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ANALYSIS OF GLYPHOSATE IN SOIL SAMPLES FROM A SUGARCANE FIELD IN COROZAL BELIZE

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Abstract: This paper presents the results of the analysis of soil samples from a sugarcane field in Ranchito, Corozal Belize for the presence of agrochemicals in them. Chromatographic analysis revealed the presence of glyphosate as the only compound present in 16 of the 20 soil samples analyzed. The presence of glyphosate is an indication that this herbicide, classified as carcinogenic by the Cancer Research Center, is still being used. Therefore, the use of this herbicide carries a risk of contamination for both Belize and Chetumal due to the proximity of the fields to bodies of water located in these areas. In addition, the 20 soil samples were analyzed by measuring conductivity, pH, extractable nitrogen and phosphorus content. The average pH of the 20 samples analyzed was 6.94 ± 0.07 and for conductivity an average value of 0.605 ± 0.107 dS/m was calculated. The average phosphorus concentration of the 20 samples analyzed was 18.70 ± 3.26 mg/kg. The objective of this study is to investigate the presence of glyphosate in soil samples from field plot of cultivated crops.
Keywords: glyphosate, sugarcane crop, environmental contamination, chromatographic analysis

INTRODUCTION

The use of herbicides and pesticides for the sugarcane agroindustry in northern Corozal Belize represents a serious contamination problem. In recent years the Pesticides Control Board (PCB) of Belize, the main regulatory body for the use and management of herbicides and pesticides for agricultural use, indicates that since 1980 the use of these in agricultural fields increased (Board, 2016). Recently, the Control Board developed a strategic plan (2017-2021) to regulate the use of these polluting chemicals; however, this board reports the current use of herbicides and pesticides in agricultural activities as glyphosate, diuron, picloram, gramuron and ametryne. Glyphosate is a herbicide widely used worldwide for weed control and is a non-selective and systemic broad-spectrum herbicide so it is found in all plant tissues sprayed with this herbicide. Glyphosate and its degradation metabolite aminomethylphosphonic acid (AMPA) are contaminating compounds; a report by the International Agency for Cancer (IARC) concluded that there were sufficient data and studies to establish a relationship between exposure to glyphosate and certain cancers in animals (IARC, 2020), where there are several scientific studies showing that there is sufficient evidence that glyphosate is a carcinogenic compound (Andreotti et al., 2018, Berry, 2020, Mink et al., 2012). Aminomethylphosphonic acid (AMPA), whose structural formula is CH6NO3P, is a degradation product of glyphosate and its main metabolite. The main route of glyphosate deactivation is hydrolysis to aminomethylphosphonic acid (AMPA). This compound is a weak organic acid of low toxicity with a phosphoric acid group. It has a polar character and high solubility in water. Its half-life is approximately 3 years. AMPA was discovered in lettuce and barley grown within one year after soil treatment with glyphosate (Mink et al. 2012). Due to the aforementioned, glyphosate represents a contamination problem because when used in crop fields such as sugarcane, it can be bioaccumulated by plants and transported from the soil to nearby bodies of water.

MATERIALS AND METHODS

STUDY AREA

20 soil samples were collected from a 2 ha sugarcane plot (200 x 100 m) located in the village of Ranchito Corozal Belize with coordinates of Latitude 18°21'48.1" North and 88°24'30.2" West. The soil samples were labeled as M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12, M13, M14, M15, M16, M17, M18, M19 and M20 and were collected at a distance of 20 meters from each other The plot was sampled on March 26, 2022 following the simple sampling method indicated in the NOM-021-RECNAT-2000 standard. Samples were collected on March 26, 2022, during that month there was no rainfall.

CHROMATOGRAPHIC ANALYSIS

20 soil samples were collected in 200 ml plastic bottles and were sieved to remove stones. Ten g. of sieved soil were taken and 100 ml of dichloromethane were added and then placed in a rotary evaporator at 40°C and 300 rpm to evaporate the dichloromethane to dryness and then diluted in 30 µl of dichloromethane and 5 µl were manually injected for analysis.

GAS CHROMATOGRAPH EXPERIMENTAL CONDITIONS

A Perkin Elmer 9000 series gas chromatograph equipped with ionized flame detector was used for the analysis of the soil samples the experimental conditions were as follows: Injector temperature 250 °C with a temperature program of 70 °C for 2 min and temperature increments of 10 °C/min up to 280 °C. The mass coupling conditions were: ionization source temperature (230 °C), transfer line temperature (250 °C) and an ionization energy of 70 eV.

SOIL CHARACTERIZATION

Soil conductivity and pH

They were measured using the method proposed in NOM-021-RECNAT-2000, which consisted of preparing an aqueous soil extract (1:2 w/v) and measuring the pH and conductivity of the extract with a pH meter and a conductivity meter. Ten g of soil was weighed and 20 ml of deionized water was poured in. The mixture was left for 30 min, with manual stirring every 5 min. The soil extract was filtered twice with a closed pore filter and pH and conductivity were measured with a Hanna portable pH and conductivity meter.

RESULTS AND DISCUSSION

SOIL CHARACTERIZATION

The results of the soil determinations of the analyzed samples are presented in Table 3.1. The average pH of the 20 samples analyzed was 6.94 ± 0.07 this result indicates that the soil pH of the plot was neutral according to NOM-021-RECNAT-2000. No significant difference in pH was found among the 20 samples analyzed (α = 0.10). As for the conductivity values, an average value of 0.605 ± 0.107 dS/m was calculated; according to NOM-021-RECNAT-2000, conductivities lower than 0.8 dS/m correspond to soils with low salinity, so the soil presents ideal conditions for any crop. The average phosphorus concentration of the 20 samples analyzed was 18.70 ± 3.26 mg/kg. These concentrations of phosphorus in the soil are adequate for any crop according to the NOM-021-RECNAT-2000 standard, so this type of soil does not present a deficiency of this nutrient.

Sample	pH	Conductivity (dS/m)	P (mg/kg)	Sample	pH	Conductivity (dS/m)	P (mg/kg)
1	6.80	0.343	19.89	11	6.98	0.638	16.46
2	6.92	0.652	12.78	12	7.04	0.529	21.36
3	7.04	0.581	18.61	13	6.95	0.682	20.98
4	6.78	0.474	15.37	14	6.99	0.699	17,85
5	6.98	0.521	16.43	15	7.01	0.593	22.72
6	6.91	0.792	21.59	16	6.93	0.602	21.87
7	6.92	0.663	18.37	17	6.98	0.588	19.04
8	7.01	0.574	21.12	18	6,91	0.497	18.77
9	6.94	0.553	20.68	19	6.87	0.622	19.69
10	6.93	0.692	18.74	20	6.91	0.801	21.74

Table 3.1: Soil characterization results of the analyzed plot.

CHROMATOGRAPHIC ANALYSIS OF SOIL SAMPLES

The excessive use of glyphosate and its impact on the environment has promoted the chemical analysis of glyphosate in water, soil and food. Due to the complexity and specific characteristics of the molecule to be analyzed in the first stage it must be detected and subsequently quantified. In the case of soil and water samples, its detection is particularly difficult because it can be diluted to very low concentrations. In the analysis of the plot that is the subject of this thesis study, the chromatograms obtained for samples M1, M2, M3, M4, M6, M7, M8, M10, M14, M16, M17, M18, M19 and M20 confirmed the presence of the herbicide glyphosate. Figure 1 presents the chromatograms for samples M1, M6, M18 and M19. This is indicative of the use of at least this herbicide in weed control for the sugarcane crop in the analyzed plot. Glyphosate is a compound that does not contain a complex chemical structure, but having four highly polar groups makes it difficult to analyze by conventional methods, the results obtained show that trace concentrations of this herbicide are present and the chromatograms for samples M16, M19 and M20 presented the highest peaks of glyphosate. For samples M5, M9, M11, M12, M13, M15, the presence of glyphosate was not detected. This may be due to the transportation of the samples by land, where they first had to be transported from the Ranchito Corozal plot to the Environmental Chemistry laboratory in Chetumal for subsequent transport by parcel to the Metabolic Engineering laboratory of the Center for Research and Advanced Studies of the IPN (CINVESTAV) for chromatographic analysis. It is important to emphasize this transfer, since there is no chromatography laboratory at the University of Quintana Roo, the analysis had to be carried out at that research center, so other chemical compounds such as pesticides or herbicides that could be present were probably volatilized, this could be confirmed in a later study. However, the importance of this work lies in the fact that despite claims by some sugarcane growers that glyphosate is not currently used, the chromatograms for the aforementioned samples show evidence of the use of this toxic and carcinogenic herbicide. The use of this herbicide poses problems for Mexico given the border between Belize and Chetumal. In fact, the plot analyzed represents approximately 10% of the 2000 hectares of plots used in Corozal for planting sugarcane and given its proximity to Chetumal, the New River and the Bay of Belize, as can be seen in Figure 2; this herbicide and other chemical compounds that could continue to be used would represent contamination problems for Belize and Chetumal.

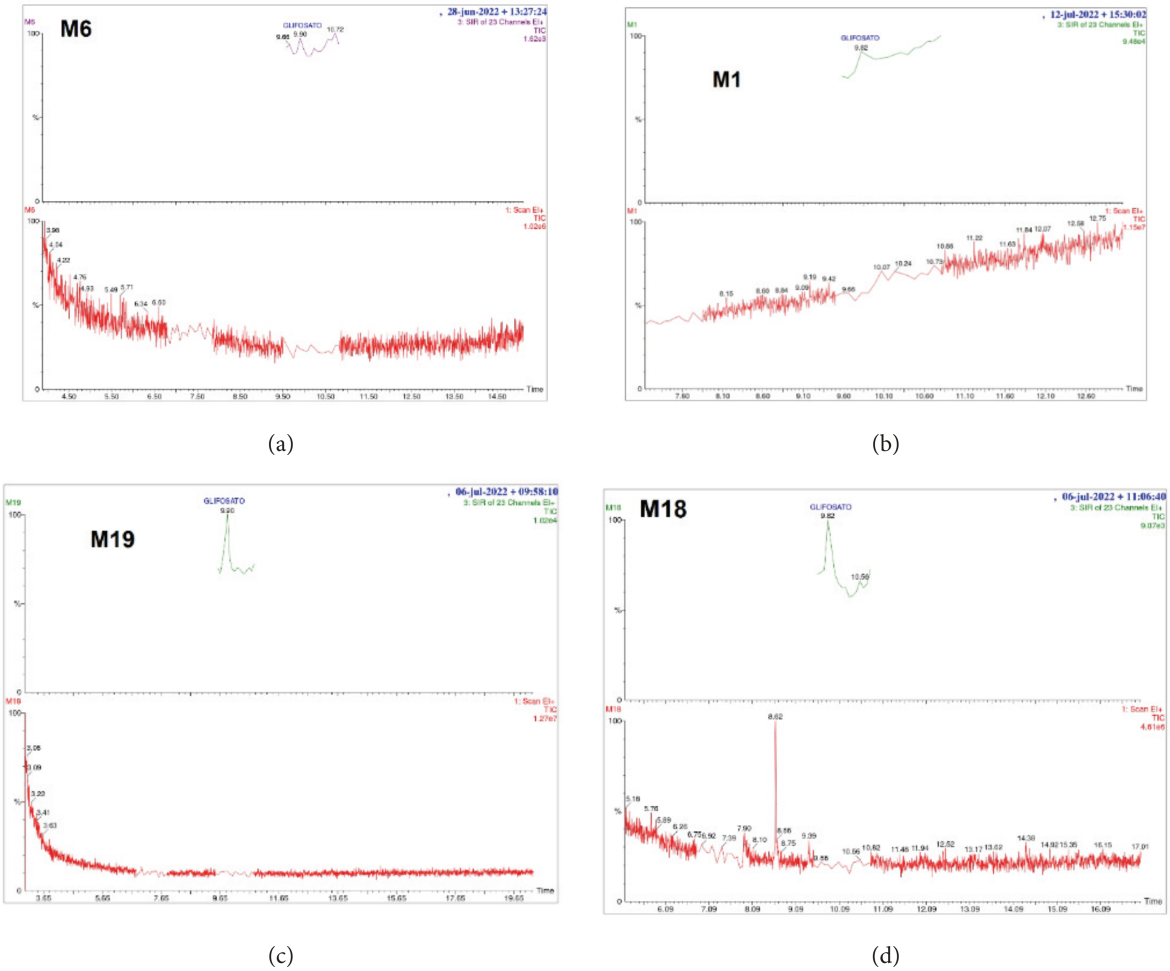
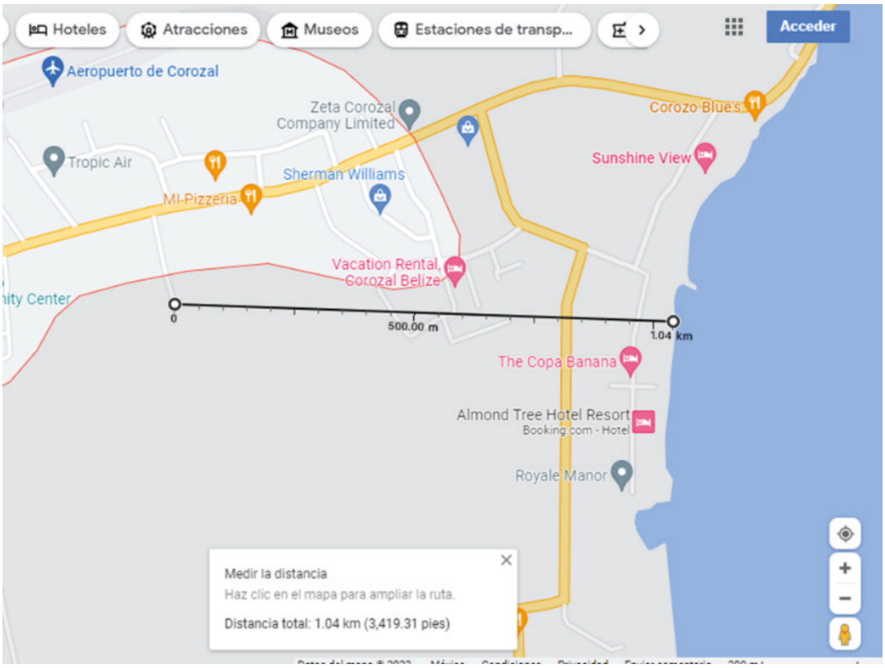


Figure 1. Chromatograms corresponding to samples M1, M6, M18 and M19.



Distance from the analyzed plot to Corozal Bay.

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