LEARNING TOXICOLOGY THROUGH OPEN EDUCATIONAL RESOURCES

ENVIRONMENTAL MONITORING SCHEME AND RELATED ACTIVITIES

Camelia DRAGHICI, Ileana MANCIULEA

Transilvania University of Braşov

c.draghici@unitbv.ro, i.manciulea@unitbv.ro

Universitatea TRANSILVANIA din Braşov

Erasmus+

1. INTRODUCTION

This unit contains the following:

- environmental monitoring objectives;
- environmental monitoring scheme;
- related activities;
- what means to characterize the quality of the environment.

At the end of this unit, students will be able to understand:

- the importance of the environmental monitoring activity;
- the structure of the monitoring systems – flow scheme and related activities;
- the necessary activities to undergo for the pollutants measurements from environmental samples.

For a better understanding of the following presentation, the environmental monitoring definition is needed. Thus, **environmental monitoring (EM)** is a complex activity based on data acquisition about the state of the environmental quality, obtained after long term and systematic measurements of environmental parameters and indicators, with spatial and temporal coverage, organised in such way to ensure the pollution control.

Specialists in environmental monitoring are concentrating their efforts on the modifications of the environment "properties", registered as a consequence of the pollution and/or other influencing natural or anthropogenic factors. Thus, different types of monitoring have been delimited and further developed, like:

- *geophysical monitoring* – surveying geophysical modifications;
- *chemical monitoring* – surveying the chemical composition changes occurring in the environment;
- physical monitoring – surveying physical properties (noise, radioactivity);
- *biochemical monitoring* – surveying the biochemical changes.

Due to the complexity of the environmental compartments composition, the chemical monitoring will always be an interdisciplinary approach, a team work with specialists with different backgrounds: chemists, biochemists, biologists, environmentalists, hydrologists, meteorologists, geographers, statisticians, ICT specialists, physicists, toxicologists, epidemiologists, others.

The following presentation will focus on the **chemical monitoring**, mainly on the analytical process of samples from different environmental compartments (air, water, soil). The monitoring results are designed to be useful to evaluate the status of the environment and of the pollution influence on the public health.

2. MONITORING FLOW AND RELATED ACTIVITIES

The monitoring can be conducted having two main different targets, affected by the pollution and/or other influencing natural or anthropogenic factors:

- *environmental monitoring* – surveying the environment components;
- *biological monitoring* – surveying the health status of the plants and animals.

A general description of the environmental monitoring flow stages, including the most important processes involved, are presented in Figure 1., and will be further presented in details:

1. planning stage,
2. execution stage,
3. and evaluation stage.

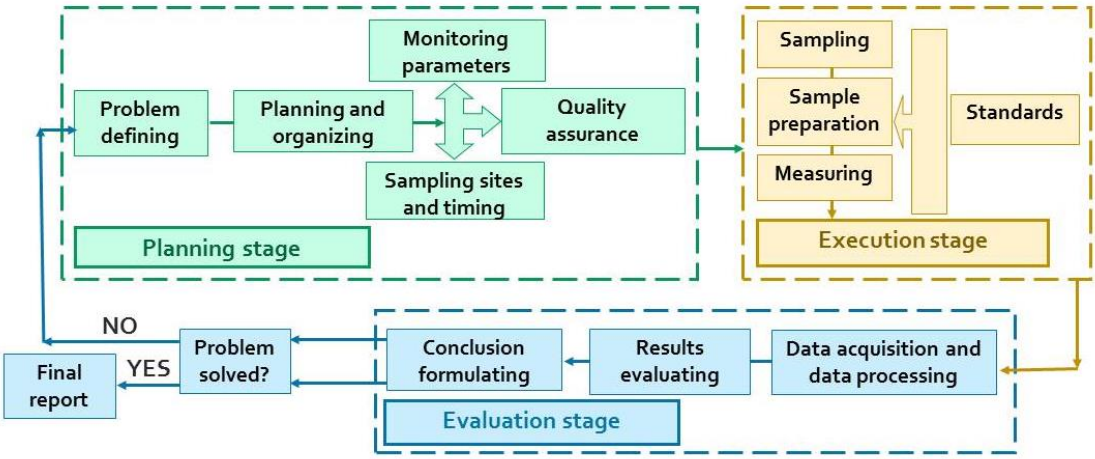

Figure 1. Environmental monitoring flow main stages.

2.1. PLANNING STAGE

The first stage of the environmental monitoring activities is the planning one, which begins with problem defining (Figure 2.).

Problem defining

When an environmental undesirable event occurs, the problem should be carefully defined, in order to allow formulating the objectives and their related actions, planning the required procedures.

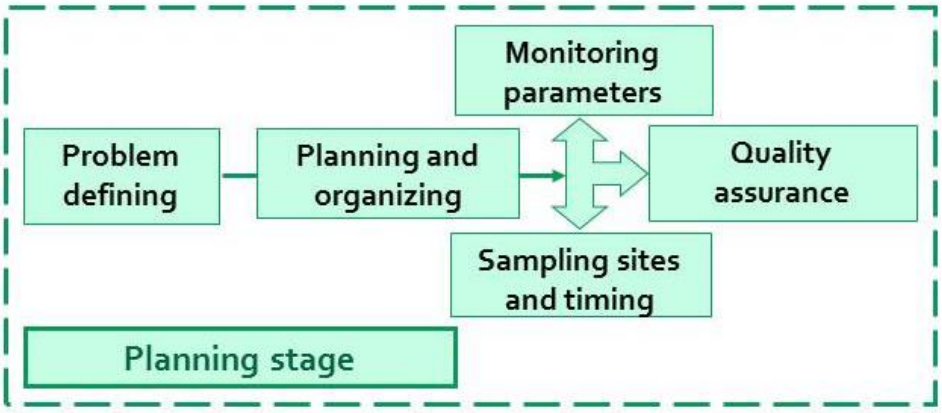

Figure 2. Planning stage of the environmental monitoring flow.

Problem defining means to firstly answer to the following questions:

a. do we have an environmental problem or not;
b. is there any activity with significant environmental impact identified?

If the answers are positive, the aim and objectives for the environmental monitoring are established.

Planning and organizing

After defining the environmental problem, the next step is to organize the system, which follows several aspects:

- establishing the responsible and competent institutions in charge to carry out the environmental monitoring program;
- organizing the responsible laboratories with specialized personnel with adequate analytical equipment and methods;
- organizing the monitoring program, by establishing the monitoring parameters of interest, sampling points and timing/campaigns, sampling and analytical procedures, data evaluation procedures.

All the activities involved are subject of internal quality assurance and external quality control system.

2.2. EXECUTION STAGE

The second stage of the environmental monitoring activities flow is the execution one. During this stage the analytical process occurs (Figure 3.).

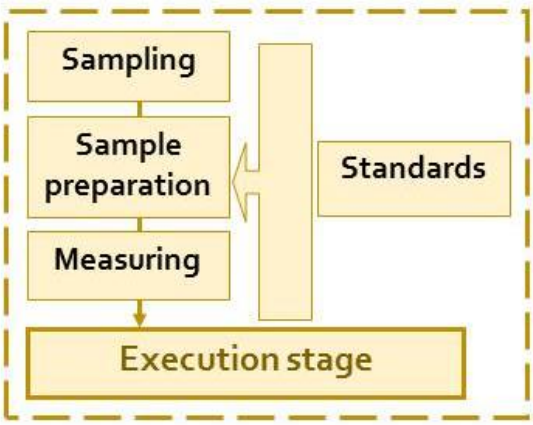

Figure 3. Execution stage of the environmental monitoring flow.

The analytical process consists in all the activities performed in order to determine the value of the parameters of interest, from sampling to measurements.

Sampling is a generic term, defining two activities performed on environmental samples: (1) sample up-take from environmental media (also simply used as “sampling”) and (2) sample preparation, or sample pre-treatment.

Thus, while **sampling** implies the sample up-take / collection from air, waters, soils or biota, **sample preparation** involves all the activities carried out by specific methods and techniques, in order to bring the compound of interest (pollutant), present in different matrixes, in a measurable form.

Measuring the environmental parameter is based on specific analytical methods and techniques available and applicable for different sample matrixes and for different pollutants.

For environmental samples, there are **standardized methods** for all analytical steps, sampling, sample preparation and measurement.

2.3. EVALUATION STAGE

The execution stage, including the analytical process, is followed by the evaluation one (Figure 4.). This consists of activities designed to convert the information obtained from the measurements (data) into useful result-based information.

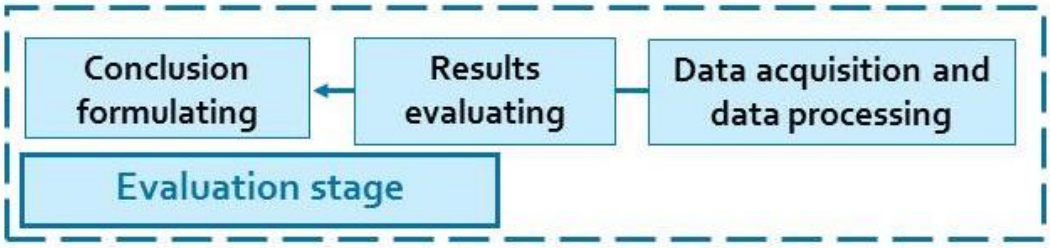

Figure 4. Evaluation stage of the environmental monitoring flow.

Data acquisition and data processing

Measurement data are registered, in a data base (data acquisition) system, specific to each measurement instrument and equipment. Data are further processed based on physical-chemical laws, formulas and calculations will be used to finally expressed them as useful information, as results.

Results evaluating

The results are evaluated and presented as such, **in tables**, or used to design the most relevant **di(multi)dimensional graphs**.

Commonly, the monitoring graphs are showing the evolution in space or in time of the environmental parameters, most often presented as pollutants concentration. The graphical way to present the monitoring results will enable the decision makers to formulate conclusions and take relevant decisions.

Conclusion formulation

If the conclusions respond to the identified problem, a final monitoring report can be completed (Figure 1.). If the conclusions do not answer to the formulated problem, the cycle of monitoring steps is resumed, and starts by identifying the failing stages in problem solving.

To resume, Figure 1. shows the environmental monitoring program cycle, that includes the main stages of the activities carried out, from the problem defining, to the final report completing.

3. ENVIRONMENTAL MONITORING ACTIVITIES AND RELATED OUTPUTS

Environmental monitoring is a complex surveillance process aiming to deliver the most relevant information on the presence of the pollutants in environmental components / compartments: air, water, soil and biota.

Following the same main stages of the environmental monitoring cycle, we will further present the activities linked to the related outputs. The planning, execution, and evaluation stages were kept with the same colours shown in the previous scheme (Figure 1.), and the results/outputs of the corresponding activities are presented in red boxes (Figure 5.).

3.1. ENVIRONMENTAL COMPONENTS

Our further presentation will be dedicated to the environmental monitoring, being interested on samples up-taken from different environmental components and their specific sub-systems:

- air – outdoor and indoor air;
- waters – surface waters and groundwaters;
- soil – soils and subsoil;
- biota – micro-organisms, plants and animals.

Air and water are complex systems, in fluid aggregation states, mainly homogeneous. Due to their mobility properties, air and water are both considered as vectors of the pollutants propagation.

For both air and water, emissions and immissions may be separately monitored. **Emissions** consist in pollutants released in the environment from different sources (called emissary), while **immissions** consist in the total content of pollutants in the environment, resulted as exposure to a combination of emissions (total emissions).

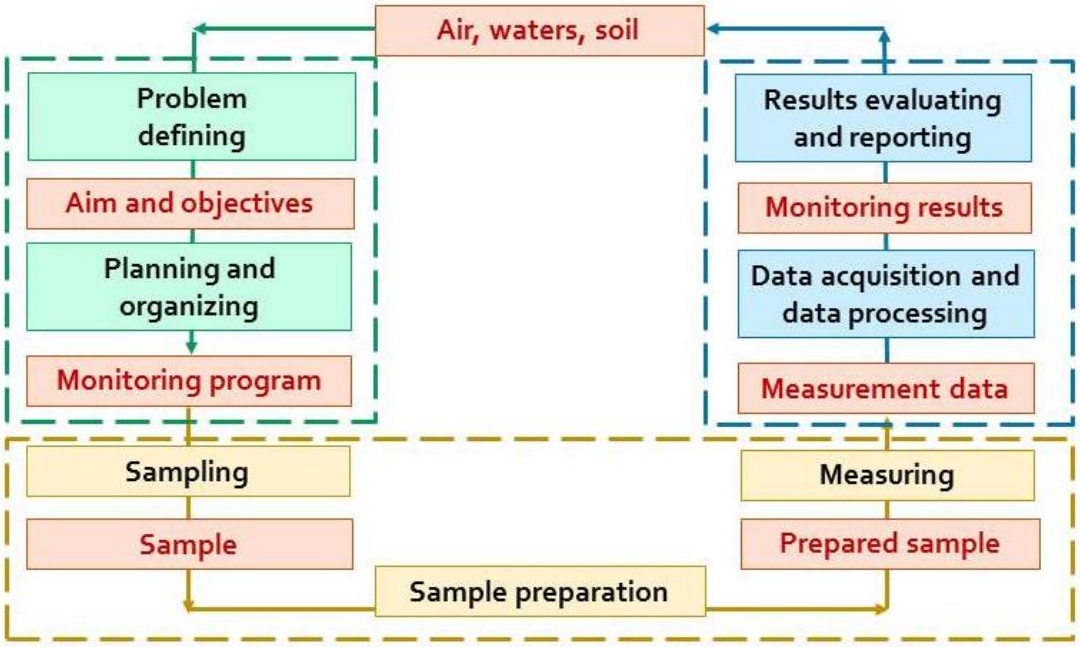

Figure 5. Environmental monitoring flow and the related outputs.

Pollutants presence in air and water is evaluated as:

- concentration,
- dispersion velocity,
- flow.

Soil is a more complex system, more heterogeneous, considered as an interface that takes up and retain pollutants from air and water.

Pollutants presence in soil is evaluated by:

- concentration,
- retention time,
- other retention indicators.

Biota consisting of plants and animals, is involved in processes like biotransformation, bioaccumulation, and biomagnification of the pollutants, thus being used as biomonitors.

As expected, pollutants presence in biota is evaluated by different parameters as for their presence in air, water and soil:

- concentration (quantity),
- bioaccumulation rate,

– other bioaccumulation indicators.

Emissions and immissions are terms of no relevance related to the soil and biota quality characterisation.

3.2. ENVIRONMENTAL MONITORING AIM AND OBJECTIVES

As a result of defining the problem, the aim and the objectives of the environmental quality monitoring program can be formulated. These may vary depending on the type of monitoring program, based on research projects or on institutional systemic measurements.

Environmental monitoring may be subject of interest for projects developed by **research** teams. They propose to provide objective information on the quality of air, water and soils, aiming to determine the relationship between the pollutants presence in the environment and their impact on living organisms, by:

– identifying population exposure and its health impact;
– studding the dose-response relationship;
– identifying threats to natural ecosystems.

The second type of monitoring is based on systemic measurements, organized by authorized institutions. In this case, the aim is to determine the pollutants presents in the environment (pollution control), to but also to identify population exposure and assess its health impact.

Taking into account that the systemic based environmental monitoring is part of the environmental management system, the main **objectives** are:

– providing objective input to air and water quality management, land-use planning;
– determining compliance with national or international regulations; the results are compared with the accepted limits of the pollutants concentrations in air, water, soil;
– identifying apportioning pollution sources, causing modification on the environmental quality;
– identifying threats to natural ecosystems;
– informing the public about environment quality and establishing alert systems;

- developing and validating management tools such as models and geographical information systems;
- developing policies and setting priorities for environmental management actions;
- quantifying trends to identify future problems or progress in achieving management or control targets.

Based on statistical processing of the data registered by environmental monitoring and public health data bases, the accepted limits of the pollutants concentrations in the environmental compartments are established.

3.3. MONITORING PROGRAM

The output of the planning and organization stage is the monitoring program, taking into account the following:

- establishing the parameters or indicators to be monitored;
- fixing the position of sampling sites and points;
- fixing the monitoring campaigns, in terms of duration of the monitoring program, sampling and measurements rhythm;
- choosing the sampling and measurement methods and techniques;
- establishing the procedures for the measurement data acquisition and processing, in order to obtain the monitoring results;
- fixing the rhythm and way of reporting.

Thus, by presenting the environmental components, establishing the aim and objectives, as well as the monitoring program, the planning stage outputs of the EM are completed (Figure 6.).

3.4. ENVIRONMENTAL SAMPLES

Sample is a portion of a system (in our case of the environment) representative of the place and moment of sampling. Following the sampling operations, samples are collected from the environment compartments, then prepared for analysis.

Environmental samples, being multi-component mixtures, are very complex, due to several considerations:

1. **sample aggregation state:**

– *gaseous,* like atmospheric air, indoor air, any gaseous emissions;
– *liquid,* like waters (surface, groundwater), wastewaters, leachate;
– *solid,* like soil, biota, sewage sludges, sediments;

2. **sample nature,** of mineral origin (inorganic compounds) or biological origin (organic compounds);
3. **sample composition:**

– *(more) homogenous,* like air, waters;
– *(mostly) heterogenous,* like aerosols, smoke, waters with suspended matter, sewage sludge, sediments, soil, biota;

4. **solubility of the samples compounds:**

- *water soluble compounds* (hydrophilic);
- *water insoluble compounds* (hydrophobic).

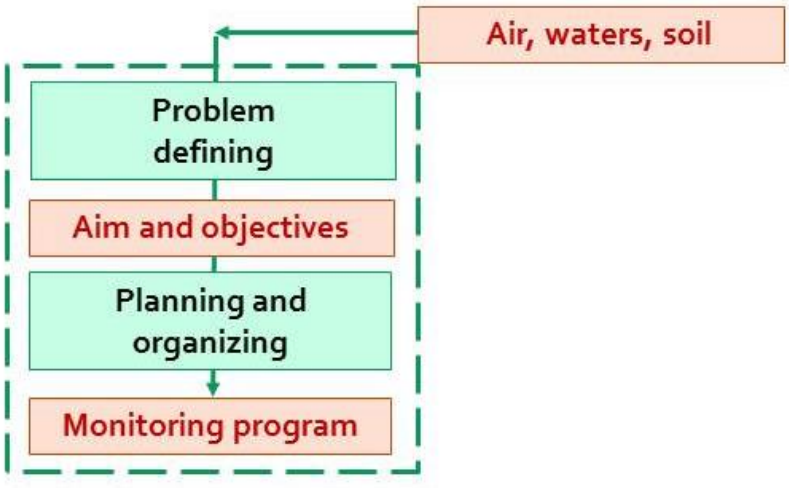

Figure 6. Environmental monitoring planning stage and the related outputs.

3.5. MEASUREMENTS DATA

After collecting and preparing such complex samples, the characterization of a sample consists in determining the quality parameters, in particular the concentration of the pollutants present in environmental samples, based on measurements:

– *qualitative analysis*, responding to the question "*what* pollutants are present in the sample?"
– *quantitative analysis*, responding to the question "*how much* of each pollutant is present?".

Measurements are based on analytical methods using adequate equipment. For environmental analyses, **standard analytical methods** are available, regulated by accredited institutions and organisations. In the laboratories for environmental analysis, **non-standard** methods are also accepted, both standard methods and non-standard methods being subject of **method validation** prior to use.

Measurements are providing data, expressed in specific units to the analytical method and equipment. Data are acquired and stored in data acquisition systems. Most of them, nowadays, are specialised software delivered together with the measurement equipment. These softs ensure not only the data acquisition, but also preliminary data processing, and may display data in different modes: tables, graphs, diagrams.

With the measurements data, the execution stage and the related outputs of the EM were presented (Figure 7.).

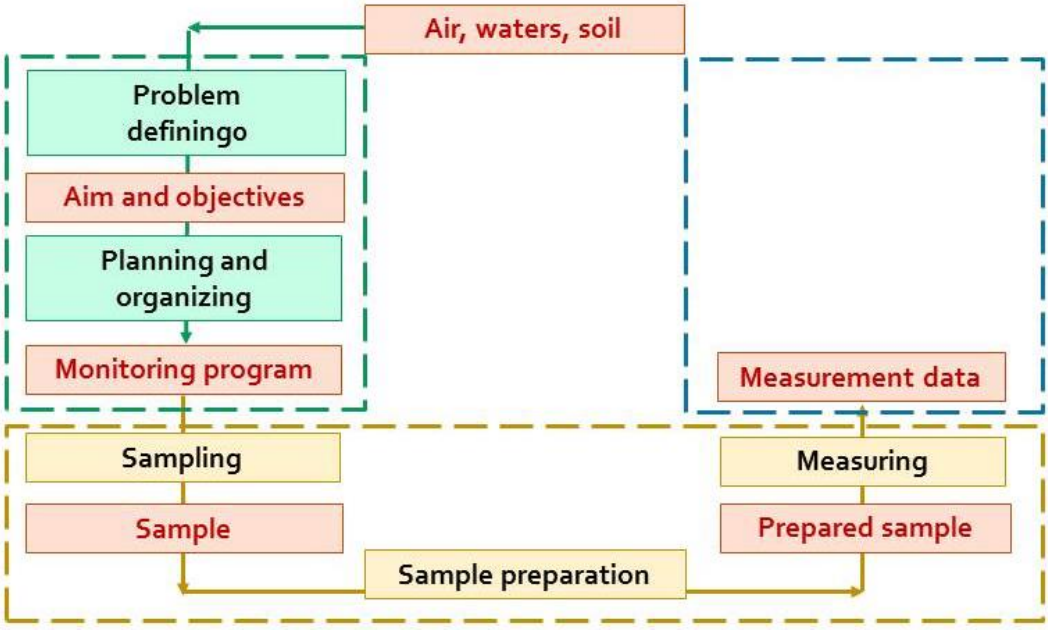

Figure 7. Environmental monitoring execution stage and the related outputs.

3.6. MONITORING RESULTS

Data obtained from measurements are processed on the basis of physical-chemical laws, being transformed into results. The monitoring results are expressed as pollutants concentrations, in units according to the regulations.

Concentration means any reporting of the analyte (pollutant) content to the sample. Concentration units depend on the aggregation state of the sample (gaseous, liquid or solid) and on quantity level of the analyte and of the sample.

In Table 1. are presented examples of pollutants concentration units specific to the content of the pollutants in gaseous, liquid and solid samples, according to regulations:

- in gaseous samples concentrations are expressed as ratio of pollutant mass (mg, μg) to gaseous sample volume (m^3);
- in liquid samples concentrations are expressed as ratio of pollutant mass (mg, μg, ng) to liquid sample volume (L, mL);
- in solid samples concentrations are expressed as ratio of pollutant mass (mg, μg, ng) to solid sample mass (g, kg).

Table 1. Concentration units for pollutants content in environmental samples.

Sample aggregation state	**Examples of samples**	**Concentration units***
gaseous	gaseous emissions, atmospheric / indoor air	mg/m^3; $\mu g/m^3$
liquid	waters, biological fluids	ppm: mg/L; μg/mL ppb: μg/L; ng/mL
solid	soils, sediments, sewage sludge, biota	ppm: mg/kg; μg/g ppb: μg/kg; ng/g (mass of dry sample)

* ppm – parts per million; ppb – parts per billion

The monitoring results are reported to authorized institutions or to any group that has launched a monitoring program and are further subject of statistical analysis, reviewing and publishing or dissemination.

With the presentation of the pollutants concentration reporting, the last stage of environmental monitoring, the evaluation one, was completed (Figure 5.). The results must respond to the aim and objectives of the monitoring program, thus closing the monitoring stages cycle.

REFERENCES

1. Chunlong C.Z., Fundamentals of Environmental Sampling and Analysis, John Wiley & Sons, Hoboken NJ, USA, 2007.
2. Colbeck, I., Draghici, C., Perniu, D., (Eds), Environmetal Pollution and Monitoring, in EnvEdu series, ISSN 1584-0506, ISBN 973-27-1169-8, Romanian Academy Press, Bucharest, 2003.
3. Draghici, C., Chirila, E., Complex Characterization of Polluted Samples, in L. Simeonov, M. Hassanien (Eds.), Exposure and Risk Assessment of Chemical Pollution – Contemporary Methodology, Springer-Verlag, Berlin, Heidelberg, New York, 2009, 165-180.
4. Manahan S.E., Environmental Chemistry, CRC Press LLC, Boca Raton FL, USA, 2001.
5. Patnaik P., Handbook of Environmental Analysis, 2nd Edition, CRC Press, Taylor and Francis Group, Boca Raton FL, USA, 2010.
6. https://www.eea.europa.eu/
7. https://ec.europa.eu/jrc/en/research-topic/environmental-monitoring

https://toxoer.com

Project coordinator: Ana I. Morales
Headquarters office in Salamanca.
Dept. Building, Campus Miguel de Unamuno, 37007.
Contact Phone: +34 663 056 665