MALNUTRITION OF THE AQUATIC AND TERRESTRIAL ECOSYSTEMS OF THE COLOMBIAN

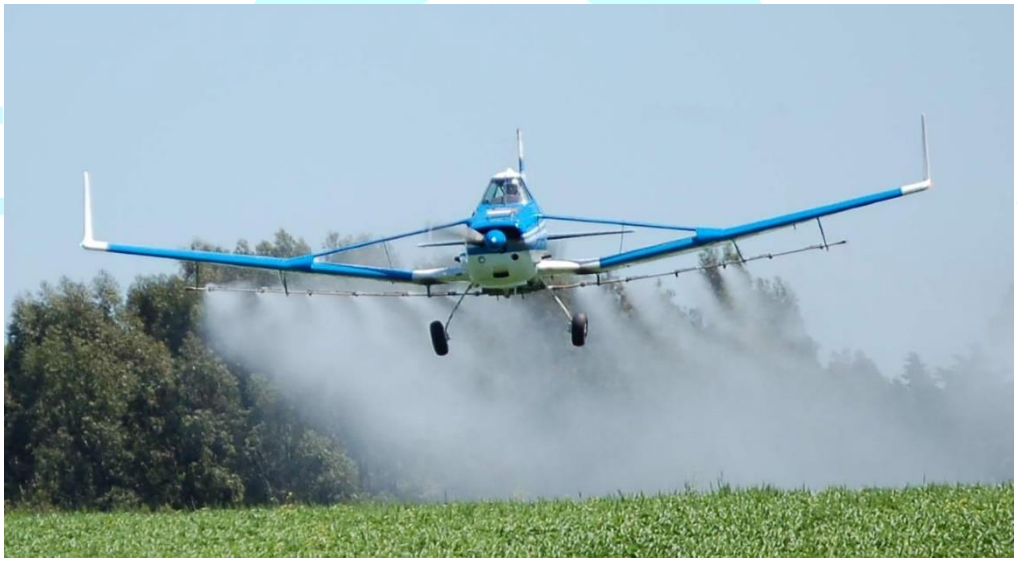
CARIBBEAN: ONE OF THE MAIN PROBLEMS OF USE OF GLYPHOSATE IN THE FUMIGATIONS OF ILLICIT

CROPS BY THE GOVERNMENT OF COLOMBIA.

RESUME

In the present study carried out in 2022, it was characterized by evidencing the environmental impact on aquatic ecosystems of the use of herbicides such as glyphosate, which is largely used to eradicate illicit crops in Colombia. In the research, the Ecoceanos Corporation managed to characterize the poor state of health in 4 species of fish and 3 species of mangroves. Physiognomic aspects of the forest and its health index were evaluated. 78 interviews were conducted with people who are part of Indigenous Zenú communities in the settlements near the areas studied on the Island of Barú, Bolívar – Colombia to evaluate the knowledge and community behavior about the mangroves and fish that were part of their food and economy. It was identified in the mangroves sedimentation of residues, Arboreal degradation, high salinity and decrease of nutrients, in the species of fish investigated we evidenced signs of toxicity and mortality. In response to this study, the Ecoceanos Corporation was able to determine mitigation and restoration strategies for the affected ecosystems to carry out impact projects that improve the community conditions of the Zenú Indigenous Communities.

Keywords: Keywords: Glyphosate, fumigation, Illicit crops, Ecosystems, Mangroves, Environment.



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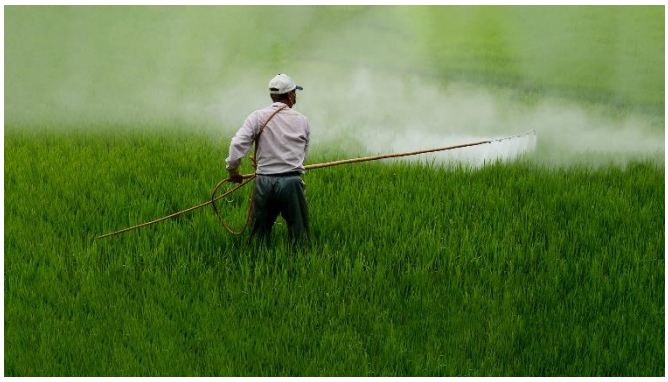
INTRODUCTION.

The issue of spraying with glyphosate is a debate that day by day takes more force due to the evidence that has been presented of its negative impact on the environment, the Colombian government implements the spraying of this herbicide as a measure for the eradication of illicit crops, but this type of solutions although they are effective in the fight against drug trafficking must be expanded taking into account other issues that revolve around the herbicide, its impacts on the environment and the complications it can generate in aquatic and terrestrial ecosystems.

The manual spraying with glyphosate, recently approved by the National Narcotics Council of the Colombian state, the responses to the State's demands for damages due to the spraying, and the future implementation of the peace agreements between the National Government and the FARC guerrillas, are issues that demand that the debate remain on the table and that it be given the necessary importance, as it will continue to be key to drug trafficking, environmental health and public health in Colombia.

That is why the ECOCEANOS Corporation seeks to guide future decisions based on evidence, through research carried out on the impacts of glyphosate on the environment and knowledge about its rigor and results.

The conclusions obtained in the ECOCEANOS corporation allowed the planning of various projects of reforestation of affected areas and mitigation of climate change which seeks to finally benefit the communities in terms of awareness and together with educational institutions to create strategies that through the projects positively impact indigenous populations, marine and terrestrial ecosystems.



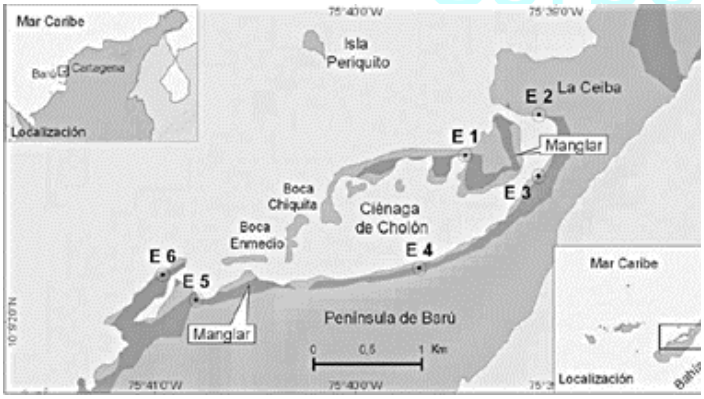
This fight has forced the Colombian government to eradicate illicit crops and one way to do this is aerial spraying with glyphosate which is one of the main producers of climate change due to the process that occurs after the residues of this are established in the earth, denitrifying the soil. The ECOCEANOS Corporation together with the indigenous communities and institutions such as the Universidad de Sucre carried out a study where it was determined the interference that the use of this herbicide has in the degradation and even destruction of marine ecosystems because its spraying leads to the waste that is impregnated in the land to water sources that cross extensions of lands affecting the Zenú indigenous communities that have these sources for their survival and also both aquatic and terrestrial ecosystems

The water flows that flow into the sea provide damage to marine ecosystems because much f the glyphosate residues produced by activities in agricultural crops and destruction of illicit crops end up in the sea intoxicating in their passage the mangroves that thanks to their high productivity and their abundant organic detritus, they make them a preferential site for the accumulation of waste which is sedimented and impregnated in soil.

STUDY AREA.

It was determined as a study area the island of Barú (Colombian Caribbean) which is located in the department of Bolívar 18 km south of Cartagena, between 10º 19' and 10º 18' N and 75º 42' and 75º 31' W. Barú has an approximate size of 8000 hectares and is separated from the mainland by the Guayacá and Estero pipes and by the Dique channel. Its limits are established as follows: to the south and east with the bay of Barbacoas, to the north with the Nuestra Señora del Rosario archipelago (which forms the Corales del Rosario y San Bernardo-PNNCRSB National Natural Park) and to the northwest

with the bay of Cartagena and the island of Tierra Bomba, The present work was carried out in the swamp of Cholón, where six sampling stations were located as shown in the following image:



In general, the National Park has a typical coastal tropical climate with an annual temperature of 27.7 ºC (minimum of 21 ºC and maximum of 33 ºC), strongly influenced by the sea (relative humidity of 80-85%) (Bohórquez, 2002). For the area, three different climatic periods are identified throughout the year: the first is a dry season (summer), which covers from December to April, characterized by strong winds from the northeast sector (NE) and weak and scarce rainfall. The second is a time of transition (May, June and July) during which the trade winds are mild, predominantly those of the N and NE sector, which increase during the month of July (summer of San Juan). The third is a wet season (winter), which operates from August to November and is characterized by a regime of weak winds of variable orientation and a regime of abundant rainfall. For the study area the climate is predominantly semi-arid, with relatively high humidity and temperatures throughout the year. The rainy periods are cloudier, more humid, with less evaporation and variation in the daily temperature, while the dry period is characterized by high temperatures and evaporation, this being the only contribution of fresh water because in Isla Barú there are no rivers that contribute fresh water to the ecosystem (Leblé and Cuignon, 1987). The salinity in the water varies between 34.4 and 35.4 and in the soil between 3.26 and 4.38, which causes the presence of clearings in the forest, according to what was recorded by Agudelo-Ramírez (2000). Figure 1. Ciénaga de Cholón where the sampling stations are indicated.

STUDY METHODOLOGY.

To specify the structure of the mangrove tree volume in the Cholón swamp, 5 sampling stations were located, whose location can be seen in figure 1 In each station a linear transect was located perpendicular to the coastline with the help of a tape measure. The length of the transects depended on the extent of the mangrove strip present in each season; Station 1 had a length of 90 m, stations 2 and 4 each had 20 m, and stations 3, 5 and 6 had an extension of 100 m. Along the transects were located and delimited three plots of 10 x 10 m (0.01 ha) every 20 m. In stations 2 and 4, whose length perpendicular to the coastline was no longer than 20

m, the plots were located parallel to the coastline. All individuals and species of both mangroves and fish of large taxa found in the plots of each station were counted and identified. Each mangrove individual had their circumference measured at chest height with the help of a flexible tape measure; based on this data, the diameter at chest height (DAP) was calculated. Likewise, the total height of each tree (up to the highest living part of the tree) was measured by means of an extendable rod. During the structure sampling, the physical description of the plots was carried out and the vegetation profile was represented along the structure transect. In addition, the Importance Value Index (IVI) was calculated in order to determine the most important species and diametric category for the study area based on the number of individuals found by species and category and the basal area of each of these.

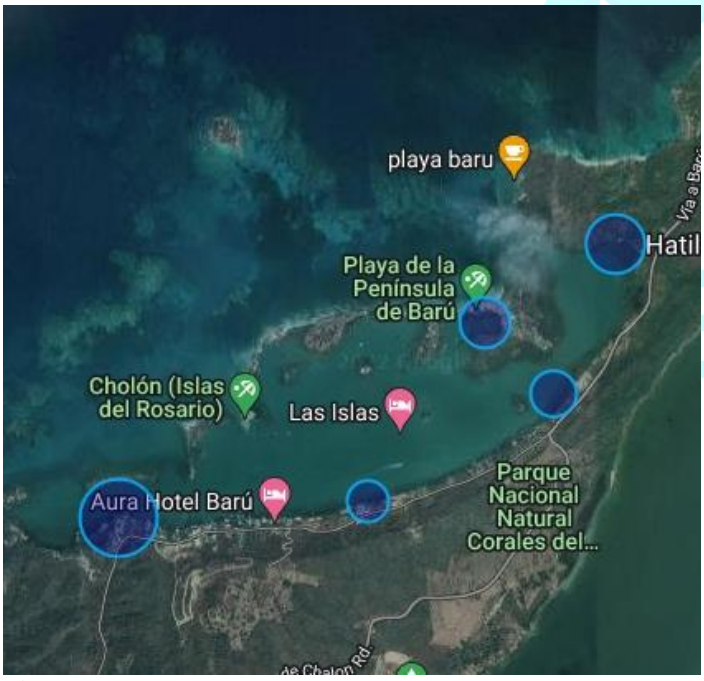


Figure 1.

Regeneration was calculated in terms of the reproductive capacity of the fish and the mangroves being able to produce new individuals. This was done through the counting of seedlings and their growth within the different seasons as well as the identification of fish species and approximate volume of the taxon which allowed us to calculate the rate of regeneration during the study period. The knowledge of the number of established seedlings observed is the most reliable indicator to understand the transformations to occur in vegetation in response to a natural disturbance or produced presence of glyphosate residues. For the study of mangrove regeneration, a linear transect perpendicular to the coastline was located within stations 1, 2, 3 and 6. This length depended on the extent of the mangrove strip at each site (which was mentioned above). The transect of regeneration was not located on the structure, but contiguous to it; Thus, by carrying out structural samplings, damage to the seedlings present was avoided as the field progressed in order to assess the presence of seedlings and chemical residues sedimented along the regeneration transect in a width of 1 m and bimonthly from April to October. Seedling growth was also estimated by demarcating three 1 m plots in a systematic random manner every 20 m along the transect, with the help of the plots the idea was to establish motion sensors to approximately determine the volume of a fish taxon. In each plot, the seedlings present were counted, the total height (from the base of the stem to the apex) was measured, and each seedling on its stem was marked with bands of rhotex tape that were previously labeled with a code for identification. The labels were sprayed with a plastic coated copper wire to the stem of each seedling, so that they were loose and did not interfere with the growth of the seedlings. Four bimonthly data were obtained between April and October 2016. Finally, linear regression analysis was used to calculate the growth rate in height and this was extrapolated to a monthly value.

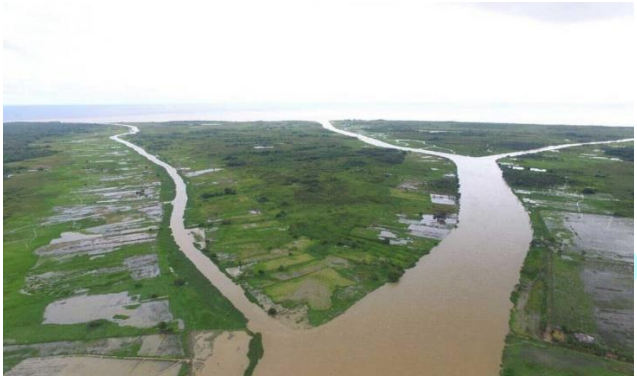
RESULTS.

In addition to chelating plant nutrients, glyphosate can decrease mineral content by degrading beneficial organisms, including indole-acetic microbes (a growth-promoting auxin), earthworms, mycorrhizal associations, phosphorus and zinc uptake, microbes such as Pseudomonas, bacillus that convert insoluble oxides from soil to bioavailable forms of iron and manganese, nitrogen-fixing bacteria such as Bradyrhizobium, Rhizobium and organisms involved in the biological control of soil diseases that reduce root uptake of nutrients. When used in agriculture, this

compound penetrates the soil, seeps into the water and its residues remain in crops: it is in what we eat, in the water we drink, in our bodies and in the air we breathe, In Ecoceanos corporation we identify that the rapid spraying of these herbicides is harmful to the flora and fauna because the denitrification effect on the soil makes this one of the the main foci of conduit.

In the research process we were able to determine the presence of residues with glyphosate adhered to the gills of the fish, affecting their respiration. They also adhere to and destroy algae and phytoplankton and affect the feeding and reproduction of aquatic life in general, this thanks to the fact that subtracting plant samples evidenced principles of death or mutations of mangroves.

The mouth of rivers in the sea is one of the main causes that influence damage to marine ecosystems because all agrochemical wastes such as glyphosate and other herbicides are dragged by the currents of water sources ending up in the ocean affecting the flora and fauna which directly affects the communities.



EFFECTS OF GLYPHOSATE ON AQUATICECOSYSTEMS.

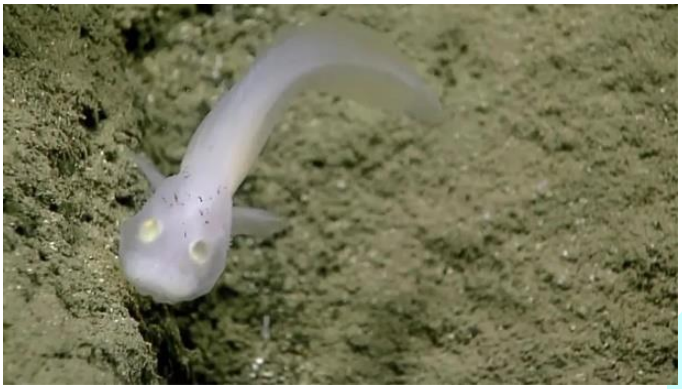
In this study we identified the toxic effects that glyphosate has on local waters and fish species. For 10 years, research has been conducted. With the support of universities and international organizations, we have carried out projects to demonstrate the negative effects of this herbicide on native species such as the tarpon (Prochilodus lineatus), the yamú (Brycon Amazonicus), the ghost fish, the bocachico (Prochilodus magdalenae) and the white cachama (Piaractus brachypomus). By applying the necessary and sufficient amounts we were able to establish its toxic effect on the fish.

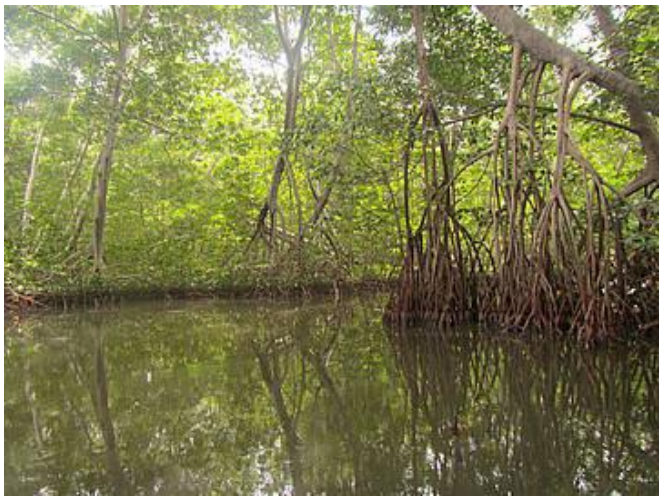
For the present study we took specimens of each of the stations of the transect and of the species Yamú and Bocachico we made a process of basic toxicology. We work controls without glyphosate in water and concentrations of 10 and 30 ppm (parts per million). In both cases there was 100% mortality. With these results we determined that these two species are quite sensitive to exposure to the herbicide, it should be noted that species such as Yamú and Bocachico are highly consumed in the department of Bolivar,Sucre and Córdoba, regions near the sea and large extensions of mangroves. These species of fish are mostly used for breeding and reproduction because they are part of one of the main means of livelihood for indigenous families.

In the realization of this study we identified that before dying the fish showed extreme signs of the nervous system, which was identified in an alienated swim of the fish in the aquariums, to which were added symptoms of respiratory distress that were confirmed in the necropsy by the dark brown color that the gills took, which indicates the low oxygenation in the blood. These evaluations were made following the conditions of bioethics.

Another study was conducted on the effects of glyphosate on the Pez Fantasma, a species native to the Gulf of Morrosquillo and the islands of the rosary that communicates generating electric waves to alert a risk situation, we identified that unlike Bocachico and Y Amú, the ghost fish was much

more resistant, because for it to show signs a concentration of 90 ppm was needed. He also presented a video in which this animal, which is normally nocturnal, was seen leaving its shelter in broad daylight and climbing to the surface of the aquarium to seek better oxygenation.





The symptoms of this fish were also alteration of the nervous system and respiratory distress. We noticed that the coloration of the blood changed drastically; With the concentration of 90 ppm of glyphosate the blood is very dark, an indicator that it is not oxygenating. This fish usually emits slingshots between 700 and 800 Hertz however when it began to be exposed to glyphosate, the wave reached 1,200 Hertz, it should be noted that when this fish emits a wave of similar values is warning that there is something negative in the environment.

The ghost fish usually inhabits tropical waters and is associated with coral reefs and white bottoms.

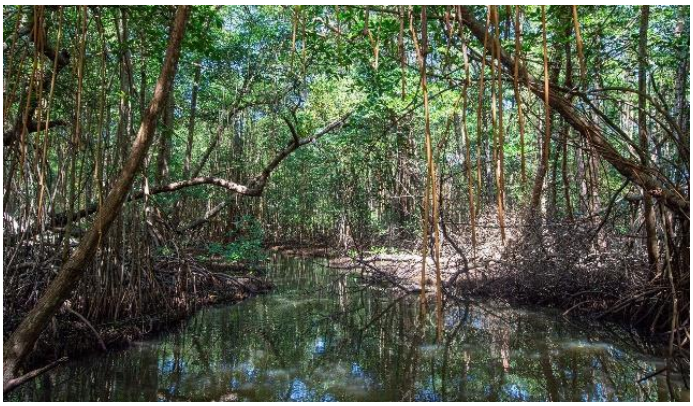
GLYPHOSATE AND ITS EFFECT ON MANGROVES.

It is very important to clarify that an investigation around the impact of herbicides such as glyphosate in a complex ecosystem such as a mangrove forest, at least six subsystems must be examined, among which are: soil, water, fauna, climate, mangrove trees, aerobic and anaerobic microorganisms.

The study areas were determined by 6 sampling stations, among the types of mangroves that were identified are red mangrove, bobo mangrove, smoke mangrove and avicennia germinans or black mangrove, (maangles in critical state), the results of the study obtained yielded alarming results because we managed to identify glyphosate residues in the mangroves as well as in the species of fish that inhabit that area which is prone to receive residues from mouths of water sources in the sea.

Mangrove mangroves due to their high productivity and abundant organic detritus, make them a preferential site for the accumulation of chemical waste. In part of the study area, areas containing glyphosate concentrations up to 17% of the dry weight of surface soils were identified.

The residues of this herbicide were also detected in the sediments of a stream adjacent to the area of Barú, Bolívar – Colombia as a result of the manual spraying of glyphosate on soybean crops that were near mangrove forests. Analysis of the sediment profile indicated that the residues penetrated to a depth of 10 cm.



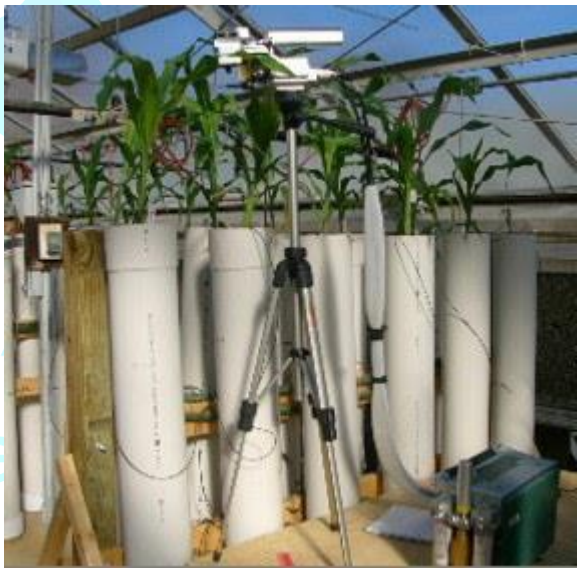
Research into the effects of contamination by herbicide residues in mangroves has intensified over the past 6 years. However, most research has focused on the effect of glyphosate residues on mangrove tree and fauna subsystems. The short-term effects on seedlings and mangrove trees are related to suffocation and death when rivers disperse herbicide sediments from the spraying of illicit crops and other crops in which glyphosate is used. Likewise, mangrove vegetation can die from direct poisoning with low molecular weight aromatic compounds when these damage the cell membranes of the roots and the normal process of salt exclusion is prevented. So far, the long-term effects appear to be particular for the different plant and animal species associated with the mangrove ecosystem, depending on the concentration and type of herbicide, as well as the intensity of pollution.

It is very important to understand that residues from the spraying of glyphosate on crops sooner or later end up in the sea through the water sources present in the soil, this fact leads to the decrease of the pH of the sea which increases acidification.

IMPACTS OF GLYPHOSATE ON TERRESTRIAL ECOSYSTEMS.

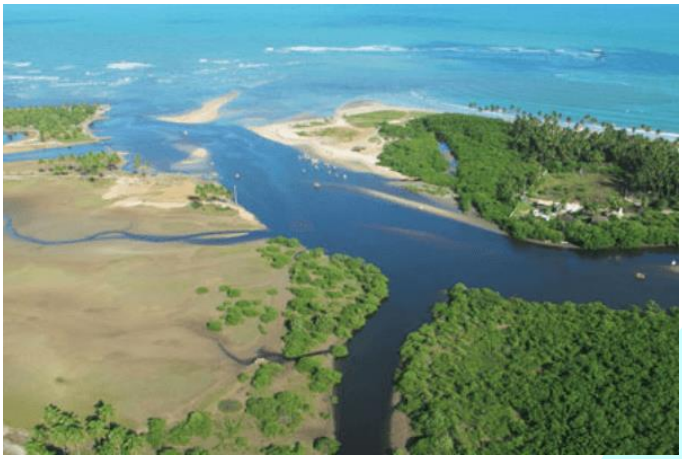
Glyphosate is defined as: "a systemic herbicide that, when applied to plant foliage, is absorbed through tissues to kill broadleaf plants, weeds and grasses" (ChemicalSafetyFacts). This herbicide is one of the main producers of nitrous oxide which absorbs infrared radiation contributing to the greenhouse effect; This gas is produced mainly in the soil, through the nitrification and denitrification processes produced by glyphosate. Ecoceanos corporation and the University of Sucre In a field study, on a soil was evaluated the effect of fertilization and inoculation with glyphosate in a corn crop in the department of Sucre, on nitrous oxide emissions. The gases were extracted from PVC cylinders and the reading was performed with gas chromatography. The emissions obtained yielded increasing data from planting to physiological maturity of the crop, for all treatments; This behavior was associated with evolution

presented by soil moisture. Nitrogen fertilization significantly increased emissions ($P<0.05$) and the inoculation variable only presented effects with the highest level of fertilization ($P=0.09$). The highest values were observed in fertilized treatments with higher doses and inoculated. The variable that best explains emissions is the level of nitrates in the soil ($r2 = 0.1899$; $P=0.0231$).



In addition, glyphosate, being an agrochemical, represents a source of environmental pollution. The most affected ecosystems are aquatic environments, as they are vulnerable natural receptor systems for substances emitted by agricultural and industrial activities (Manahan, 2007). In this way, the water sources surrounding the territories of Zenu communities subjected to spraying are seriously affected. Eradicating illicit crops may seem a correct practice but the effects of this type of chemicals on ecosystems is of great impact which should lead the

Colombian government to restructure its policies or elimination plans towards these practices which not only affect the crop, but also ecosystems, communities and as previously explained the water sources which are the drivers of chemical waste produced by the spraying this practice.



Honey bees are one of the main pollinators of a wide variety of agricultural crops, so they are often exposed to multiple agrochemicals that are applied in the fields, to carry out a study in Ecoceanos corporation together with the University of Sucre, bee larvae were raised in a laboratory where the specimens were provided with food with glyphosate, a situation similar to what might occur in an agricultural environment. From this, we detected that the larvae developed more slowly. That is, many of them took longer to become adults and reached lower weights than those who did not ingest glyphosate.

The results show that, even when the doses used were not lethal, the long-term consequences would be negative for the survival of bees, from which we managed to deduce that glyphosate reduces the development of the immune system of bees and endangers the safety of hives.

By growing more slowly (up to 40% less) some bees may not reach adulthood, and if they did, they would do so with a small size (up to 30 percent). This implies lower reserve levels and an impoverished immune system, which reduces the likelihood that the hive will survive periods of low resources and its population dynamics can be altered.

Even though the genetic information inside the hive was the same, the bees responded differently to the effects of glyphosate. This was related to the occurrence (or not) of previous stress situations of exposure to glyphosate.

Finally, we conclude that the impact of glyphosate is serious because there are multiple ecosystems that can be affected. Creating impact mitigation strategies is a complex job, but not impossible and as a corporation we will seek to implement conservation projects for those affected habitats and for communities to face this type of problems and as well as a corporation to tend to social welfare.

GLOBAL LEGAL SITUATION OF GLYPHOSATE.

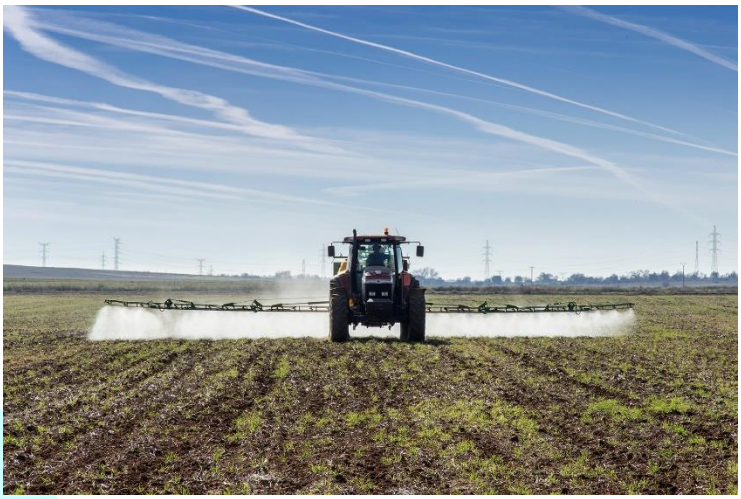
Certain productive groups, individual farmers, universities and some municipalities have initiated voluntary processes to reduce the use or eliminate glyphosate and other highly hazardous pesticides. Market certifications are also increasingly requiring the withdrawal of certain pesticides from the production package on some crops. Civil society groups are pressuring regulatory authorities on the need to remove pesticides with proven chronic effects on people's health and environmental health from fields and tables. The Global Sugarcane Platform (BONSUCRO) seeks that the pesticides applied (including ripeners) in the production of sugarcane, do not exceed 5.00 kilograms of active ingredient (i.a)

/ ha / year, seeking to minimize air, soil and water pollution. (BONSUCRO 2016).

Globally, more and more countries are enforcing stronger regulations on glyphosate. For example, the European Union decided in 2017 to renew the glyphosate license on its territory for 5 more years, despite the fact that Belgium, Greece, France, Croatia, Italy, Cyprus, Luxembourg, Malta and Austria opposed its renewal. In France, a ban is announced for all its uses, including agriculture, before 2022, with state support for processing, regardless of the decision of the European Union. Germany intends to ban glyphosate by the end of 2023, when the current European Union authorization period expires; It has been mainly biologists who have sounded the alarm about the precipitous decline, partly due to herbicides, of insect populations, as well as the alteration of ecosystems, including plant pollination.

Other countries have banned it to be applied in public places (France, Holland, Scotland, Italy, among others). In cities like Barcelona and Madrid there is a ban on use in parks; in the Municipality of Hernani, in the Basque Country, it was banned in public spaces. In total, more than 150 municipalities in Spain have declared themselves free of glyphosate in public spaces.

In Finland pre-harvest application is not allowed for grains used as seed or food. The feed industry does not accept grains that have been treated with glyphosate. In Colombia, aerial spraying was banned as part of the program to eradicate illicit crops. Recently in Mexico, by presidential decree of December 2020, the actions to be carried out by the dependencies and entities that make up the Federal Public Administration are established, within the scope of their competences, to gradually replace the use, acquisition, distribution, promotion and import of the chemical substance called glyphosate and the agrochemicals that contain it as an active ingredient, for sustainable and culturally appropriate alternatives that maintain production and are safe for human health, the country's biocultural diversity and the environment. Thus, the import and use of glyphosate will be reduced until the total elimination of its use in 2024, promoting sustainable alternatives. Vietnam also decided to ban the registration, import and use of all products containing glyphosate.



CONCLUSIONS.

Glyphosate is a substance that, due to its physicochemical characteristics, is highly polluting for all types of water; It is a substance that does not degrade inside any plant so from that moment it enters and contaminates the human food chain. Large grain producers and exporters use it as a desiccant, so in many countries food consumers are inevitably exposed to the herbicide, even if they have never seen an application in the field. This herbicide could be producing systemic poisonings that are not very noticeable to the farmer's eye, in perennial crops such as coffee, oil palm, citrus and forestry, among others where its use is greater, which gradually reduce their productivity and increase in the incidence of complexes of diseases that are difficult to diagnose; In addition, the ability of plants to obtain nutrients from the soil is decreased, due to direct damage to the root system and the gradual loss of soil fertility due to the decrease in the microbiota that transforms organic matter into bioavailable nutrients for the plant.

It is the most widely used herbicide in the world and is not only used in crops, but also in non-agricultural areas, roadsides, railways, pipelines, canal edges and even in parks and recreation places in urban areas, so exposure to city dwellers is also a fact. Farmworkers

are the ones on the front lines of exposure and not even practicing organic farming exempts them from having glyphosate residues in their bodies. In agricultural fields, wise nature is already reacting to the constant applications of glyphosate on populations of weed plants. Every day plant biotypes are added to the long list of weeds resistant to this herbicide, so not only market certifications, restrictions or prohibitions of glyphosate and legal lawsuits against its manufacturers, will soon make this molecule abandon the "technological packages" with which it tries to maintain an unsustainable agriculture that does not respect the health of people or the natural balance of the environment. There are proven alternatives to this herbicide in most crops and use situations. For this reason, the agroecological ways of producing food have not been forgotten and every day the contribution of tactics and innovative technologies in the ways of cultivating the land is greater, motivated by the need for an agriculture that produces food without poisons and to maintain a healthy environment that keeps the best treasure of the farmer, your health.

BIBLIOGRAPHIC REFERENCES.

- Agencia Internacional de Investigación en Cáncer (IARC), Organización Mundial de la Salud (OMS). (2017). Monografía 112. Algunos insecticidas organofosforados y herbicidas. 464 p Agüero, R, Portugués, P, González, M, Rodríguez, A. (2017).

- Actividad herbicida de tres sustancias de origen natural. En Memorias XXIII Congreso Latinoamericano y III Iberoamericano de Malezas. ALAM. Cuba. 224-227 Alonso, L; Demetrio, P; Etchegoyen, A; Marino, D. (2018).
- Glyphosate and atrazine in rainfall and soils in agroproductive areas of the pampas region in Argentina. Science of the Total Environment. 645: 89-96 Andréa, M., Peres,T., Luchini,L., Bazarin,S., Papini,S., Matalio,M., Savoy,V. (2003).

- Influence of repeated applications of glyphosate on its persistence and the soil bioactivity. Pesquisa Agropecária Brasileira 38 (11): 1329-1335. Andreasen C., Stryhn H. y Streibig, J.C. (1996).

- Decline of the flora in Danish arable fields. Journal of Applied Ecology 33,619–626. Benachour, N., Seralini, G. (2009).

- Glyphosate Formulations Induce Apoptosis and Necrosis in Human Umbilical, Embryonic, and Placental Cells. Chemical Research in Toxicology 22 (1): 97-105. Biblioteca Cenicafé. (2009).

- Avances Técnicos 383. Gerencia Técnica. Disponible en: https://biblioteca.cenicafe.org/bitstream/10778/356/1/avt0383.pdf BONSUCRO The global sugarcane platform. (2016).

- Estándar de Producción BONSUCRO, Guía para el Estándar de Producción Bonsucro para la UE. Versión 4.2 London, United Kingdom. 60 p. Bradshaw, L. D., Padgette, S. R., Kimball, S. L. & Wells, B. H. (1997).

- Perspectives on glyphosate resistance. Weed Technology, 11(1), 189-198. Cakmak, I., Yazici, A., Tutus, Y. y Ozturk, L. (2009).

- Glyphosate reduced seed and leaf concentrations of calcium, manganese, magnesium, and iron in non-glyphosate resistant soybean. European Journal of Agronomy, 31, 114-119. Clarimón, L. y Cortés, A. (2016).

- Alternativas al uso de glifosato y otros herbicidas de síntesis química. Zaragoza, España. Recuperado de: https://www.ccoo.es/cf089f5ee22ced87a15305a825155072000051.pdf