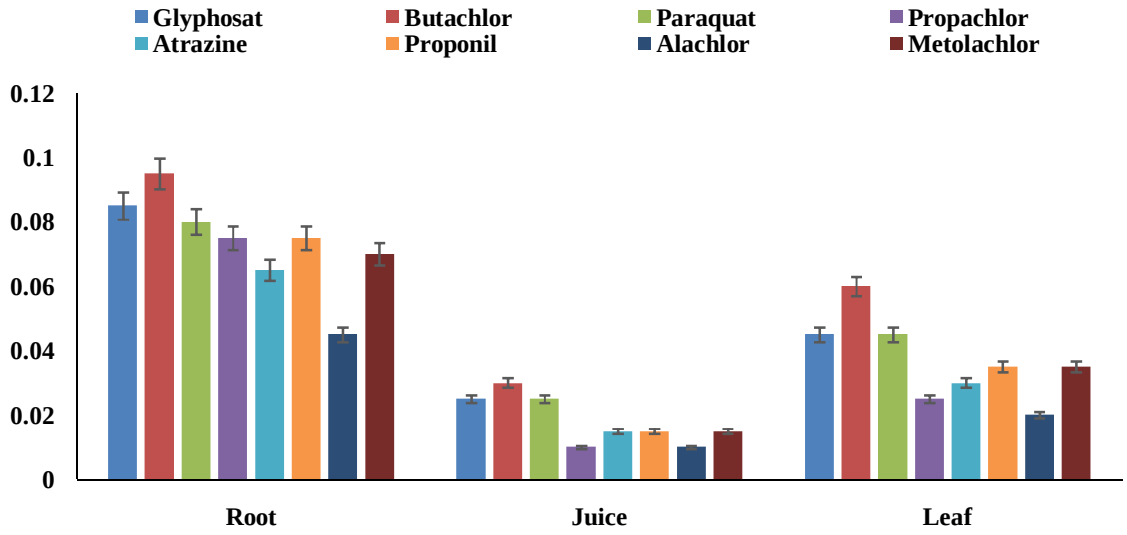

Figure 4:

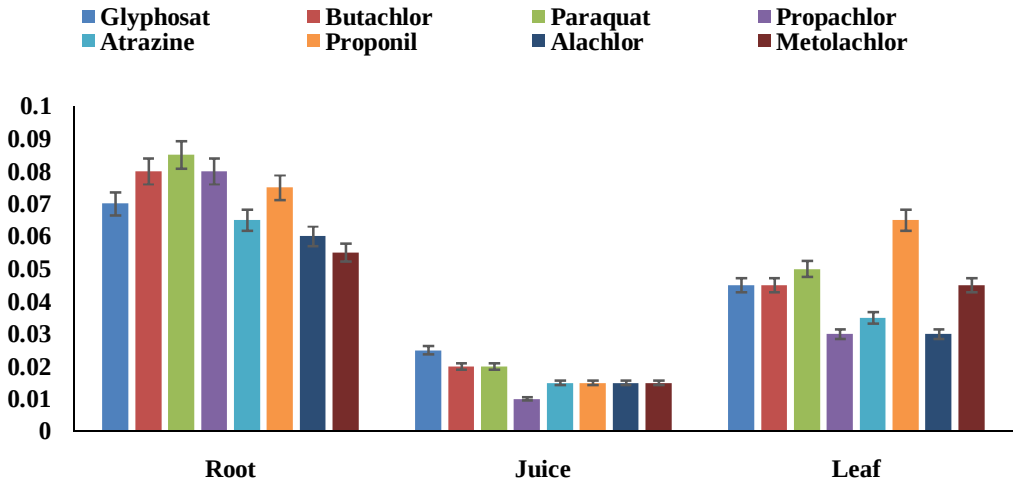

Figure 5:

Total Concentration of Some Herbicides Residues in Different types of Sugarcane Samples

The total concentration of herbicide residues in different part of the B47-419 sugarcane sample from savannah sugarcane plantation is as presented in Figure 6.The total concentration of glyphosate is 0.13 mg/kg; 0.23 mg/kg butachlor; 0.19 mg/kg paraquat; 0.21 mg/kg propachlor; 0.11 mg/kg atrazine; 0.16 mg/kg propanil; 0.11 mg/kg alachlor and 0.08 mg/kg metolachlor. For that of SP71-6180 sugarcane sample from savannah sugarcane plantation as presented in Figure 4.9. The total concentration of glyphosate is 0.14 mg/kg; 0.12 mg/kg butachlor; 0.14 mg/kg paraquat; 0.12 mg/kg propachlor; 0.15 mg/kg atrazine; 0.13 mg/kg propanil; 0.11 mg/kg alachlor and 0.12 mg/kg metolachlor. The total concentration of herbicide residues in CO 997 sugarcane sample from savannah sugarcane plantation as presented in Figure 6. The total concentration of glyphosate is 0.10 mg/kg; 0.21 mg/kg butachlor; 0.15 mg/kg paraquat; 0.15 mg/kg propachlor; 0.13 mg/kg atrazine; 0.12 mg/kg propanil; 0.12 mg/kg alachlor and 0.09 mg/kg metolachlor. The total concentration of herbicide residues in COC 671 sugarcane sample from savannah sugarcane plantation is as presented in Figure 6. The total concentration of glyphosate is 0.16 mg/kg; 0.19 mg/kg butachlor; 0.15 mg/kg paraquat; 0.11 mg/kg propachlor; 0.11 mg/kg atrazine; 0.13 mg/kg propanil; 0.08 mg/kg alachlor and 0.12 mg/kg metolachlor. For that of CO 6806 sugarcane sample, the total concentration of glyphosate is 0.14 mg/kg; 0.15 mg/kg butachlor; 0.16 mg/kg paraquat; 0.12 mg/kg propachlor; 0.12 mg/kg atrazine; 0.16 mg/kg propanil; 0.11 mg/kg alachlor and 0.12 mg/kg metolachlor Figure 6.

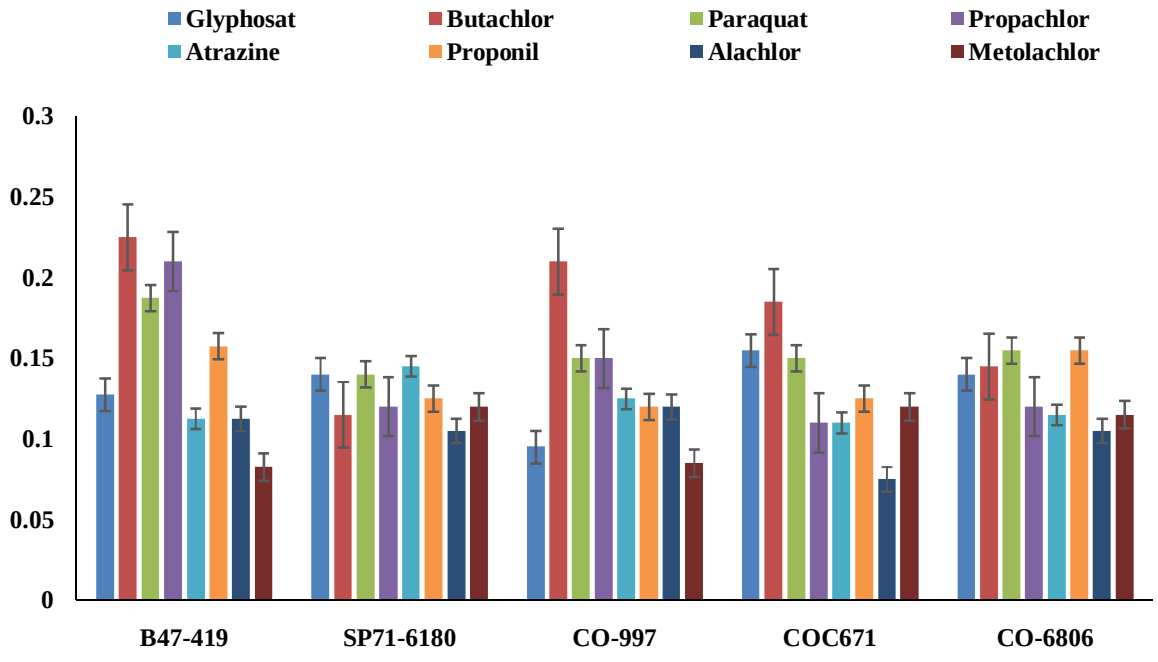

Figure 6:

Percentage of Some Herbicide Residues in Sugarcane Sample

The percentage of herbicide residues in sugarcane samples from savannah sugarcane plantation is as presented in Figure 7. The percentage of glyphosate in sugarcane samples is 22%; 26% butachlor; 29% paraquat; 15% propachlor; 2% atrazine; 4% propanil; 2% alachlor and 2% metolachlor. Paraquat was the most dominant herbicide determined in the sugarcane sample with 29% followed by butachlor 26%, while atrazine 2%, alachlor 2% and metolachlor 2% shows the lowest aboundances in the sugarcane sample.

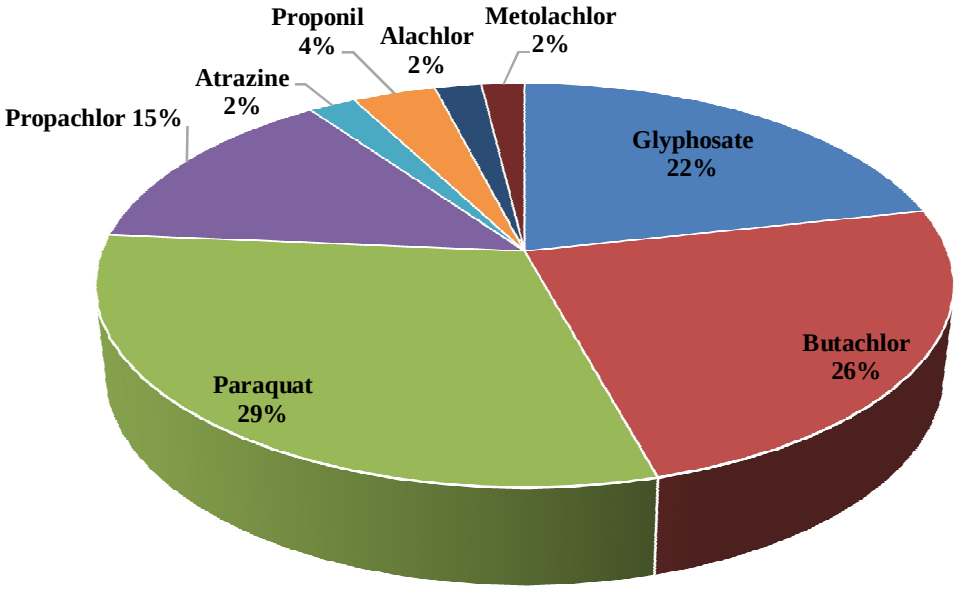

Figure 7: Percentage of herbicide residues in sugarcane samples from Savannah Sugarcane Plantation

DISCUSSION

The result of this research work revealed that in all the five species of sugarcane sample studied, the total maximum concentration of 0.16 mg/kg glyphosate was detected in COC-671 sugarcane sample, while the minimum concentration of 0.10 mg/kg glyphosate was observed in CO-997 sugarcane samples. The levels of glyphosate in the five species of sugarcane samples were significantly higher in the root, while juice shows the lowest concentration. The concentration of glyphosate in all the sugarcane samples were lower than the WHO and FAO maximum residue limit (MRL) of 2.0 mg/kg and the acceptable daily intake value (ADI) of 1.0 mg/kgbw.

The highest concentration of Butachlor was 0.23 mg/kg in the sugarcane samples which was detected in B49-419 sugarcane sample, while SP71-6180 sugarcane samples shows the lowest total concentration of 0.12 mg/kg butachlor. The levels of butaclor in the five species of sugarcane samples were significantly higher in the root, while juice shows the lowest concentration. These results are in agreement with the study carried out by Deka and Gogoi [14] which indicate a concentration range of 0.012 and0.007 mg/kg residues in rice grains and straw after treatment with butachlor at 2.0 kg/ha rate. In their study,it was reported that butachlor residues in rice crop were found below the maximum permissible residue limit (0.25mg/kg) in soil.The adverse health effects of butachlor on human includes weight loss, weight changes in internal organs, reduced brain size together with lesions. The concentration of butachlor in all the sugarcane samples were higher than the WHO and FAO maximum residue limit (MRL) of 0.1 mg/kg

and lower than the acceptable daily intake value (ADI) of 0.5 mg/kg.

Paraquat was the most dominant herbicide detected in sugarcane samples. In all the five species of sugarcane sample studied, the total maximum concentration of 0.19 mg/kg paraquat was detected in B47-419 sugarcane, while the minimum concentration of 0.14 mg/kg paraquat was observed in SP71-6180 sugarcane samples. Relatively, the levels of parauat in the five species of sugarcane samples were significantly higher in the root, while juice shows the lowest concentration. The concentration of paraquat in the five species of sugarcane samples were much lower than the WHO and FAO maximum residue limit (MRL) of 0.5 mg/kg, but higher than the acceptable daily intake values (ADIs) of 0.005 mg/kg.

The highest level of propachlor concentration in the sugarcane samples was detected in the B49-419 sugarcane sample (0.21 mg/kg), while COC671 sugarcane sample shows the lowest total concentration of 0.11 mg/kg propachlor. The levels of propachlor in the five species of sugarcane samples were significantly higher in the root, while juice shows the lowest concentration.

Atrazine concentration of 0.15 mg/kg was recorded as the highest in the sugarcane samples which was detected in the SP71-6180, while COC671 sugarcane samples shows the lowest total concentration of 0.11 mg/kg atrazine. The levels of atrazine in the five species of sugarcane samples were significantly higher in the root, while juice shows the lowest concentration. Atrazine is slightly to moderately toxic to humans and other animals. It can be absorbed into the bloodstream through oral, dermal and inhalation exposure. Symptoms of poisoning include abdominal pain, diarrhea and vomiting, eye irritation, irritation of mucous membranes, and possible skin reactions [15]. At very high doses, rats showed excitation followed by depression, slowed breathing, incoordination, muscle spasms, and hypothermia [16]. After consuming a large oral dose, rats exhibited muscular weakness, hypoactivity, breathing difficulty, prostration, convulsions and death[16]. The concentration of atrazine in the five species of sugarcane samples were much higher than the WHO and FAO maximum residue limit (MRL) of 0.05 mg/kg, but higher than the acceptable daily intake values (ADIs) of 0.02 mg/kg.

The herbicide, propanil had the highest concentration of 0.16 mg/kg in the sugarcane sample which was also detected in the B47-419 sugarcane sample, while CO-997 sugarcane samples shows the lowest total concentration of 0.12 mg/kg propanil. The maximum residue limits (MRL) is the maximum amount of the herbicides residue which is found in food substances that will not cause any health effect or hazard [17]. The levels of propanil in the five species of sugarcane samples were significantly higher in the root, while juice shows the lowest concentration. The concentration of propanil in the sugarcane samples detected in this study fell below the WHO and FAO maximum residue limits (MRLs) of 2.0 mg/kg. The acceptable daily Intake values (ADIs) of propanil in the sugarcane samples is 0.2 mg/kg.

The concentration of alachlor in all the five species of sugarcane sample studied revealed that the CO-997 sugarcane sample had a total maximum concentration of 0.12 mg/kg alachlor, while the total minimum concentration of 0.08 mg/kg alachlor was observed in COC-671 sugarcane samples. The levels of alachlor in the five species of sugarcane samples were significantly higher in the root, while juice shows the lowest concentration. The concentration of alachlor in all the sugarcane samples was lower than the WHO and a FAO maximum residue limits (MRL) 0.2 mg/kg, and were higher than the acceptable daily intake value (ADI) of 0.01 mg/kgbw.

Metalochlor had a total maximum concentration of 0.12 mg/kg metalochlor, detected in SP71-6180 and CO-6806 sugarcane sample, while the minimum concentration of 0.08 mg/kg metolachlor was observed in B49-419 sugarcane samples. The concentration of metalochlor in the five species of sugarcane samples were higher than the WHO and FAO maximum residue limit (MRL) of 0.05 mg/kg and the acceptable daily intake values (ADIs) of 0.1 mg/kg.

Generally, the concentrations of the studied herbicides in all the sugarcane samples were significantly higher in the roots, while the juice shows the lowest values. This results further proof that paraquat and butachlor are the most dominant used herbicides in the study area. All the herbicides used are mostly synthetic organic compounds.

CONCLUSION

Results obtained from this study show that the sugarcane samples from the three agricultural locations contained some amounts of herbicides. There are significant differences in the mean concentrations of herbicides at the various sampling locations. The study also revealed that most of the studied herbicide residues were significantly higher than the WHO and FAO maximum residue limits (MRLs) and acceptable daily intake values (ADIs) values.

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