AIR POLLUTION BIOMONITORING WITH BEES IN TROPICAL ENVIRONMENTS

Experiments and first outcomes

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33th Edition

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Introduction – Why bees?

The bee, sentinel of the environment and pollutant-detecting entity

Area of activity = 3 Km^2

APIDIAG: French technology (by INRA -APILAB), adapted and validated in tropical conditions by NBC in French Guiana in 2014, based on sampling and analysis of bee samples to measure traces of:

- **PM10, PM2.5 particles**
- **heavy metals**,
- **organic compounds**:
  - dioxins / furans,
  - PCB,
  - PAH,
  - VOC,
  - pesticides (using the wax)

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The Team

* C^{3}MAG - Materials Characterization Center of the "*Université de Guadeloupe*"

Introduction

Phase 1 – APIDIAG technology transfer by NBC and APILAB to UA (Université des Antilles in Guadeloupe)

Phase 2 – First contact and training with beekeepers from Guadeloupe

Phase 3 – Installation of the biomonitoring system in Guadeloupe

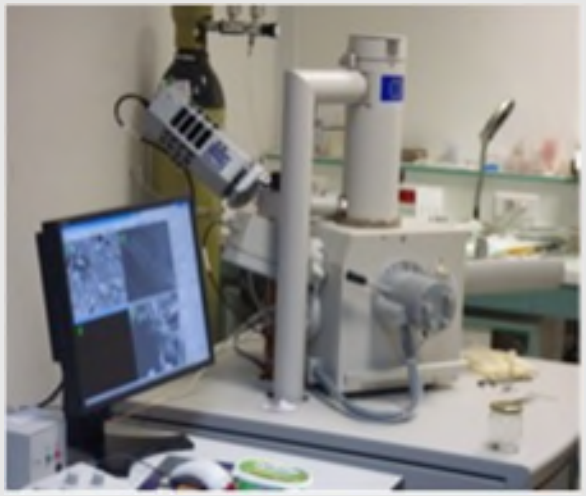
Phase 4 – Sampling campaign

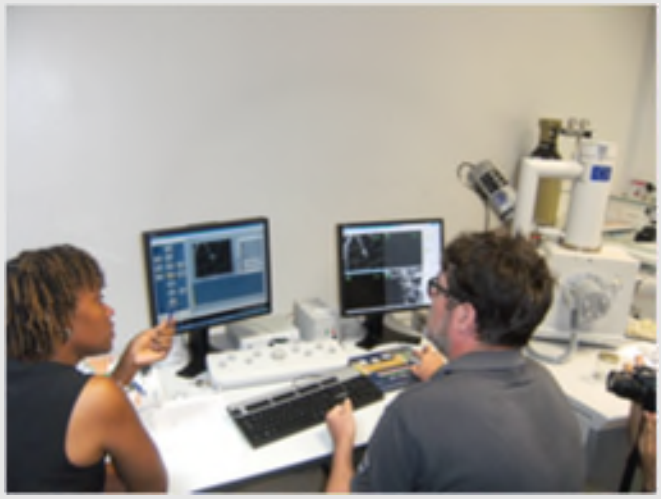
Phase 5 – Analysis and interpretation of the results

		Avr. 16	Mai 16	Juin 16	Juil. 16	Aout 16	Sept. 16	Oct. 16	Nov. 16	Dec-16
Phase 1	Transfert APIDAG									
Phase 2	Beekeeping training									
Phase 3	System setup									
Phase 4	Sampling									
Phase 5	Analysis									
Phase 6	Final report									

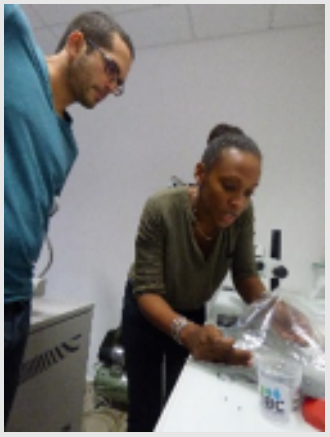
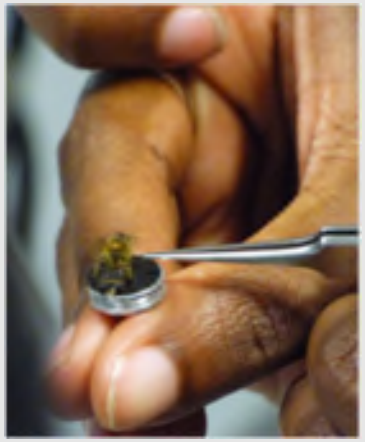
Phase 1 : APIDIAG Technology Transfer

Experimental setup: Scanning Electron Microscope (SEM + EDX) at C^{3}MAG





Sample Preparation

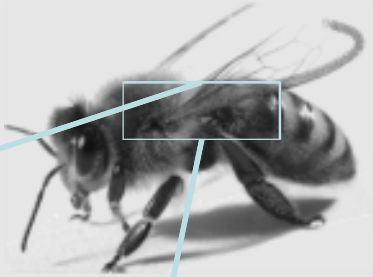



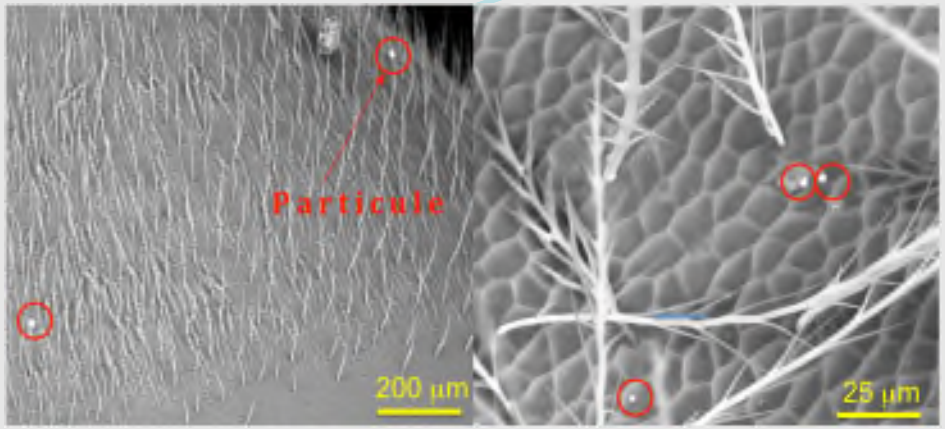
* C3MAG - Materials Characterization Center of the University of the West Indies and Guyana (Guadeloupe)

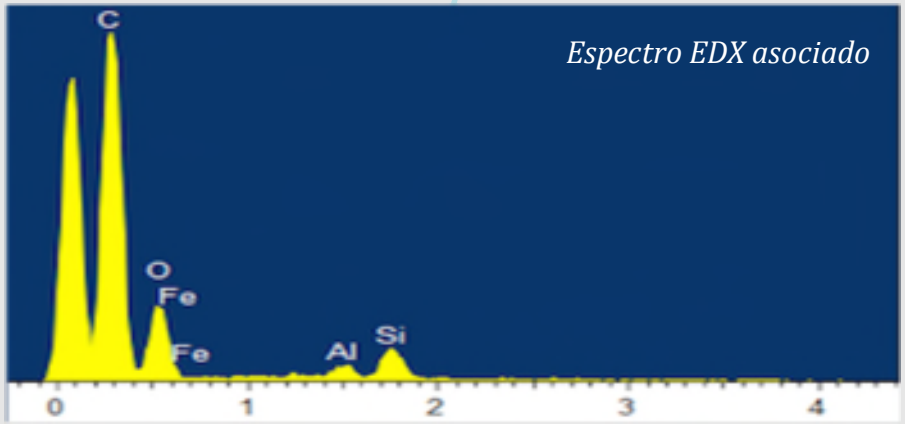
Phase 1 : APIDIAG Technology Transfer

IN LABORATORY

- SEM Image of the backside of a bee
- Production of a high resolution image of the sample surface







- Elemental chemical analysis by energy dispersive spectrometry (EDX)

Qualitative and semi-quantitative study of particles

Phase 2 : Training with beekeepers

Goals:

- Technical exchanges with APIGUA professional beekeepers.
- Selection as a target species of Apis melifera (honey bee among the 30 species of Guadeloupe).
- How to choose the right location for the system.
- Determination of sampling periods taking into account the beekeeping season in Guadeloupe
- Knowledge of the current regulations and the well being of the residents.
- Knowledge of the associated health aspects.

Training in the premises of APIGUA (Baie-Mahault)

Field Visits

Phase 3 : Establishment of the bio-surveillance device

Where and When to measure?

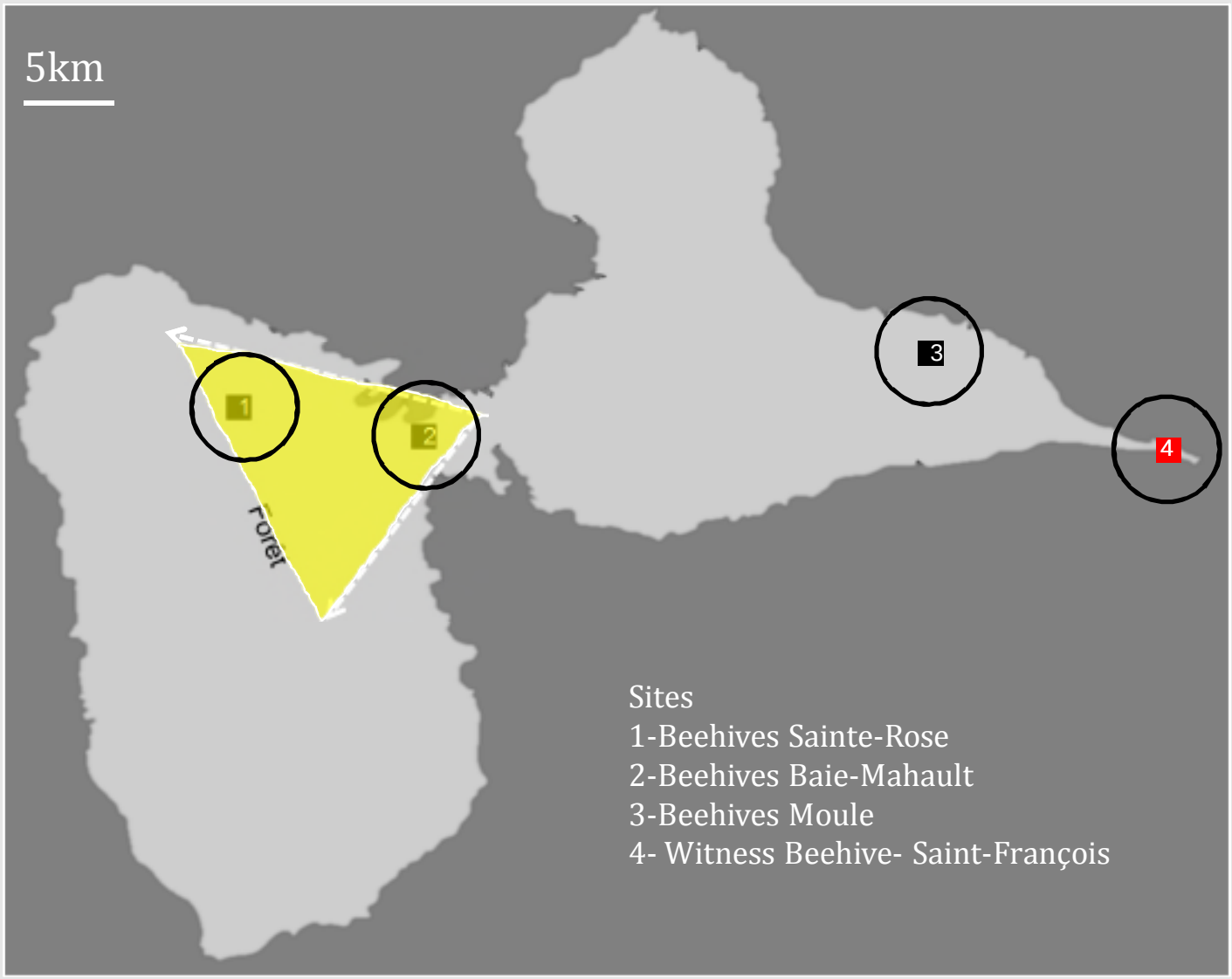
- Active Biomonitoring: allows you to choose measurement locations and uses bees bred for this purpose.

- Types of sampling points:

  Witness (« white zone » limited pollution)
  Impact zones (under the influence or not of an anthropogenic source).

- The sampling frequency depends on the local context.

Phase 3: Establishment of the bio-surveillance device



Phase 4: Sampling Campaign

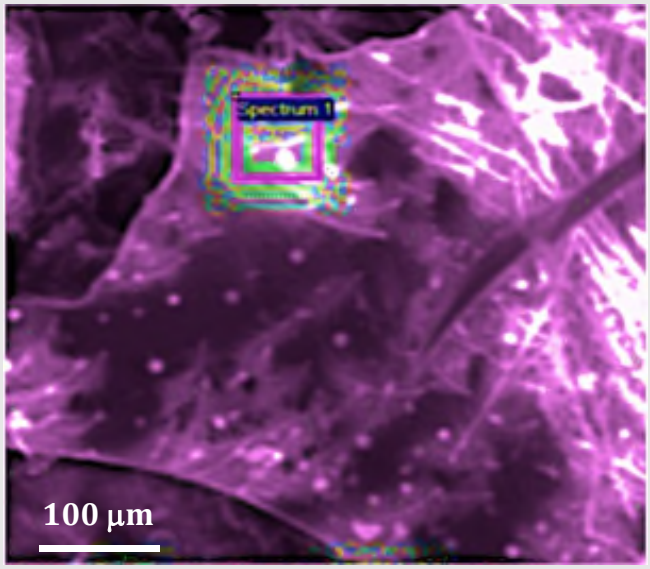
ISO 14001

On-site sampling carried out with professional beekeepers

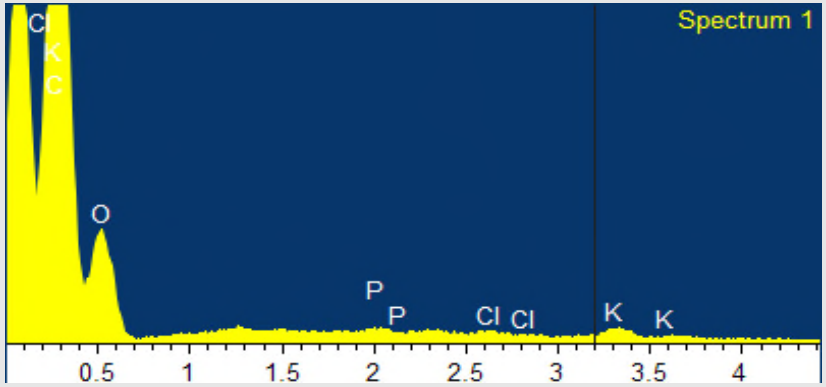
Norma XP X43-909 para el biomonitoreo activo del medio ambiente utilizando abejas melíferas. AFNOR.

Phase 5: Results Analysis

Identification of compounds by SEM and microanalysis EDX: Example 1



Exemple of SEM image obtained

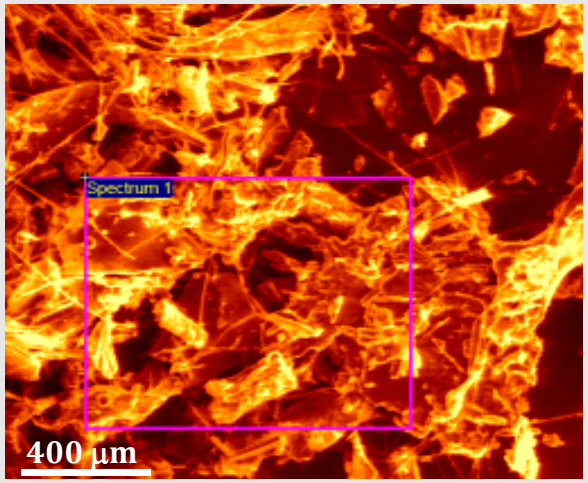


Exemple of EDX spectrum obtained

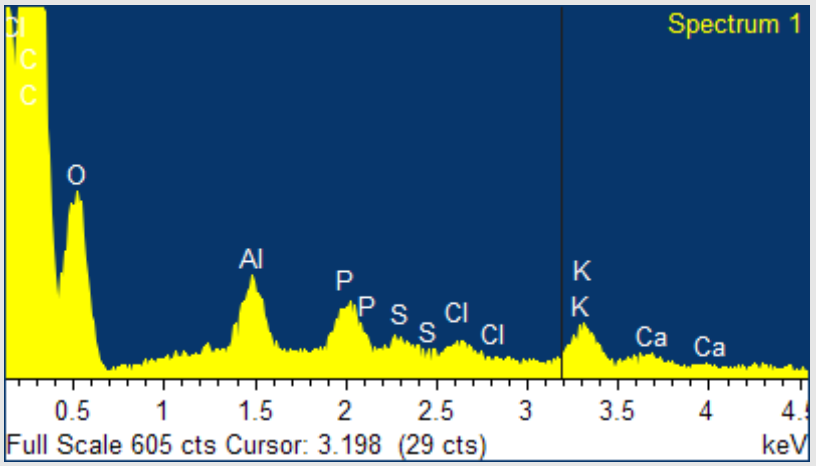
- Organic particles (PM10 and PM2.5) essentially embracing potassium (K), phosphorus (P) and chlorine (Cl).
- Possible origin: Pollens recovered by bees, agricultural products (i.e. fertilizers)

Phase 5: Results Analysis

Identification of compounds by SEM and microanalysis EDX



Exemple of SEM image obtained

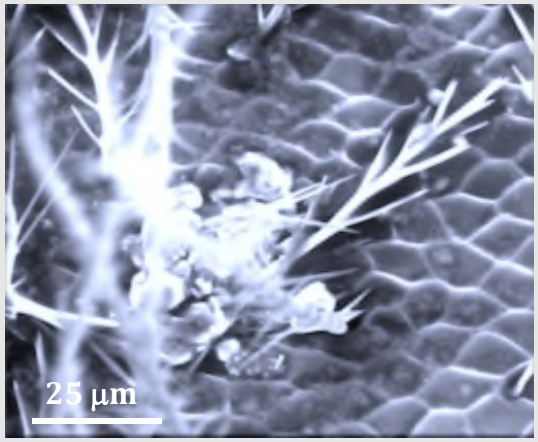


Exemple of EDX spectrum obtained

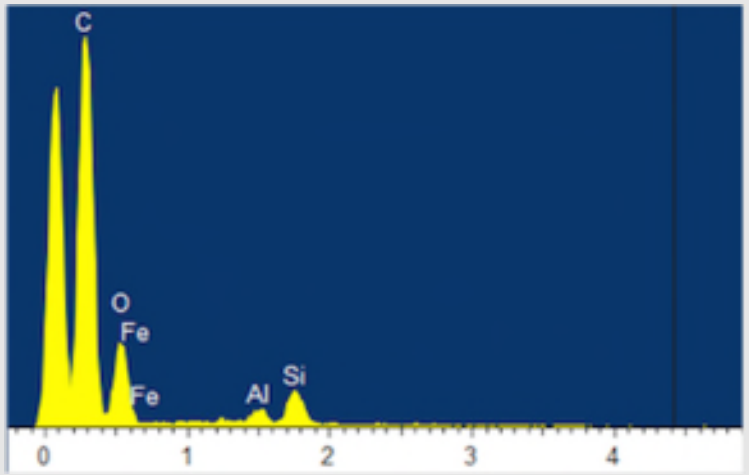
- Other particles formed of calcium (Ca) and sulfur (S).
- Possible origin: Gypsum ($CaSO_4$), raw material in cement production, (i.e. Antillean Cement and Lafarge located within a radius of less than 3 km from the sampling apiary).

Phase 5: Results Analysis

Identification of compounds by SEM and microanalysis EDX



Exemple of SEM image obtained



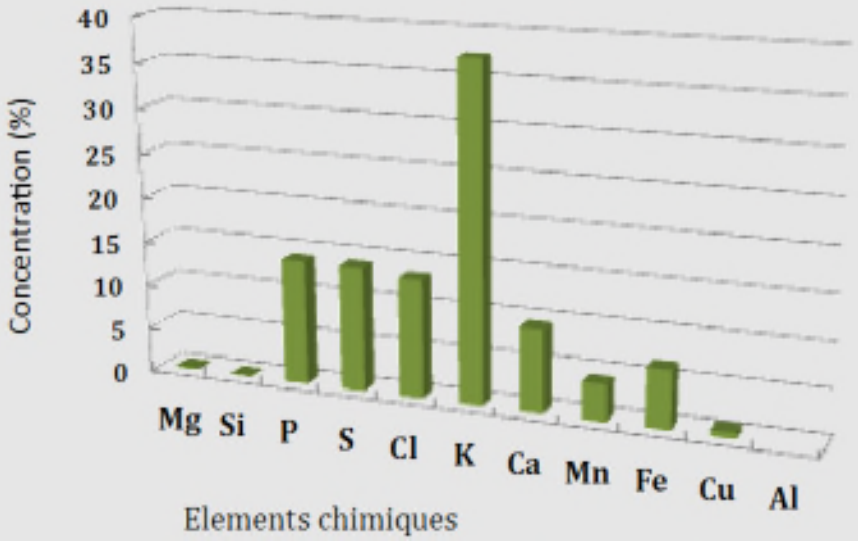
Exemple of EDX spectrum obtained

- Other particles formed of aluminum (Al), silicon (Si) and iron (Fe)
- Possible origin: an air quality alert had been recorded, with the presence of a high level of PM10 particles (> 50 mg/m^3 on average over 24 hours), related to the passage of sub-Saharan sand mists on the ground. Guadeloupe archipelago.

Phase 5: Results Analysis

Additional analysis by X-ray fluorescence spectrometry (for heavy metals)


Fluo X Device



- Correlation of the results obtained by SEM/EDX from available equipment in the research laboratories of the UA
- High Resolution Detection - Heavy Metals (Copper)

Phase 5: Results

Supplemental analysis by GC / MS (for organic compounds)


Lyophilizator

soxhlet

Evaporateur rotatif

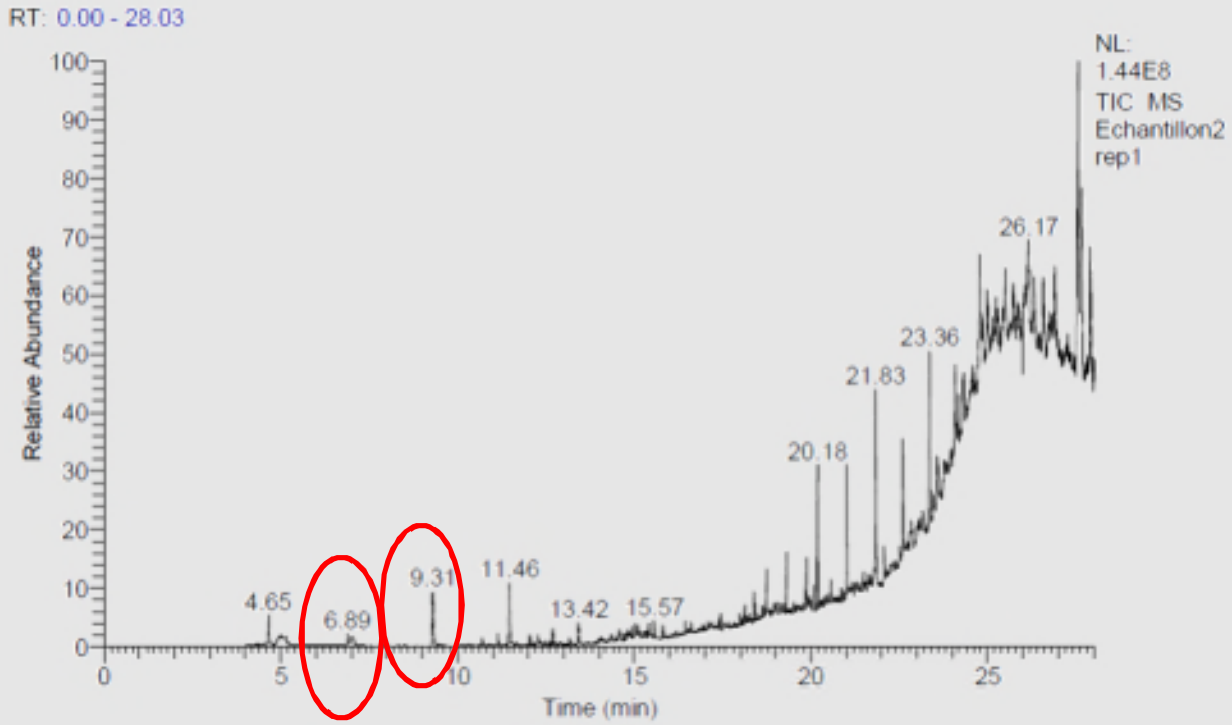
Colonne de florisil

Ampoule à décanter

- Establishment of a protocol for the analysis of organic compounds

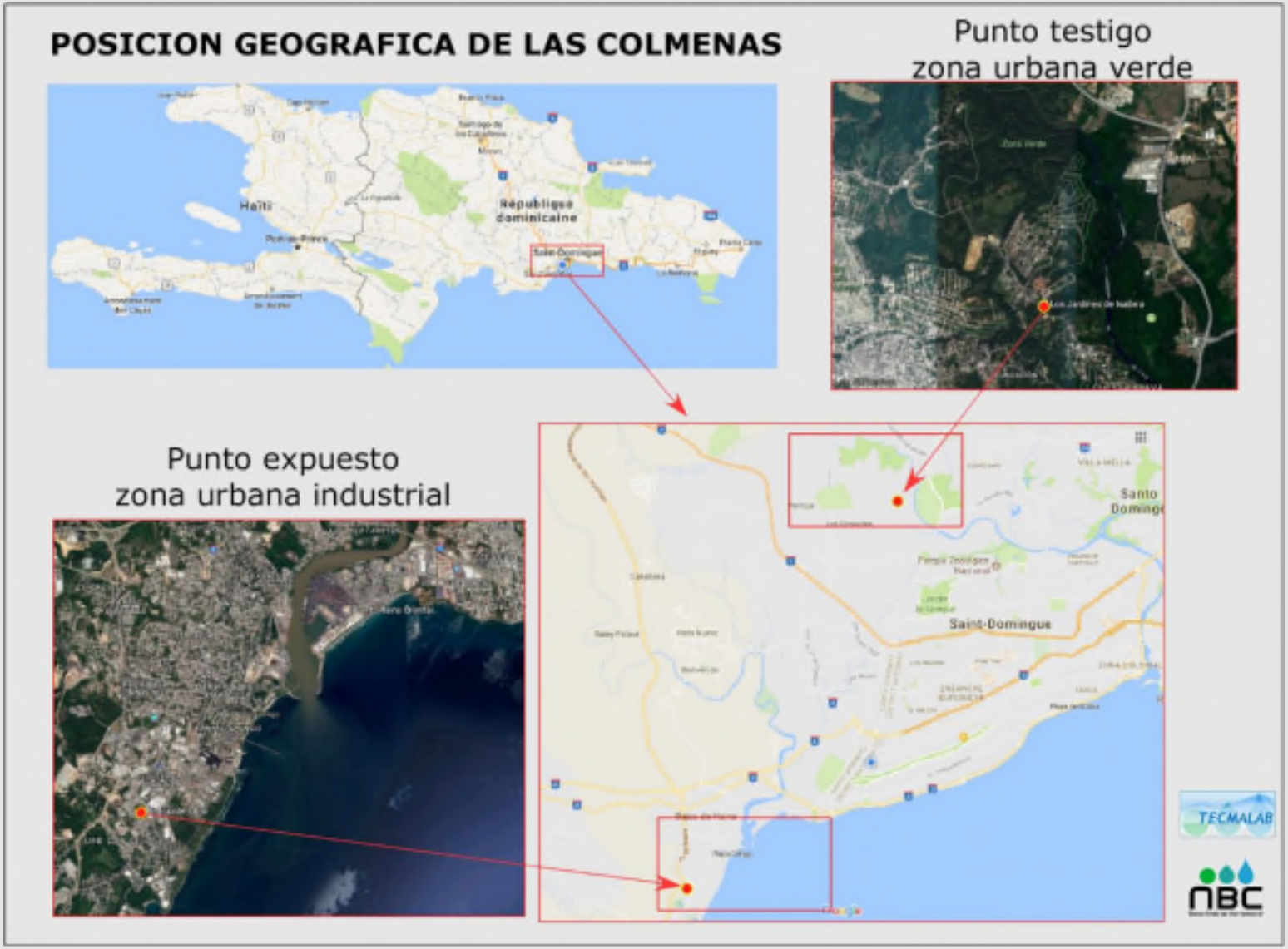
Phase 5: Results Analysis

Supplemental analysis by GC / MS (organic compounds)

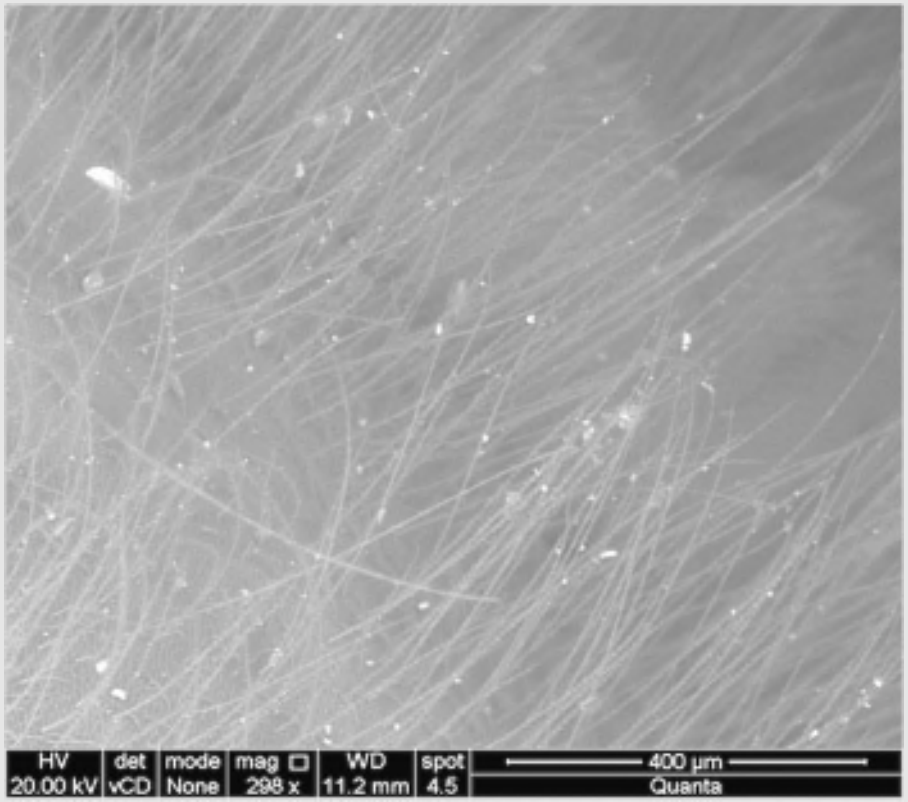


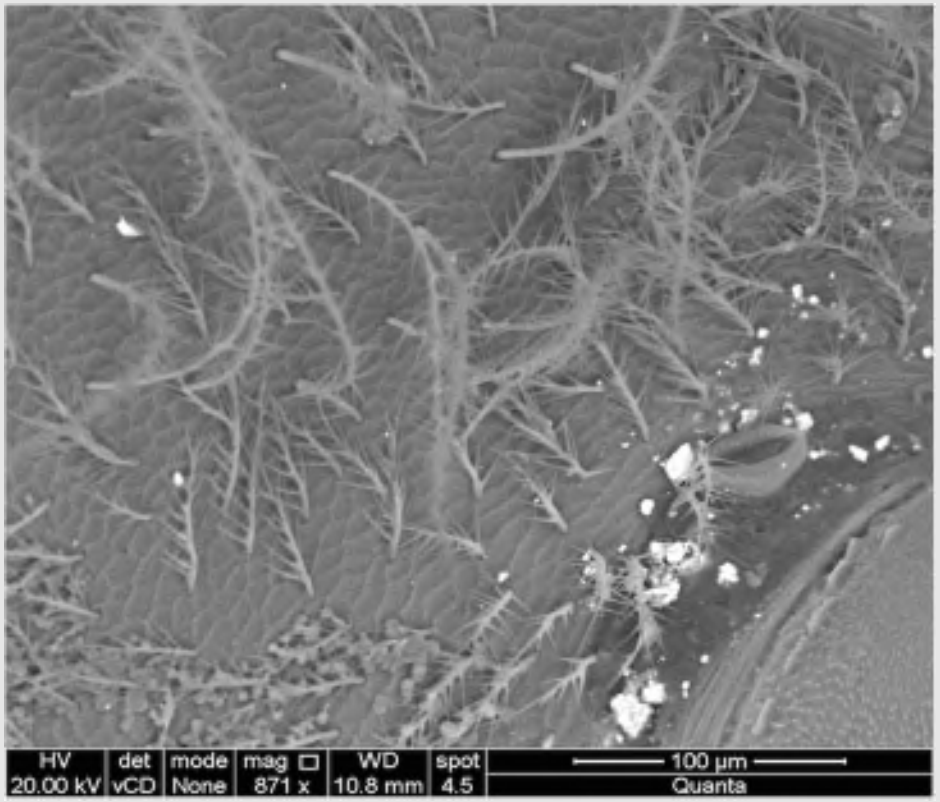
- Compounds belonging to the siloxane family (anthropogenic origin)

Phase 5: Results Analysis – Dominican Republic



Phase 5: Results Analysis





Phase 5: Results Analysis

Origen de las partículas	Clase de partículas	Lugar de exposición (Zona Industrial)		Lugar de exposición testigo	
		18/11/2017	04/02/2018	18/11/2017	04/02/2018
	Número de partículas analizadas	88	87	26	35
Medio Ambiente	Aluminosilicatos	Raro	Raro	Abundante	Abundante
	Calcio	Abundante	Abundante	Abundante	Abundante
	Arena	Raro	Abundante	Nada	Raro
	Elementos medioambientales	Abundante	Abundante	Abundante	Abundante
Antrópico	Óxido de hierro	Raro	Raro	Nada	Raro
	Cromo	Muy notable	Nada	Nada	Nada
	Titanio	Muy notable	Muy notable	Nada	Nada
	Zinc	Muy notable	Nada	Trazas	Nada
	Hierro	Nada	Notable	Notable	Notable
	Aluminio	Nada	Nada	Trazas	Nada
	Sulfato de bario	Nada	Raro	Raro	Raro
	Plomo	Muy notable	Muy notable	Nada	Nada
	Arsénico	Nada	Trazas	Nada	Nada
	Circonio	Nada	Nada	Notable	Nada

Abundante → Particles representing **more than 20%**.

Raro → Particles representing **between 2% and 20%**.

Notable → Particles found **very rarely**.

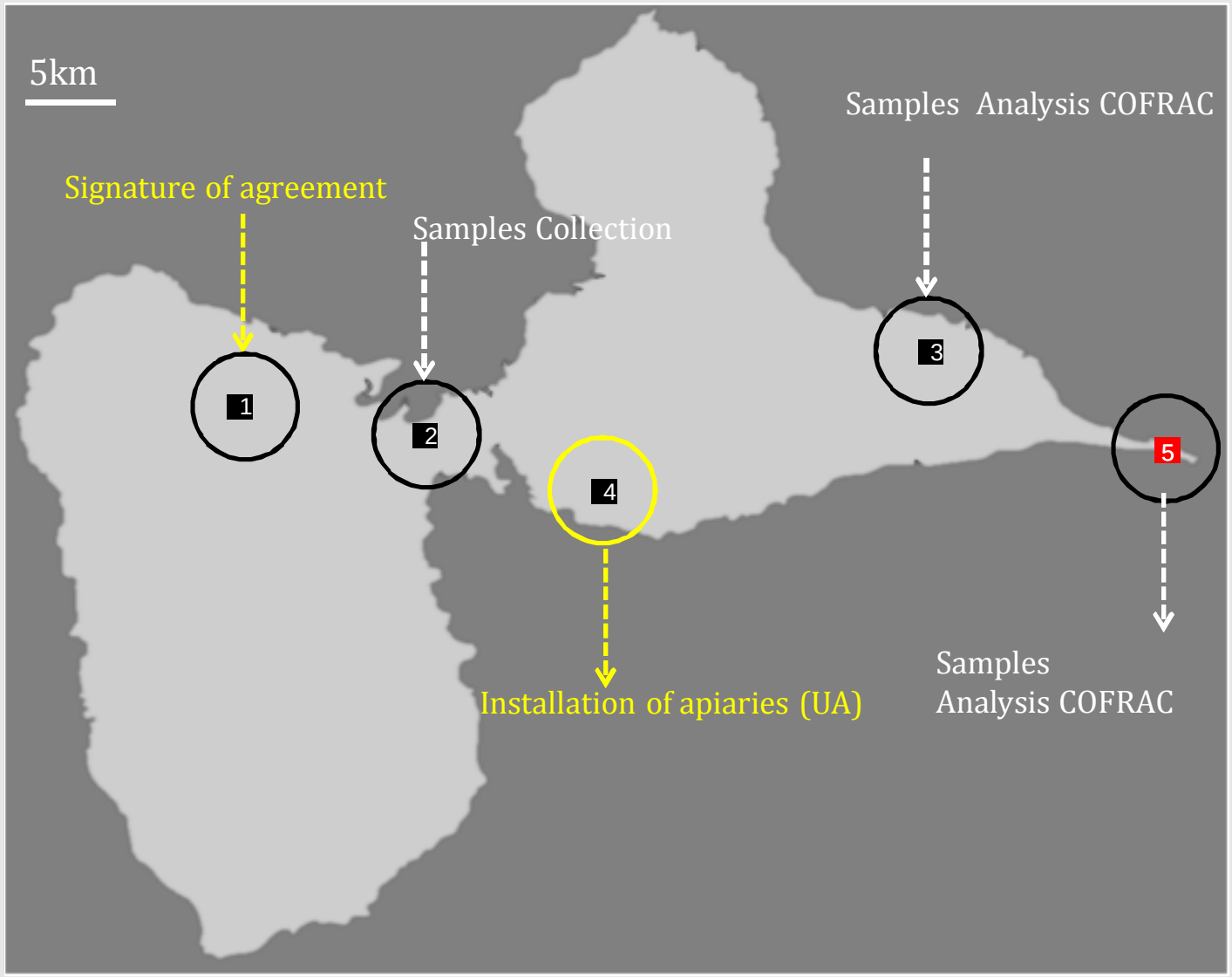
Muy notable → Elements from a specific anthropogenic origin.

Conclusions

- **Succesful validation of the technology in tropical enviroments**.
- Implementation of the device in close collaboration with professional beekeepers (APIGUA).
- Detection of atmospheric pollutants in accordance with the local sentinel environment.
- In parallel, implementation of experimental protocols for analysis of inorganic and organic compounds (contribution to research).
- Double technology transfer of biomonitoring of air pollution with bees in Guadeloupe:
  - Biomonitoring method for a generalization of the process in Guadeloupe.
  - Acquisition of protocols and analytical know-how and valorization of the equipments of the laboratories of the UA - The objective is that the UA becomes in the short term the analytical center APIDIAG of the Caribbean zone: 1st customer NBC and its clients (CNES , Cement works, Air Liquide, Bananas plantations ...)
- Development of new cooperations in the Caribbean and South America.

Example of NBC Customer in Guyane

To be continued in Guadeloupe



Commercial development and first applications

Guyane :

- Cement Guyanais
- Guiana Space Center - Spaceport of Europe

Dominican Republic:

- Industria de almacenamiento de gas
- Banana's plantation (agriculture)

Next steps

Guyane :

- Construction companies and careers
- Mines
- Districts

Dominican Republic:

- 5 Airports
- Total (gas stations around the country))
- Total (Santo Domingo City)
- The Minister of Agriculture
- Municipality of Santo Domingo
- Mines, electrical companies, steel industry, etc.

Colombia:

- Commercial and training visits in prospective

REPUBLICA DOMINICANA
Ministerio de Agricultura
"Año del Fomento de la Vivienda"

Santo Domingo, D. N.
Martes, 03 de mayo de 2016.

MA-2016-12068

Señor
Nicolás BREHM
Ingeniero Agua y Medio Ambiente
Director Ejecutivo TECMALAB, SRL
Su Despacho.

Distinguido Señor:

Cortésmente, tenemos a bien dirigirnos a usted, en ocasión de informarle que el Departamento de Inocuidad Agroalimentaria (DIA) de este Ministerio, tiene interés de colaborar con el *Proyecto de Transferencia de la Tecnología para el Bio-monitoreo de la Calidad del Aire por Medio de las Abejas y Métodos Analíticos Asociados*, con el financiamiento del Fondo de Cooperación Regional (FCR) de la República de Francia, que actualmente se está ejecutando en la Isla de Guadalupe y la República Dominicana, respectivamente.

El interés de este Departamento radica en que este Proyecto pretende apoyar a ambos países en la determinación de la contaminación del aire por residuos de plaguicidas y otros contaminantes, así como apoyar a los Laboratorios nacionales en la transferencia de tecnología y metodologías analíticas innovadoras, y en este sentido, aportaría información de mucha importancia para las labores de gestión de riesgo en el uso de plaguicidas y contaminantes químicos en República Dominicana.

Sin otro particular por el momento, aprovechamos la oportunidad para saludarle con sentimientos de alta consideración y estima.

Atentamente,

Ángel Estévez
Ministro de Agricultura

AE
RR/LMMR

Related projects and other analysis

Distance control of the beehive:

- Weight control.
- Temperature.
- Humedity.

Proteines oxidation:

- To evaluate the effects of the environment around the beehive in the bees.

Pesticides analysis:

- Reconstruction of a hole made in the beehive.
- Control of the bioaccumulation time.

Acknoledgments

- Benoit Foucan-Pérafide (APIGUA)
- Jack Passave (APIGUA)

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- Corine Jean-Marius (UA - COVACHIM-M2E)
- Ronald Ranguin (UA - COVACHIM-M2E)
- Yves Bercion (UA - C3MAG)

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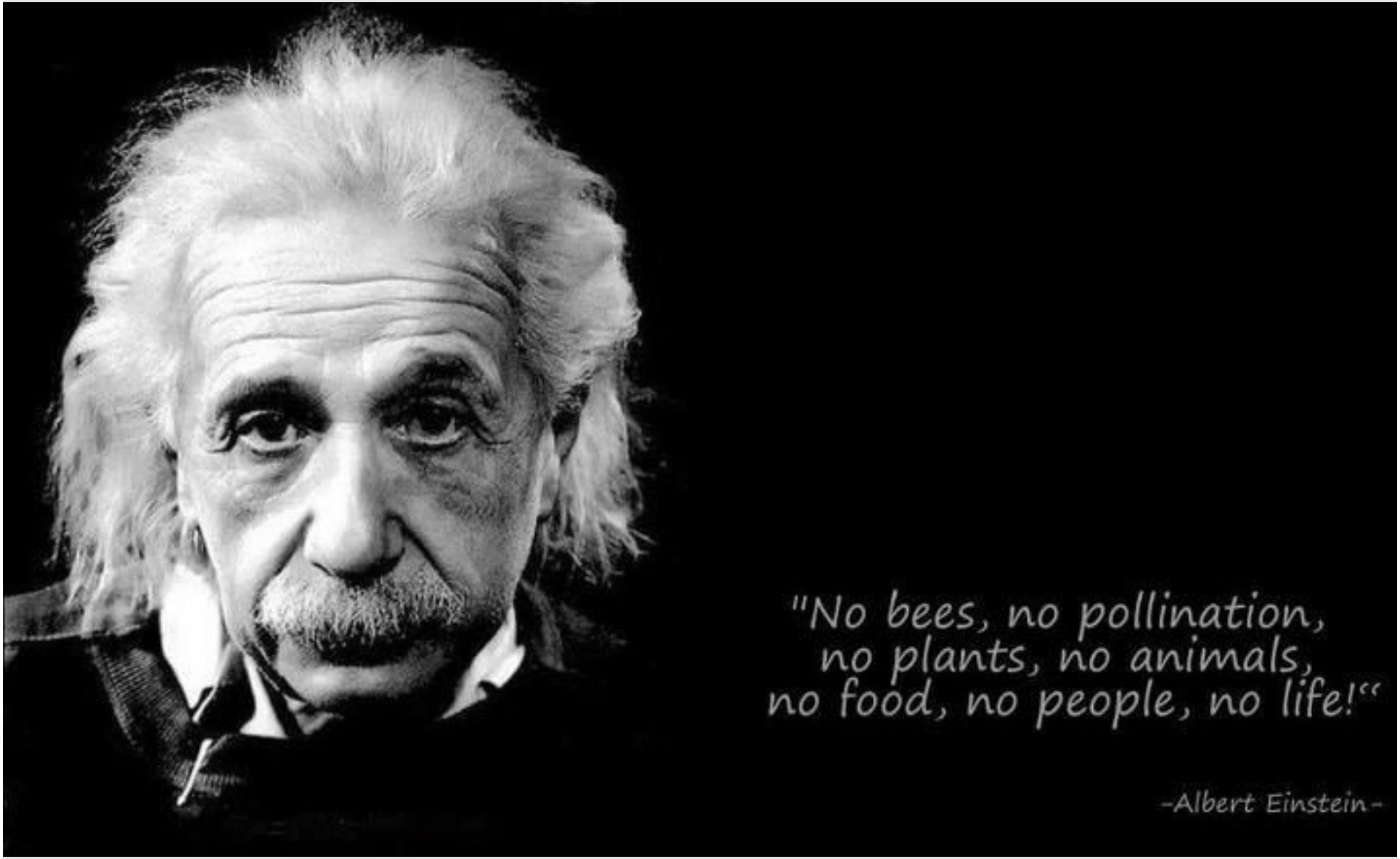
- Jean-Philippe Champenois (NBC)

- Benjamin Poirot (APILAB)
- Omar Perdomo & Yolanda Leon (INTEC)



Gracias por su atención

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