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The works must be unpublished and refer to topics of Agriculture-Forest, Pathology-Sustainable, Forest, Management, Horticulture, Engineering and Integrated Water Useand other topics related to Biotechnology and Agricultural Sciences.

Presentation of Content

In Volume number six, as the first article we present, *Measurement of polluting emissions of vehicles with gasoline engines, using static test*, by JIMENEZ-GARCIA, Juan A, CALDERON-NEPAMUCENO, Dora M., GASPAR-SÁNCHEZ, Noé and TORRES-TOVAR, Rigoberto, with ascription in the Universidad Autónoma Del Estado de México, as a second article we present, *Determination of the KG-CO_2 / M^2 of a hydraulic concrete pavement*, by ACEVES-GUTIERREZ, Humberto, LOPEZ-CHAVEZ, Oscar, MERCADO-IBARRA, Santa and GALINDO-CEJUDO, Ignacio, with ascription in the Instituto Tecnológico de Sonora, as third article we present, *Effect of light periods and substrates in the seed germination of capiron (Calycophyllum Spruceanum) in the Colombian Amazon*, by BANDO-ROJAS, Miller & GELPUD-CHAVEZ, Cristian David, with secondment in the Instituto Tecnológico del Putumayo, as fourth article we present, *Implementation of the use of condensed water from air conditioners in the development of chemistry laboratory practices at the Instituto Tecnologico de Cancún as an alternative in the distilled water*, by TORRES-RIVERO, Ligia Adelayda, UGARTE-OLLARVES, Yohana Desiree, HERNADEZ-CHAVEZ, Silvero and BEN-YOUSEFF, Brants Cherif, with ascription in the the Instituto Tecnologico de Cancún.

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Measurement of polluting emissions of vehicles with gasoline engines, using static test

Medición de emisiones contaminantes de vehículos con motor a gasolina, empleando prueba estática

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Abstract

The pollutant emissions of vehicles with gasoline engine are analyzed, carrying out a verification of polluting emissions with static test, which allows knowing the chemical composition of five combustion gases coming from the exhaust of cars: CO, CO, NOx and unburned hydrocarbons (HC) as well as excess oxygen (O2). Random tests of emissions of polluting gases of private vehicles will be carried out, taking as sample the vehicles that move to the facilities of the UAEM Nezahualcóyotl University Center. The results will be analyzed based on the criteria established in the pollutant emission standards established for the circulation of light automotive vehicles (NOM-041-SEMARNAT-2015, NOM 042-SEMARNAT-2003 and NOM-EM-167- SEMARNAT-2016). As a result of the investigation, the polluting emissions from car exhaust were measured, the relationship between the type of pollutant found, the possible causes or failures in the emission control systems of gasoline vehicles was established. The preventive maintenance strategies.

Measurement, Emissions, Gasoline Engine, Gasoline

Resumen

Se analizan las emisiones contaminantes de vehículos con motor a gasolina, realizando una verificación de emisiones contaminantes con prueba estática, lo que permite conocer la composición química de cinco gases de combustión provenientes del escape de los automóviles: CO, CO, NOx e hidrocarburos no quemados (HC) así como el oxígeno (O_2) excedente. Se realizarán pruebas aleatorias de emisiones de gases contaminantes de los vehículos particulares, tomando como muestra a los vehículos que se trasladan a las instalaciones del Centro Universitario UAEM Nezahualcóyotl. Los resultados se analizarán con base a los criterios establecidos en las normas de emisiones contaminantes establecidas para la circulación de vehículos automotores ligeros (NOM-041-SEMARNAT-2015, NOM 042-SEMARNAT-2003 y la NOM-EM-167- SEMARNAT-2016). Como resultado de la investigación, se midieron las emisiones contaminantes provenientes de los escapes de los automóviles, se establece la relación entre el tipo de contaminante encontrado las posibles causas o fallas en los sistemas de control de emisiones de los vehículos a gasolina lo que permitió establecerán las estrategias de mantenimiento preventivo.

Medición, Emisiones, Motor a Gasolina, Gasolina

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Introduction to sources of environmental pollution

Environmental pollution is part of modern life, is intrinsically linked to the development of large cities, as a result of the production of goods, the excessive use of energy for our economic activities; of housing, to transport and recreate us. The main cause of all air pollution is the combustion of all types of fuels. Since 1700 fossil fuels such as coal, oil and natural gas have been used to boost industrial development and the comforts of modern life, but it has been impossible to avoid undesirable side effects. Smog, acid rain, global warming and climate change (Donahue, 2018) are due to the polluting emissions produced during the combustion of fossil fuels (Cengel & Boles, 2012), as well as the process of economic activities that the man performs for his lift.

In the present work, the pollutant emission standards for light automotive vehicles are analyzed, emission control strategies for the transport sector and air quality monitoring are considered. Finally, the physical characteristics of the M-P Gas equipment are presented, with which polluting emission tests are carried out in mobile sources, in order to verify that they comply with the different regulations of polluting emissions from a technical point of view.

Nature of air pollution problems

There is a finite amount of natural resources on the planet, air, land and water resources and, as the population increases the portion available for each person decreases. From the formation of the world until 1900, the world population reached 1,700 million. For 1974, the world population was 3,900 million (Warner, 2010) and it is currently estimated that the world population in the order of 7,432 million (DESA, 2015).

The increase of the global population of the last decades, with an increase of the demand of energy and its availability associated with a high level of life to satisfy the energy requirements of the citizens of modern life, could result in non-contracted emissions of environmental pollutants, in catastrophic proportions.

The rational control of air pollution is based on four basic assumptions (Warner, 2010) which are: the air is public domain, air pollution is an inevitable concomitant of modern life, scientific knowledge can be applied to demarcate public standards and methods to reduce air pollution should not increase such pollution in other sectors of the environment.

General classification of air pollutants

To classify air pollutants, it is necessary to define the term air pollution. "Air pollution can be defined as the presence in the outdoor atmosphere of one or more pollutants or their combinations, in such quantities and with such duration that they are or may affect human life, animals, plants, or property, that interferes with the enjoyment of life, property or the exercise of activities " (Warner, 2010)

One way to define air pollution is to define the chemical composition of dry, "clean", or "normal" air and then classify all other materials or the increased amounts of such materials present in the atmospheric air composition. (Finlayson-Pitts & Pitts, 2000). In table 1 the chemical composition of dry atmospheric air is shown.

Substance	Volume (percent)	Concentration (ppm) [a]
Nitrogen	78.084 ± 0.004	780,900
Oxygen	20.946 ± 0.002	209,400
Argon	0.934 ± 0.001	9,300
Carbon dioxide	0.033 ± 0.001	315
Neon		18
Helium		5.2
Methane		1.2
Krypton		0.5
Hydrogen		0.5
Xenon		0.08
Nitrogen dioxide		0.02
Ozone		0.01 – 0.04

* Ppm= Parts per million

Table 1 Chemical composition of dry atmospheric air
Source: (Warner, 2010)

Table 2 presents a general classification of the types of pollutants to the atmosphere.

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1.- Particulate Matter.	5.- Carbon monoxide.
2.- Sulfur-containing compounds.	6.- Halogenated compounds.
3.- Organic compounds.	7.- Radioactive compounds.
4.- Compounds that contain Nitrogen	

Table 2 Classification of pollutants in the atmosphere
Source: (Warner, 2010)

Table 3 shows the primary and secondary pollutants of gaseous pollutants in the air (Warner, 2010).

Class	Primary Pollutants	Secondary contaminants
Sulfur-containing compound	SO_2, H_2S	SO_3,H_2SO_4,MSO_4[a]
Organic compounds	Compuestos de C_1 - C_5	Cetonas, Aldehídos, Ácidos
Compounds that contain Nitrogen	NO, NH_3	NO_2 MNO_3[a]
Carbon Oxides	CO, (CO_2)	(ninguno)
Halogen	HCI, HF	(ninguno)

[a] MSO4 and MNO3 denote sulfate and nitrate compounds, respectively

Table 3 General classification of gaseous air pollutants
Source: (Warner, 2010)

Effects of the particular in the air on human health

The particles alone or in combination with other pollutants represent a very serious health hazard, contaminants enter mainly the human body through the respiratory tract, since it has been determined that more than 50% of the particular between 0.01 and 0.1 μg penetrating in the pulmonary cavity are deposited there (Warner, 2010).

Particles with toxic effect of one or more of the following three ways (Warner, 2010):

1. The particle can be intrinsically toxic due to its inherent chemical and / or physical characteristics.
2. The particle may interfere with one or more of the mechanisms that usually clear the respiratory system.
3. The particle can act as a conductor to a toxic substance absorbed.

The smog is formed mainly of ozone (O_3), which is located at ground level, likewise contains several chemical substances such as carbon monoxide (CO), particles of matter such as soot and dust and volatile organic compounds (VOC) such as benzene, butane and other hydrocarbons. The harmful ozone located at ground level should not be confused with the high ozone layer useful in the stratosphere, and that protects the Earth from the harmful ultraviolet rays of the Sun. Ozone located at ground level is a pollutant with several adverse health effects (Cengel & Boles, 2012)

The main source of nitrogen oxide (NOx) and hydrocarbons are automobile engines that on hot days react in the presence of sunlight to form ozone at ground level.

Ozone (O_3), a contaminant that mixes with carbon dioxide (CO_2), causes human body weakening, irritating the eyes and damaging the alveoli of the lungs, while carbon dioxide causes that the soft, spongy tissue of the lungs hardens, causing respiratory failure such as asthma (Cengel & Boles, 2012). Any exposure to ozone damages the lungs little by little just like the cigarette when breathing it, avoiding getting out of the home can considerably reduce the damage to the respiratory system.

Carbon monoxide (CO) is considered a poisonous gas without odor or color produced mainly by the engines of vehicles and that accumulates in large amounts in areas of traffic congestion, which prevents the body's organs from being oxygenated enough to bind to oxygen-bearing red blood cells. In low concentrations carbon monoxide decreases the amount of oxygen supplied to the brain, other organs and muscles of the body, deteriorates the reactions and reflexes of the body, for such reasons is considered a threat would be for the vulnerable population and in high conditions the CO it can be fatal (Cengel & Boles, 2012).

Contribution of the transport sector to environmental pollution

Worldwide the transport sector, which includes the movement of people and goods by cars, trucks, trains, boats, aircraft and other vehicles. The majority of greenhouse gas emissions from transport are CO2 emissions resulting from the combustion of petroleum products, such as gasoline, in internal combustion engines.

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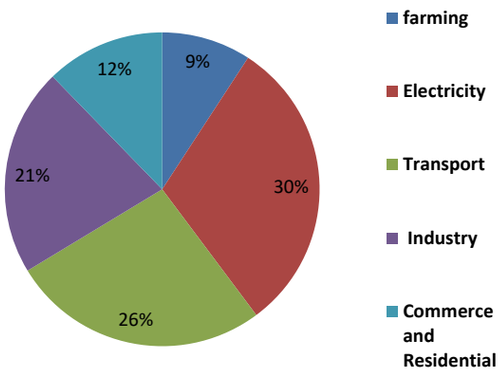
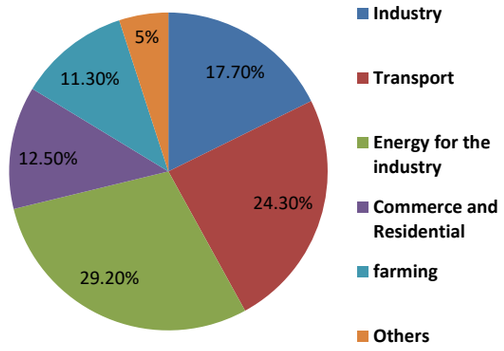
The largest sources of greenhouse gas emissions related to transport are caused by passenger and light truck vehicles, sport utility vehicles, trucks, and minivans, which account for more than half of the sector's emissions. The rest of the greenhouse gas emissions come from other modes of transport, including cargo trucks, commercial aircraft, ships, ships and trains, as well as pipes and lubricants (EPA, 2016).

In 2014, greenhouse gas emissions from transport represented around 26% of total emissions in the United States (EPA, 2016), and 24.3% for the European Union (European Commission, 2015). As far as the transport sector is concerned, it is the second largest contributor of greenhouse gas emissions in the United States and the European Union after the electrical and industrial sector, as can be seen in the graphs in figure 1.



a) CO2 emissions from the United States Total Emissions in 2014 = 6.870 million metric tons of CO2 equivalent



b) Polluting Emissions of the European Union by economic sector

Figure 1 Polluting emissions by sector a) United States b) European Union
Source: Own Elaboration with information (EPA, 2016)

In the case of Mexico, it is estimated that the transport sector is one of the main emitters of pollutants nationwide, being responsible for 90.03% of carbon monoxide (CO) emissions and 45.67% of nitrogen oxides (NOx), in all the country. Within the transport sector, passenger vehicles - known as light vehicles - emit 74.41% of CO, 52.55% of NOx, 73.55% of Volatile Organic Compounds (VOC) and 94.50% of ammonia (NH_3). These pollutants contribute to the formation of ozone in the atmosphere (Navarro, 2014; Schauer, et. al. 2002).

Emission control strategies of the transport sector

The emission control strategies to the atmosphere aim at the elimination, or the reduction to acceptable levels, of those agents (gases, particles in suspension, physical elements and to a certain extent biological agents) whose presence in the atmosphere can cause adverse effects in the people's health (irritation, increased incidence or prevalence of respiratory diseases, morbidity, cancer, excess mortality) or in their well-being (sensory effects, interference with visibility), detrimental effects on the life of plants and animals, damage to materials of economic value to society and damage to the environment (for example climatic modifications).

The serious risks associated with radioactive contaminants, as well as the special procedures for their control and evacuation, require that the greatest attention be paid to them (Maystre, 2010)

For more information on the emission reduction strategies generated by transport, consult the National Institute of Ecology (INE, 203).

Monitoring of air quality

A control system for air pollution is to ensure that excessive concentrations of air pollutants do not reach sensitive receptors (people, plants, animals, etc.). A well-designed system will prevent the exposure of a receiver to a harmful concentration of pollutants.

We can see that air pollution control systems combine different control techniques, usually both technological and administrative.

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The selection of atmospheric pollution controls must be made according to the problem that must be solved and taking recommendations established by Maystre (2010).

EPA Standards

The Environmental Protection Agency (in English: Environmental Protection Agency, better known by the acronym EPA) is an agency of the federal government of the United States responsible for protecting human health and protecting the environment: air, water and soil.
The act to safeguard clean air of 1990, authorized the EPA to establish the standard NAAQS, for its acronym in English: National Ambient Air Quality Standards, for contaminants considered harmful to the health of vulnerable social sectors (Kuts, 2008), primary limits seek the health of the sensitive population, such as asthmatics, children and elderly and the secondary standard limits seek to reduce the impact on visivilidad, damage to animals, crops, vegetation and buildings, these limits can be seen in table 4 (Kuts, 2008).

Pollutant	Primary limits	Exhibithion time	Secondary limits
CO	9 ppm (10 μg/m^3)	8 hours	-
	35 ppm (40 μg/m^3)	1 hora	-
Lead	1.5 μg/m^3	Quarterly average	Same as primary
NOx	0.053 ppm (100 μg/m^3)	Anual average	Same as primary
PM_{10}	150 μg/m^3	24 hours	Same as primary
$PM_{2.5}$	35 μg/m^3	24 hours	Same as primary
O_3	0.08 ppm 0.12 μg/m^3	8 hours 1 hour (Applicable to area limits)	-
SO_X	0.03 ppm 0.14 ppm	Anual average 3 hours	0.5 ppm 1,300 μg/m^3

Table 4 National Standards for Ambient Air Quality (USA)
Source: (Kuts, 2008)

Criteria for polluting emissions established in the NOM -ER- 167-SEMARNAT 2017

The emerging standard NOM-ER -167 SEMARNAT 2017, establishes the emission limits of pollutants for motor vehicles that circulate in Mexico City, Hidalgo, State of Mexico, Morelos, Puebla and Tlaxcala.

The main modification with respect to its predecessor regulations is that it establishes as a test method the OBD OBD and OBD II On-Board Diagnostic system, which expresses the level of pollutant emissions of the vehicles according to the distance covered, ie in (gr / km), of the following gases: CO, HC, NOx. Therefore, there is no comparison with the static test that was carried out in the present investigation, but it establishes the following levels of polluting emissions for 2005 and previous vehicles.

Weight	HC	CO	NOx	02
W>400 Kg W< 3857 Kg Year: 1993 and previous	350	2.5%	2000	2%
W>400 Kg W< 3857 Kg Year: 1994-2005	100	0.7%	700	2%
W> 3857 Kg Year: 1993 and previous	400	3.0%	-	2%
W> 3857 Kg Year: 1994-2005	100	0.5%	.	2%

Table 5 Limits of polluting emissions for gasoline vehicles 2005 and earlier
Source: Own Elaboration with information from the NOM- EM- 167 SEMARNAT 2017

Official Mexican Standards regarding polluting emissions from related mobile sources

The official Mexican standards in environmental matters and regarding emissions from mobile sources, for automotive particles are shown in table 6.

Emissions from Mobile Sources	
NOM-041-SEMARNAT-2011	It establishes the maximum permissible limits of emissions of polluting gases coming from the exhaust of the automotive vehicles in circulation that use gasoline as fuel
NOM-042-SEMARNAT-2003	It establishes the maximum permissible limits of emissions of total or non-methane hydrocarbons, carbon monoxide, nitrogen oxide and particles from the exhaust of new motor vehicles whose gross vehicle weight does not exceed 3,857 kilograms, which use gasoline, liquefied petroleum gas, natural gas and diesel, as well as evaporative hydrocarbon emissions from the fuel system of such vehicles.

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NOM-044-SEMARNAT-2006	It establishes the maximum permissible limits of emissions of total hydrocarbons, non-methane hydrocarbons, carbon monoxide, nitrogen oxide, particles and smoke opacity that will be used for the propulsion of new motor vehicles with gross vehicle weight greater than 3,857 kilograms, as well as for new units with gross vehicle weight greater than 3,857 kilograms equipped with this type of engines.
NOM-076-SEMARNAT-2012	It establishes the maximum permissible levels of unburned hydrocarbons, carbon monoxide and nitrogen oxide from the exhaust, as well as evaporative hydrocarbons from the fuel system, which use gasoline, liquefied petroleum gas, natural gas and other alternative fuels and that use for the propulsion of automotive vehicles, with gross vehicle weight greater than 3,857 kilograms new plant.
NOM-077-SEMARNAT-1995	Establishes the measurement procedure for the verification of emission levels of the opacity of the smoke coming from the exhaust of the automotive vehicles in circulation that uses diesel as a fuel

Table 6 Environmental standards of mobile sources
Source: Own Elaboration with information from SEMARNAT (2011,2003, 2006, 2012, 1995.)

Measurement of polluting emissions from mobile sources using the M-P Gas Analysis Module

The M-P gas analysis module is a portable gas analyzer manufactured by OTC, a member of the *Bosch Automotive Service Solutions group*. The MP gas analysis model is used to perform vehicle diagnostic tests and to measure the emission levels of gases found in the exhaust gases of all internal combustion engines (Yinhui, et al., 2016), except two-stroke and diesel engines (Xu, et al., 2018). The gas analyzer (OTC, 2006) measures the emission levels of carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons (HC), oxygen (O_2) and nitrogen oxides (NOx).

To use the gas analyzer with the gas software M - P it is necessary to use the Genesys NGIS automotive scanner, a sampling hose or probe assembly, and an exhaust pipe.

When the equipment is properly configured, the exhaust gases enter the gas analyzer through the probe and sampling hose assembly. The probe analyzes the composition of the gases and sends the data to the Genesys NGIS automotive scanner, which allows analyzing the data and controlling the functions of the M - P gas analyzer. The general arrangement of the Genesys NGIS automotive scanner and the M - P gas analyzer are shown in figure 2.

a)

b)

Figure 2 Pollutant gas measurement system a) Genesys NGIS Automotive Scanner b) M-P Gas Analysis Module
Source: Own Elaboration

Gas analysis software configuration.

With the help of the Genesys NGIS automotive scanner, you can configure the M - P gas analyzer software, pre - installed in the scanner memory. Where different settings are configured between them:

a) Limits of polluting emissions

The adjustment of the gas emission limits allows you to introduce maximum limits for HC, CO, O_2 and NOx and a minimum limit for CO2. Then, when the live gas display screen is used, the gas emission levels above the maximum limits (or less than the minimum limit for C02) appear in red color. The main menu for setting the maximum emission limits is shown in Figure 3.

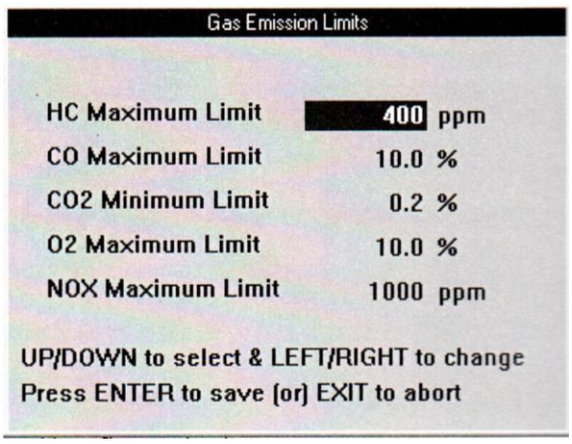

Figure 3 Setting the limit of polluting emissions
Source: (OTC, 2006)

b) Vehicle specifications

The Vehicle Specific setting allows you to select the type of gas for the tests, including: natural gas, Propane, Methane, and variable fuel.

c) Configuration of 4 or 5 gas

The adjustment of the gas configuration allows to select the gases to be included in the test. For the performance gas module, select whether to include three gases ($C0_2$, CO, and O_2), four gases (CO_2, CO, HC, and O_2), or the five gases ($C0_2$, CO, HC, O_2), and NOx).

d) Configuration AFR / Lambda

The AFR / Lambda installation program allows you to select the AFR (air-fuel) ratio or the lambda value on the live gas display screen.

Lambda is a measure used to determine if the air-fuel ratio is rich or poor. Lambda (λ) is a single point determined by dividing the fuel ratio (C) and actual air (A) supplied in the proportion of stoichiometric fuel is 14.1 air- per portion of fuel, this is (Cucchi & Hublin, 1991):

$$\lambda = \frac{Actual\ {}^{C}/_{A}}{Real\ {}^{C}/_{A}} \quad (1)$$

So in an ideal combustion λ = 1. An acceptable lambda range is between 0.9 to 1.1. A lambda less than 0.9 indicates a rich fuel air mixture and a Lambda greater than 1.1 indicates a poor fuel condition (Liu, et al., 2019). The effect of the factor λ, on the emissions of O_2, CO_2, CO, HC and NOX, is shown in figure 4.

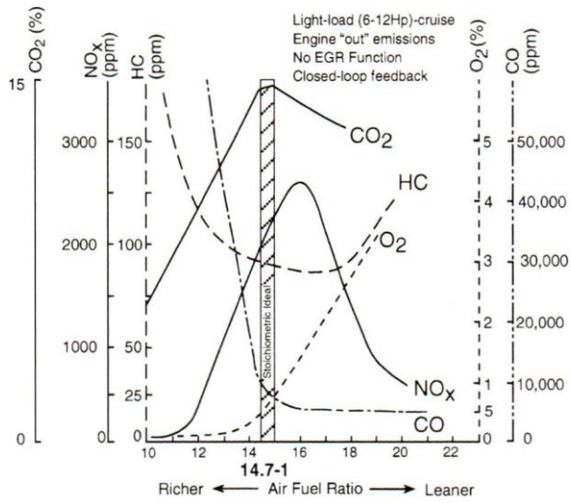

Figure 4 Stoichiometric ratio of combustible air
Source: (OTC, 2006)

With the aid of figure 6, it is expected that the polluting emissions from the exhaust of automotive vehicles, should be maintained around 0.2-1.5% in volume for O_2, below 14% volumetric for CO_2, between the 0.2 -1.5% volumetric as acceptable range for CO, unburned hydrocarbons should remain below 90 ppm and NOx should be around 2000 ppm.

Preparation and calibration of equipment

The gas measurement equipment M-P software works in conjunction with an automotive scanner, which is shown in Figure 5, the gas analyzer M-P is attached to the automotive scanner from the rear as shown in Figure 5.

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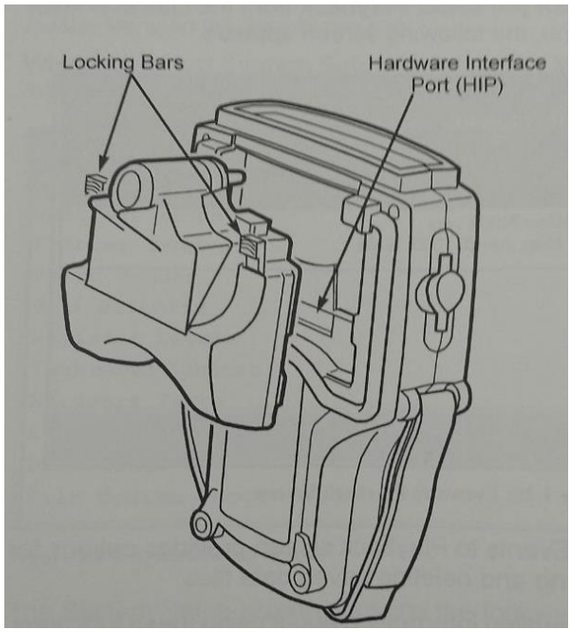

Figure 5 Connection of the M-P gas analyzer module to the Genesys automotive scanner *Source: (OTC, 2006)*

After coupling the MP gas module, the connection to the electrical energy is made by means of the charger included in the genesis automotive scanner and the gas analyzer probe is connected by means of the rubber hose as shown in the diagram of the figure 6.

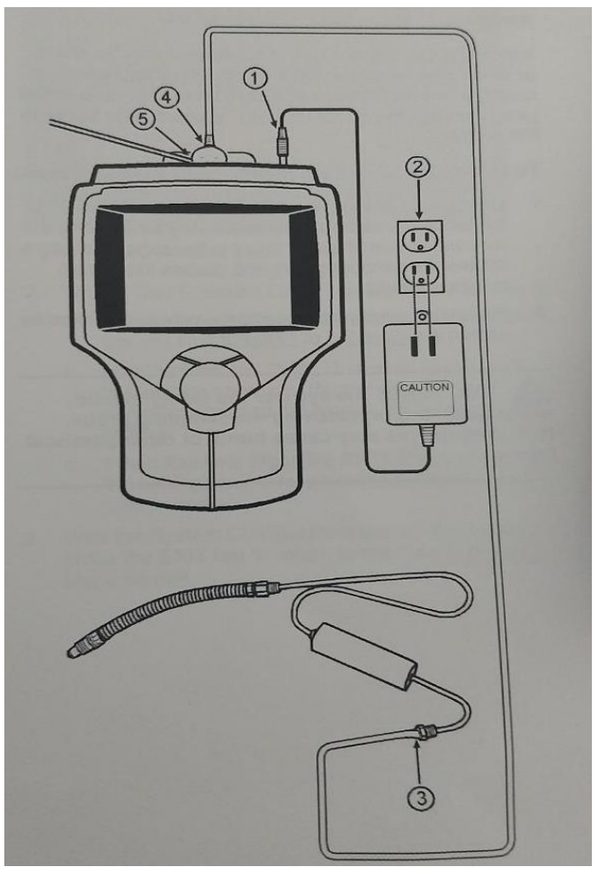

Figure 6 Connection diagram of the gas measurement probe
Source: (OTC, 2006)

After having all the equipment connected, it is necessary to select the following path in the Automotive scanner interface:

Diagnostic Tools → Gas M-P → Live gas screen → Enter

After selecting these options, a zeroing of the gas analyzer module is performed, which consists of purging the entire system to perform a correct measurement, the scanner cover, when performing this process is shown in figure 7.

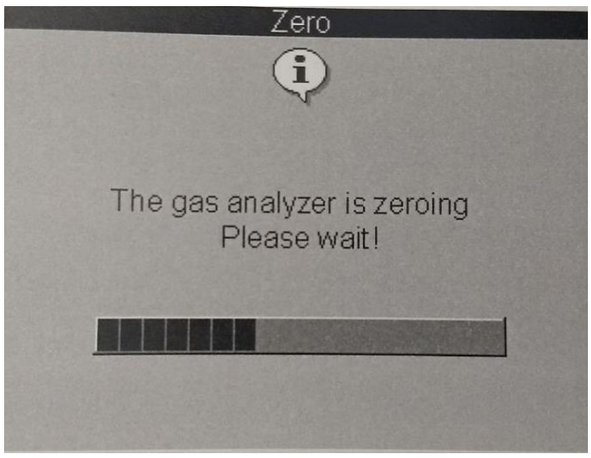

Figure 7 Automotive Scanner screen, when the gas analyzer is calibrated
Source: (OTC, 2006)

After zeroing the analyzer will allow the measurements of the exhaust gases to be made by presenting the emissions information screen shown in figure 8.

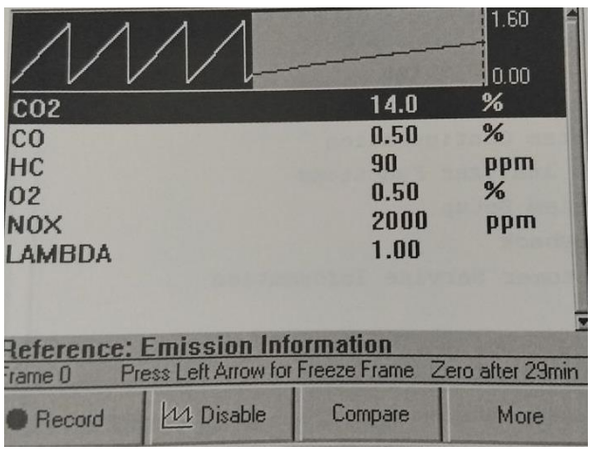

Figure 8 Emissions information screen
Source: (OTC, 2006)

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Criterion of acceptance or rejection of the vehicular verification

The criteria used for the acceptance or rejection of the vehicle verification are shown in table 7.0, under the recommendations of the manufacturer of the measuring equipment (OTC, 2006) and under the recommendations of the NOM- ER-167 SEMARNAT.

Criteria of the manufacturer (OTC, 2006)			
Gas	Accepted	Rejection	Probable causes
CO_2	CO2≥ 14%.	CO2<14%	Catalytic catalyst failure.
CO	0-14%.	CO> 14%.	Catalytic catalyst failure.
HC	HC≤ 90 ppm.	HC> 90 ppm.	Problems in vehicle combustion systems.
O_2	O_2≤ 14%	O_2> 14%	Problems in vehicle combustion systems.
NO_X	NOx≤ 2000 ppm.	Nox> 2000 ppm.	Catalytic converter failure.
Factor lamda	0.9-1.1.	Superior a 1.1 y menor de 0.8.	Lambda probe failure of the vehicle.
Criterion of the NOM ER- 167 SEMARNAT			
HC	HC≤ 100 ppm	HC> 100 ppm	-
CO	CO≤0.5%	CO> 0.5%	-
NOx	Nox≤ 700 ppm	Nox > 700 ppm	-
O_2	O_2≤ 2%	O_2>2 %	

Table 7 Criteria for acceptance or rejection of polluting emissions from gasoline vehicle
Source: Own Elaboration with information from (OTC, 2006); (NOM- EM- 167 SEMARNAT)

Results

The measurement of polluting emissions in the vehicle park of the UAEM Nezahualcóyotl University Center was carried out randomly, the polluting emissions of the verified vehicles are shown in table 8.0, it should be noted that all the vehicles at the time of the tests have a hologram of current verification, which allows them to circulate in the Megalopolis of Mexico City.

No	Model	Odometer	Cylinders	Volume
1	2002	202,469	4	1.6
2	2007	99,459	4	2.0
3	2007	131,842	4	2.0
4	2007	131,743	4	2.0
5	2013	131,262	4	2.4
6	2014	49,733	4	2.4
7	2015	44,077	4	2.5
8	2016	48,718	5	2.5
9	2017	14,982	5	2.5

Table 8 randomly analyzed vehicles
Source: Own Elaboration

Four types of tests were performed on each of the vehicles in Table 8, the first test is cold at idle when the vehicle starts with a low temperature, the second is at 1000 rpm, the third at 2000 rpm and the fourth at 4000 rpm, these last three readings at optimum engine working temperature. The results of the measurements obtained in each of the tests are shown in tables 9, 10, 11 and 12 respectively.

CO_2	CO	HC	O_2%	NO_X
10.37	0.15	358.00	11.75	48.00
14.74	0.05	63.00	19.05	2.00
14.9	0.00	15.00	10.5	0.00
14.68	0.00	5.00	11.83	96.00
14.8	0.00	5.00	6.54	2.00
14.56	0.01	11.00	4.37	2.00
15.5	0.01	10.00	22.95	2.00
15.11	0.00	5.00	0.37	0.00
15.06	0.00	15.00	2.5	3.00

Table 9 Results of polluting emissions in idle
Source: Own Elaboration

Test at 1000 rpm				
CO_2	CO	HC	O_2%	NO_X
12.77	0.33	268.00	12.65	130.00
15.16	0.02	53.00	18.5	178.00
14.89	0.03	31.00	5.49	0.00
13.49	0.06	12.00	1.64	24.00
14.86	0.3	30.00	6.57	41.00
14.52	0.11	14.00	8.28	0.00
15.27	0.13	38.00	21.55	0.00
14.67	0.00	3.00	0.26	0.00
15.02	0.00	15.00	1.45	7.00

Table 10 Results of polluting emissions at 1000 rpm
Source: Own Elaboration

CO_2	CO	HC	O_2%	NO_X
12.95	0.39	241.00	10.87	81.00
14.77	0.01	34.00	16.18	304.00
14.09	0.03	31.00	5.49	0.00
14.7	0.01	8.00	0.59	87.00
14.68	0.06	29.00	5.8	30.00
14.6	0.01	15.00	4.2	0.00
15.34	0.08	53.00	21.78	0.00
14.99	0.00	2.00	0.11	0.00
15.19	0.00	21.00	1.12	15.00

Table 11 Results of polluting emissions at 2000 rpm
Source: Own Elaboration

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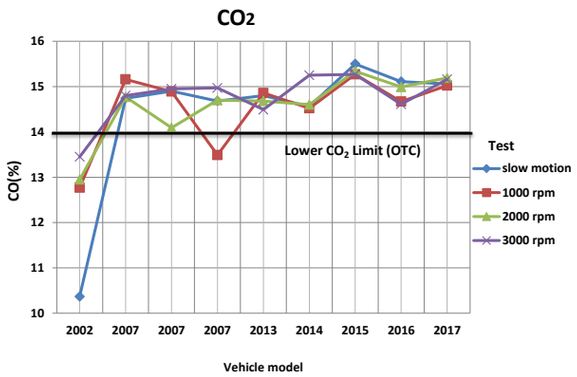
CO_2	CO	HC	O_2%	NOx
13.45	1.07	129.00	8.83	339.00
14.8	0.42	31.00	15.16	872.00
14.95	0.01	25.00	4.56	1.00
14.97	0.00	6.00	0.36	27.00
14.49	0.09	23.00	5.14	197.00
15.25	0.27	12.00	5.76	9.00
15.27	0.13	38.00	21.55	0.00
14.61	0.00	1.00	0.03	0.00
15.16	0.01	28.00	0.92	4.00

Table 12 Results of polluting emissions at 3000 rpm
Source: Own Elaboration

When performing the analysis of the emissions in each of the models of the verified vehicles, the following graphs were obtained that are presented below.

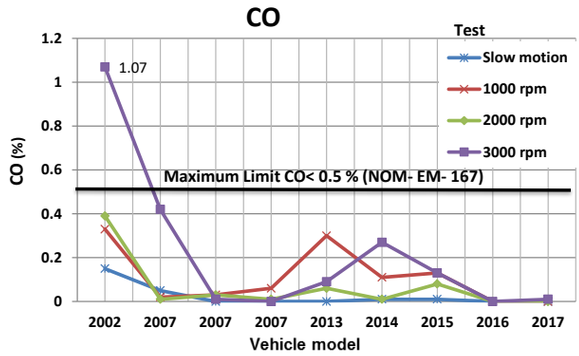
In graph 1, CO_2 emissions are shown for the vehicles studied. It is appreciated that starting with the 2007 model, CO_2 emissions are in an acceptable range, according to the CO_2 acceptance criteria> 14%.



Graphic 1.0 CO_2 emissions of the vehicles analyzed at different operating conditions
Source: Own Elaboration

Figure 2 shows the CO emissions of the vehicles analyzed at different operating conditions. It is observed that the maximum CO emissions reading occurs in the 2002 model vehicle at 3000 rpm, which is 1.07%, which does not exceed the criteria established in NOM-EM-167 SEMARNAT 2017, of CO <0.5%.

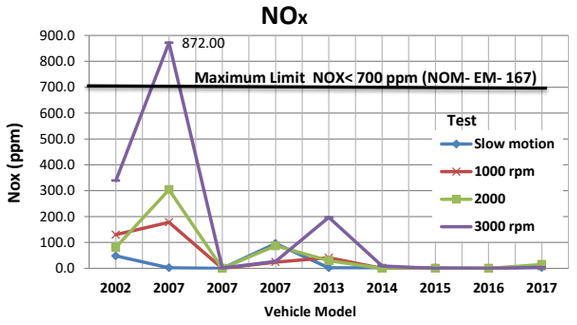
However, all other vehicles are within the range of acceptance of CO <14%. (OTC, 2006) And of the criteria CO <0.5%.



Graphic 2 CO emissions of the vehicles analyzed at different operating conditions
Source: Own Elaboration

Figure 3 shows the NOx emissions, at different operating regimes of the analyzed vehicles, it is observed that the maximum emission of NOx occurs in one of the 2007 vehicles at 3000 rpm, which is 872 ppm, which exceeds the NOx criteria <2000 ppm (OTC, 2006), but does not exceed the criterion of the NOM-EM- 167 SEMARNAT 2017, which is of NOx <700 ppm. On the other hand, all the readings obtained for the vehicles analyzed meet both established criteria.

It is also seen, in graph 3, that when increasing the operating regime of vehicles, NOx emissions tend to increase as shown in graph 3 for the operation at 3000 rpm.



Graphic 3 NOx emissions of the vehicles analyzed at different operating conditions
Source: Own Elaboration

The unburned hydrocarbon emissions of the vehicles analyzed are shown in graphic 4. It is appreciated that the maximum emission reading of unburned hydrocarbons was 358 ppm, from the model 2002 vehicle at 3000 rpm. It is appreciated that the vehicle, model 2002, does not surpass any of the HC emissions tests to which it was subjected and that the HC emissions of the rest of the vehicles studied are kept within the acceptance criterion that is HC <90 ppm.

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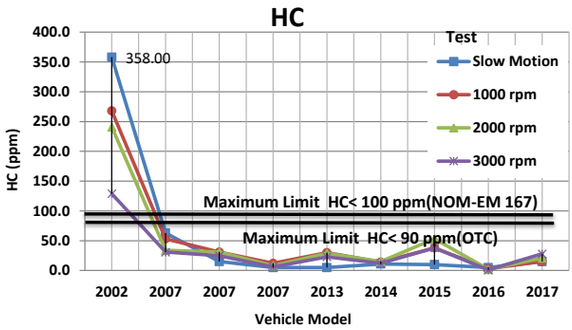
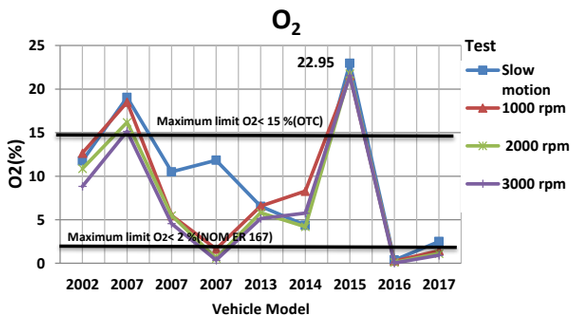


Graphic 4 HC emissions of the vehicles analyzed at different operating conditions
Source: Own Elaboration

Figure 5 shows the percentage of Oxygen present in the exhaust gases of the cars analyzed. It is appreciated that the maximum oxygen reading present in the exhaust gases of the analyzed vehicles is 22.95%, for the 2015 vehicle, in fact this vehicle together with the 2007 model does not exceed the acceptance criterion of O_2 present in the exhaust gases exhaust that is O_2 <14%.



Graphic 5 O2 emissions of the vehicles analyzed at different operating conditions
Source: Own Elaboration

Table 13 shows the number of tests accepted (A) or rejection (R) of the vehicles analyzed, taking into consideration the acceptance or rejection criteria of table 6. On the recommendation of the gas analyzer manufacturer. (OTC, 2006).

Model	CO2	CO	NOx	HC	O2
2002	3R	A	A	4R	4R
2007	A	A	A	A	4R
2007	A	A	A	A	A
2007	A	A	A	A	A
2013	A	A	A	A	A
2014	A	A	A	A	A
2015	A	A	A	A	4R
2016	A	A	A	A	A
2017	1R	A	A	A	A

Table 13 Acceptance or rejection of the vehicles analyzed
Source: Own Elaboration

Considering the stricter criteria established in NOM-ER-167 SEMARNAT 2017, concentrated in table 5, it is established that the strictest levels of polluting emissions considering: HC <100 ppm, CO <0.5%, NOx <700 ppm and O_2 <2%, table 14 shows the acceptance or rejection of the verification under these new parameters.

Model	CO	NOx	HC	O2
2002	1R	A	4R	4R
2007	A	1R	A	4R
2007	A	A	A	4R
2007	A	A	A	1R
2013	A	A	A	4R
2014	A	A	A	4R
2015	A	A	A	4R
2016	A	A	A	A
2017	A	A	A	1R

Table 14 Acceptance or rejection of the vehicles analyzed, under the criteria of the NOM ER-167 SEMARNAT
Source: Own Elaboration

Conclusions

The measurement of the polluting emissions of gasoline vehicles was carried out randomly from the vehicle fleet of the CU Nezahualcóyotl, the emission levels were evaluated under two recommendations, those of the OTC gas analyzer manufacturer, and those established in the NOM-EM- 167 SEMARNAT.

Considering the acceptance criterion of the gas analyzer manufacturer, it is concluded that four of the vehicles did not approve the vehicle verification, which were the 2002 models (it did not approve the emission of CO_2 in 3 tests and the four HC emission tests), a 2007 model (did not approve the O_2 level in the 4 tests), the 2015 model did not approve the O_2 level in the 4 tests) and the 2017 model (did not pass the CO2 emissions in the idle test).

On the other hand, considering the levels established in NOM-EM-167 SEMARNAT, it was found that all vehicles do not pass the oxygen test present in at least one of the tests to which they were subjected, except for the 2016 model unit, who passed all the vehicular verification tests to which he was subjected.

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Regarding the maximum polluting emissions found were: 1.07% CO of the vehicle 2002 in the test at 3000 rpm, 872 ppm NOx, for one of the 2007 vehicles in the 3000 rpm test, 358 ppm HC of the 2002 model vehicle in the test idle, and the presence of O_2, maximum in the exhaust gases of the vehicles analyzed was 22.95% of the vehicle 2015 for all tests to which it was subjected.

With the results obtained, it is concluded that the level of polluting emissions of the vehicles analyzed depends to a large extent on the maintenance program (tuning), the mechanical conditions of the engine, the combustion system and the exhaust system.

The fact that a vehicle approves the verification of polluting emissions establishes its physical fitness, however during the period exempted from verification (regularly six months) its mechanical physical conditions may deteriorate due to constant use and its level of polluting emissions can raise. To do this, you recommend the following actions:

1. Perform maintenance as indicated by the vehicle manufacturer.
2. Perform car cleaning and tuning system cleaning services, as established by the manufacturer's maintenance program.
3. Replace the catalytic converter, when the distributor considers it relevant in order to reduce the polluting emissions associated with its malfunction.
4. To reduce polluting emissions in the metropolitan area of Mexico City, the circulation of 2007 model vehicles is recommended, given that they present, overall, a lower level of polluting emissions than the previous models.

The expected results, from the obtained readings, it is concluded that:

The acceptable range of O_2 present in the combustion gases at the exhaust of automotive vehicles is $\leq 2\%$.

For the case of CO_2, present in the combustion gases at the exhaust outlet of automotive vehicles must be CO_2, $\leq 14\%$. The expected CO readings should be of $CO \leq 0.5\%$. The amount of HC, should not exceed 90 PPM.

Finally, the emissions of combustion NOx combustion must not exceed 700 PPM. The above recommendations taking the strictest criteria presented in the investigation.

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Determination of the KG-CO_2 / M^2 of a hydraulic concrete pavement

Determinación de los KG- CO_2/ M^2 de un pavimento de concreto hidráulico

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Abstract

One way to pollute today is through the construction of works, according to Anink, D., Boonstra, C., and Mak, (1996) the construction sector is responsible for 50% of the natural resources used, 40% of the energy consumed (including energy in use) and 50% of the total waste generated. Several studies related to GHG contamination that occur in the life cycles of construction materials have been carried out in relation to this sector, and research has also been carried out on the pollution in KG-CO_2 / M^2, per year produced by the social interest housing in its life cyclef. The objective of this work is to investigate the CO_2 / M^2 contamination of the construction of the hydraulic concrete pavement of a fractionation in Sonora using the "Emissions Inventory" method with standard CO_2 emission factors of each material, of the and volumes total works. The result obtained with the established criteria was that 84.77 kG-CO_2 / M^2 are produced in the construction, which allows us to contribute in an area of construction that is little explored in pollution through the construction of urban roads.

Efficiency, Energy, Housing, CO_2, Materials

Resumen

Una forma de contaminar hoy es a través de la Construcción de Obras, según Anink, D., Boonstra, C., y Mak, (1996) el sector de la Construcción es responsable del 50% de los recursos naturales empleados, del 40% de la energía consumida (incluyendo la energía en uso) y del 50% del total de los residuos generados. En relación con este sector se han realizado diversos estudios elacionados con la contaminación de GEI que se producen en los iclos de vida de los materiales de construcción y también se han hecho investigación de la contaminación en KG-CO_2/ M^2, por año que producen las viviendas de interés social en su ciclo de vida. El presente trabajo tiene como objetivo investigar la contaminación de CO_2/M^2 de construcción del pavimento de concreto hidráulico de un fraccionamiento en Sonora utilizando el método de "Inventario de emisiones" con factores de emisión estandar de CO_2 de cada material, de la y los volúmenes totales de obra. El resultado obtenido con los criterios establecidos fue que en la construcción se producen 84.77 kG-CO^2/M^2, lo que nos permite contribuir en un arae de la construcción poco explorada en la contaminación a través de la construcción de vialidades urbanas.

Eficiencia, Energía, Vivienda, CO_2, Materiales

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Introduction

The beings develop their life in a physical space surrounded by other organisms and the physical and socioeconomic environment. Biotic and abiotic factors interact with each other generating a place of their own and said space is called the environment (Marino, 2009). Until not very recently, the capacity of the human being to alter the environment was limited and punctual, however in the last hundred years its capacity to alter the environment has increased significantly, reaching to endanger the entire planet (CIDEAD, 2009).

The environment has endured to a certain extent the activities of the human being with a degree of suitability, producing desired goods and products, causing emissions or discharges through air, water and land. (Encinas, 2011). Atmospheric emissions, discharges or non-visible waste, generated by industries are undoubtedly the most damaging of waste produced by human activities. Its invisibility, together with the spatial and / or temporal distances to which its worst effects can be manifested, leads to a contempt that is absolutely inadmissible when viewed from the perspective of the requirements of sustainability (Ortiz y Del Cerro, 2007).

These emissions have caused what in recent decades has been mentioned, the so-called climate change where according to (IPCC, 2014) climate change is the variation of the state of the climate, identifiable (through statistical tests) in the variations of the mean value or in the variability of its properties, which persists for long periods of time, usually decades or longer periods.

In 1988, the Intergovernmental Panel on Climate Change, known by the IPCC acronym in English, was established by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP). purpose of monitoring this problem by analyzing the available scientific information (Berzosa, 2013). One of the objectives of the IPCC is to assess whether this climate change is caused by anthropogenic origin or natural, where the natural are the waste or emissions derived from both organic and inorganic materials and anthropogenic are all those activities that generate emissions produced by the man.

These gas emissions are called Greenhouse Gases (GHGs), where according to (Benavides and León, 2007) are the gaseous components in the atmosphere, both natural and anthropogenic, that absorb and emit radiation at certain wavelengths of the spectrum infrared radiation emitted by the surface of the earth, atmosphere and clouds.

The evolution of the opinion of the scientific community has gone from not being able to attribute to man any effect on the climate (IPCC, 1990) until signing that, with a greater than 90% probability, global warming is caused largely by anthropogenic emissions of greenhouse gases (GEI) (IPCC, 2014).

CO_2 is the Greenhouse Gas that has the greatest impact on the environment and one of the main causes of climate change.

Probably the intensification of the greenhouse effect, because of CO2 emissions is the greatest impact of human activities on a planetary level. It is expected that by 2100, perhaps by 2020, atmospheric CO2 will have doubled compared to the one before the industrial era.

At the current growth rate, the duplication will occur in 2,056, when 560 ppm is reached, which leads to predictions of an increase in the average temperature of the planet between 2.3 and 5.2 ° C depending on the model of general circulation used (Ortiz y Del Cerro, 2007).

The environmental impact produced by the Construction industry in the light of the Industrial Revolution is the outstanding debt that industrialized societies have to face in view of this new millennium; The truth is that the industrial revolution is a great change in the techniques used in the production of building materials, given that until then, the materials were natural, typical of the biosphere, from the immediate environment, simple manufacturing and adapted to the climatic conditions of the territory where the building was carried out (Arenas, 2008).

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The expansion of the cities and the materials with which they are built is causing a great contamination and for this the construction industry enters as one of the industries highly generating emissions and waste by the materials used that come from the earth's crust, producing 450 million tons of construction and demolition waste annually, currently the possibility of reusing and recycling this waste is very limited since only 28% is used, increasing the need to create landfills and intensify the extraction of raw materials. Construction is responsible for 50% of the natural resources used, 40% of the energy consumed and 50% of the waste generated (Symonds, Argus, Cowi and Bouwcentrum, 1999).

Research has been conducted where according to (Berzosa, 2013) in the research "Analysis of greenhouse effect emissions throughout the life cycle of the roads" where the problem of greenhouse gas emissions in the sector of greenhouse gases was analyzed the construction of Spain and, as a result, the contaminating elements or actors are the construction machinery, which is the main element (61.5 - 84.9%) followed by those emissions related to the consumption of materials (9, 5 - 32.9%).

The emissions related to the management of the natural systems constitute an appreciable percentage (3.5 - 7.1%). The transport is of little relevance in relation to the rest of the elements (0.4 - 2.2% of the total of the construction phase).

There was also an investigation where according to (Casanovas, 2009) "Sustainable construction. A strategic view "says that to be able to extrapolate the environmental impact information, from architectural projects to construction in general, it is necessary to have a series of projects that are sufficiently representative of the construction in a certain territorial area, and that be generic and be for building typologies, it suggests that the expression per square meter constructed is used, as it simplifies and makes the obtained results more easily visible and interpretable.

In the investigation "Model of quantification of CO_2 emissions produced in buildings derived from the material resources consumed in their execution" according to (Mercader, 2012) the CO_2 emissions produced in the execution of the usual building model defined as the residential block were evaluated destined to housing of official protection, derived from the manufacturing process of the material resources used in its execution.

In view of the impacts derived from climate change, the need to take measures with the aim of mitigating the possible negative effects derived (Ihobe, 2013).

The basis on which the efforts to reduce emissions must be defined, is to know the contribution of each agent in relation to greenhouse gas emissions (GHG) in order to establish the starting situation and set the objectives of reduction and evaluate the degree of success of the strategies implemented. All this involves quantifying GHG emissions and assigning emission values to the activities evaluated (Ihobe, 2013).

Currently, there are several methods to determine greenhouse gas emissions that are generated directly or indirectly from certain activities, one of the most important and widely used is that of the construction industry, with an emissions inventory, this method helps to know the amounts of CO_2 generated by the construction of a project, taking into account the emissions of the materials used, the burning of fossil fuels of the machinery used, among other factors that intervene in the work activities.

These emissions are determined with the help of standard emission factors of each material and machinery used in the work, these factors can be found in graphs or tables on the internet or and come from various sources, or from different databases made by institutions, public bodies and private ones responsible for creating the same factors.

There are other methods, one of them is the carbon footprint where it is evaluated with an approach that includes a greater scope in relation to the emission sources associated with the organization (since it analyzes the emissions from the perspective of the life cycle analysis of the evaluated concept) (Ihobe, 2013).

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The main characteristic with the emission inventory method is that you can determine the emissions generated by each activity carried out, concept of work, stages of the construction process, among others, in this way you get more specific information**.** In the present investigation refers to the CO_2 generated by a stage in the construction of roads (streets) in a subdivision of Ciudad Obregon Sonora, Mexico, this to determine the quantification in Kg-CO_2 / M2 generated by the construction process. To analyze this problem it was necessary to mention that civil engineering has been developing new and more efficient methods for urbanization, due to the economic growth of the countries, the high demand for increasingly challenging construction for civil engineering but taking care benefit the environment; However, in recent decades the construction industry has increased the impact it has on the environment, this by the emission of greenhouse gases that are generated in the process of construction materials, in the construction process of the work.

These gases have contributed to climate change and all that it entails (droughts, torrential storms, variations in temperature). CO_2 in 2010 represented 76% of the total of Greenhouse Gases anthropogenic, this being the one that has the greatest impact on the environment (IPCC, 2014), which is why it is necessary to obtain quantitative information on the CO_2 generated by the construction to know the impact that the buildings are having on the environment, and thus work so that the activities on site, the materials process go hand in hand towards the same objective, and also, generate information that can help future investigations. The hypothesis is that the emission of Kg-CO_2 / M^2 for the construction of roadsides (streets) is 100 $KgCO_2$ / M^2, with a variation of + / _ 10%.

Methodology

The present investigation is considered quantitative, since the collection and analysis of data is used to answer research questions and test previously established hypotheses, it is exploratory since there are no previous works in this area of construction, it is non-experimental and cross; the first because no situation is built but existing situations are observed, not intentionally provoked by the researcher (Hernández, 2003) and transversal, because the variables are described and their incidence and interrelation analyzed.

To carry out this project was attended by a student and professors researchers of Civil Engineering of the Technological Institute of Sonora, making the relevant calculations to obtain results, materials and equipment used, the Opus Software for obtaining of the quantities of work with which they worked on this project and the excel electronic sheet, for the calculation of the CO_2 generated by the construction, interpretation of results.

The sources of information were previous works related to the project, such as theses, articles, scientific journals, electronic bibliography in general and the HueCO_2 database to obtain emission factors. It was also necessary to make a preliminary compilation of information, which determined the emission factors to be used for the calculation of the inventory. Dell OPUS program, the concepts and quantities of work, units, materials, machinery and equipment used in the work were obtained, an east calculation was determined with the HueCO_2 database, the results of CO_2 generated by each of the concepts were obtained of work and were parameterized in Kg-CO_2/M^2.
Procedure:

1. Initial investigation: Previous collection of information, this refers to the subject of study. In this case, it was decided to look for previous research already carried out, related to the CO2 generated by the constructions.

2. Determination of factors: The emission factors to be used for calculating the emissions inventory in the established project were determined.

3. Design of the spreadsheet and transcription of data from OPUS to Excel: A budget was acquired in the OPUS program, for the design of a format with the Excel tool, of the budget to be calculated where some variables can be shown, such as the concept of work, units, materials used for the concept of work, equipment used for work concepts and as well as the quantities of work.

4. Placement of the emission factors: Once the factors are placed, the results of CO2 generated by each construction concept are obtained.

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5. Results of Kg / CO_2: The construction Kg-CO_2 / M^2 were obtained, from the emission factors file of the HueCO_2 database, this summing the total emissions of each stage in the construction and proceeded to make graphs and interpret information obtained.

Results

The data obtained in the study are presented in tables

1	Fittings	Total ($KgCO_2$)	Amounts of work	Total ($KgCO_2$)
1.01	Stroke and leveling of fittings	.1541	2888.5	445.22
1.02	Manufacture of L-type lining	30.5149	2524.5	77034.98
1.03	Manufacture of type I lining	44.1531	364	16071.73
1.04	Backing of concrete lining	1.1201	2888.5	3235.3
1.05	Backing of concrete lining	36.4384	85	3097.26

Table 1 Emissions generated in the garrison stage
Source: Own Elaboration

Table 1 shows the emissions generated in the garrisons stage for each construction concept where the total is 99,884.60 Kg-CO_2.

2	Earthworks	Total ($KgCO_2$)	Amounts of work	Total ($KgCO_2$)
2.01	Clean stroke and leveling	.1541	20177	3110.0545
2.02	Excavation in box in 2 layers of 20 cms	.7478	400	299.1392
2.03	Subgrade treatment to 90% of proctor test	.5237	23915	12523.2674
2.04	Stuffing compacted in layers of 15 cm	1.4776	5978.75	8834.0294
2.05	Construction of hydraulic base	1.6545	3587.25	5935.1332
2.06	Irrigation impregnation with asphalt fm-1	5.7741	20177	116504.9741
2.07	Decapitation, lifting and leveling of well of visit	305.9380	12	3671.2564
2.08	Demolition and rehabilitation of valve box type 2	814.3355	1	814.3355
2.09	Demolition and rehabilitation of valve box type 12	1234.9749	2	2469.9498

Table 2 Emissions generated in the earthworks stage
Source: Own Elaboration

En la tabla 2 se pueden observar las emisiones generadas en la etapa de terracería por cada concepto de obra donde el total es 154,162.13Kg-CO_2.

3	Pavement structure	Total ($KgCO_2$)	Amounts of work	Total ($KgCO_2$)
3.01	Surface sweeping by mechanical means	.3526	20177	7114.7935
3.02	Construction of hydraulic concrete pavement	53.0891	20177	1071179.758
3.03	Slab-garrison board	.0011	2888.5	3.0797
3.04	Junta de loa-poso	.0011	730	.7783
3.05	Supply and placement of curb	42.1312	12	505.5749

Table 3 Emisiones generadas en la etapa de estructura
Source: Own Elaboration

Table 3 shows the emissions generated in the pavement structure stage for each work concept where the total is 1,078,803.98 Kg-CO_2.

4	Cleaning and signaling	Total ($KgCO_2$)	Amounts of work	Total ($KgCO_2$)
4.01	Cleaning the work area with machinery	.2960	20177	5973.19908
4.02	Supply and installation of sv-poste	9.8	89.8275	880.3095
4.03	Supply and placement of die	12.4080	6	74.4479
4.04	Demolition of bench for die making	3.8730	2	7.7460

Table 4 Emissions generated in the pavement structure stage
Source: Own Elaboration

Table 4 shows the emissions generated in the pavement structure stage where the total was 6,935.70 Kg-CO_2.

5	Filling in lots	Total ($KgCO_2$)	Amounts of work	Total ($KgCO_2$)
5.01	Filling in compacted batches	.3776	7059	2664.6672
5.02	Stuffing in compacted streets	.3776	2960	1117.7751

Table 5 Emisiones generadas en la etapa de relleno en lotes
Source: Own Elaboration

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Table 5 shows the emissions generated in the filling stage in lots for each work concept where the total is 3,783.44 Kg-CO_2.

Database HueCO2		
Emission by area	84.7762	Kg-CO_2/M^2
Total in Kg-CO_2 of the work.	1343569.8741	Kg-CO_2

Table 6 Total emissions generated in Kg-CO_2 y Kg-CO_2/M^2
Source: Own Elaboration

Database In table 6 you can see the total amounts in Kg-CO2 Kg-CO_2/M^2.

Discussion of results

Discussion of results 84.77 Kg-CO_2/M^2.
Significant variations can be observed with respect to each stage of the construction process, table 2 resulted in the largest quantities of CO_2 generated with 15.4162.13 Kg-CO_2 due to the use of earthmoving machinery, according to mini ecosystems (2008), since the burning of fossil fuels is one of the main pollutants and generators of CO_2.

The hypothesis put forward was 100 Kg-CO_2 / M^2. with a tolerance of plus or minus 10%, which gives a range of values of 90-110 Kg-CO_2 / M^2., So the results are very close to the obtained

Acknowledgement

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Conclusions

The objective of this investigation was to determine the quantification of emissions in Kg CO_2 / M^2 generated by a stage in the construction of a hydraulic concrete pavement in a subdivision of Ciudad Obregón Sonora, Mexico, making use of standard emission factors obtained from different sources , the data base HueCO_2 and the amounts of work of the project to be studied, all based on the necessary data collection and the use of the quantities of work and the emission factors that with the help of an Excel format designed to obtain automatically the CO_2 results generated by each work concept.

The emissions proposed in the hypothesis were 100 Kg-CO_2 / M^2, and using an area of 15.848.44 m2 of pavement, the results obtained were 84.78 Kg-CO_2 / M^2, a value very close to the range established in the hypothesis of 90-110 Kg-CO_2/M^2

These results could be improved by using some software with included databases for the calculation since it would help to have a better management of emissions.

It is recommended to continue carrying out studies that allow the parameterization of these values in order to estimate the pollution values generated by the construction of urban infrastructure without having to repeat the way in which this research was developed.

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Effect of light periods and substrates in the seed germination of capiron (*Calycophyllum Spruceanum*) in the Colombian Amazon

Efecto de periodos de luz y sustratos en la germinación de semillas de capiron (*Calycophyllum Spruceanum*) en la Amazonia Colombiana

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Abstract

In order to determine the effect of substrates and periods of light on the germination of capirona sedes, (Calycophyllum spruceanum), the speed and germination percentage of these seeds were studied, under controlled conditions, in the department of Putumayo, Colombia, using a 3x3 factorial design (Substrate and light periods), where two variables were analyzed: the germination speed and germination percentage in a 30-day period. The analysis of variance indicated significant differences ($p \leq 0,05$) for the substrates factor, as well as periods of light and the interaction of these on the variables evaluated. The peat substrate presented the highest percentage of germination (22.89 ± 1.14a) and the highest germination rate (0.71 ± 0.03a), while in the 12 daylight hours photoperiod it showed the highest percentage of germination (18.22 ± 1.14a) and the highest germination speed (0.56 ± 0.0290a). The interaction of factors indicated that for both germination percentage and germination rate, peat * 12 daylight hours showed the highest values (44.67 ± 1.98a) and (1.34 ± 0.05a) respectively. It is recommended to include the peat substrate and the 12 daylight hours photoperiod in the germination protocols of seeds of Capiron (Calycophyllum spruceanum) in Amazonian conditions.

Viability, Latency, Physiology

Resumen

Con el objetivo de determinar el efecto de sustratos y periodos de luz sobre la germinación de semillas de capirona, (Calycophyllum spruceanum), se estudiaron la velocidad y el porcentaje de germinación de dichas semillas bajo condiciones controladas en el departamento del Putumayo, Colombia, utilizando un diseño factorial 3x3 (Sustrato y periodos de luz), en donde se analizaron dos variables: la Velocidad de germinación y el porcentaje de germinación en un periodo de 30 días. El análisis de varianza indicó diferencias significativas ($p \leq 0,05$) para el factor sustratos, al igual que periodos de luz y la interacción de estos sobre las variables evaluadas. El sustrato turba presentó el mayor porcentaje de germinación (22,89±1,14a) y la mayor velocidad de germinación (0,71 ± 0,03a), mientras que en el fotoperiodo de 12 horas luz mostró el mayor porcentaje de germinación (18,22 ± 1,14a) y la mayor velocidad de germinación (0,56 ± 0,0290a). La interacción de factores indicó que tanto para el porcentaje de germinación y velocidad de germinación, Turba*12 horas luz mostró los mayores valores (44,67 ± 1,98a) y (1,34 ± 0,05a) respectivamente. Se recomienda incluir el sustrato turba y el fotoperiodo 12 horas luz en los protocolos de germinación de semillas de Capiron (Calycophyllum spruceanum) en condiciones amazónicas.

Viabilidad, Latencia, Fisiología

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Introduction

The capirona (*Calycophyllum spruceanum*) is a native tree of the amazonian region, extending to the south of Brazil and Bolivia, below the 1200 msnm; being common in secondary forest areas, although it is also found in primary forests. It is observed in areas with high and constant rainfall, but also in areas with a marked dry season. It is a species adapted to soils mostly sandy to alluvial, fertile, sometimes temporarily flooded and in riverine areas (Reynel et al., 2003).

In Putumayo, Colombia, the capirona tree species (*Calycophyllum spruceanum*) for its high adaptation to the edaphoclimatic conditions of the area, diversity of uses and acceptance in the markets, is shown as an alternative with great potential for the development of reforestation programs; it is so Corpoamazonia, (2009) in agreement with the communities establish in the last three years 170 hectares on the banks of the Caquetá and Putumayo rivers. According to Bacchetta et al., (2008), light is one of the most important environmental factors in the control of germination, its effect on germination differs in different species, some require it, others do not, its importance is related to the role in photosynthesis that is necessary to fix a daily amount of CO2, which compensates for respiratory loss and that even modifies its structure, which is called etiolation or etching (Vásquez, 2001).

On the other hand, according to Triviño, (2008), a substrate is any solid material other than soil, natural, synthetic or residual, mineral or organic, which, placed in a container, in pure form or in a mixture, allows the anchoring of the root system of the plant, thus playing a supporting role for the plant, its function in germination is restricted to having the ability to maintain adequate humidity, allow oxygen and light to enter the seed and prevent Sun rays directly affect it, the degree of internal variation of each of these factors within each substrate, determine the germination.

The capirona (*Calycophyllum spruceanum*) despite being a native species of the Amazon, there is little information on the propagation processes, and that according to preliminary trials has shown germination percentages lower than 5%, which has hindered the propagation and multiplication of the species in the reforestation programs that have been executed by the CAR Regional.

Methodology to be developed

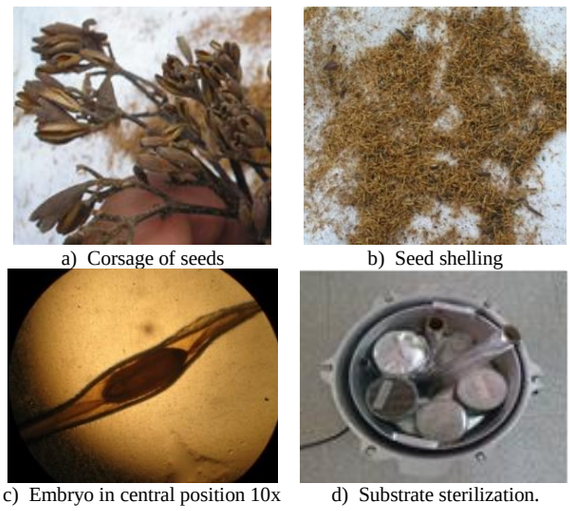
Location:

The present study was carried out in the facilities of the Biology laboratory of the Putumayo Technological Institute in the city of Mocoa, Department of Putumayo, located on the geographic coordinates of 1047355 W, 0619673 N (76 ° 39 ° 05 ° W, 01 ° 09 ° 24 ° N), with average annual temperature of 25 ° C and an average height of 672 msnm.

Preparation of Germplasm

The seeds that were used were collected in the village of the spring, Municipality of Puerto Guzmán, Department of Putumayo; following the methodology proposed by Corpoamazonia (2009), which consisted of extracting seeds from selected trees with superior phenotypic characteristics of the natural forest (Figure.1a). Branches with abundant ripe seeds were selected, fully mature fruits were selected, which showed a light brown color with pubescence on their surface and with the valves beginning to open (Figure1c).

The seeds were dried on fabrics exposed to the sun for 6 days, until a high percentage of opening of the valves and seed shedding was observed (Figure 1c). Subsequently a shatter was made with soft blows on the floor to achieve a greater detachment. This seed was sifted in a sieve to remove foreign particles, observing only the tiny, winged and elongated seeds, with the embryo in the central position (Figure1b); were stored in a paper bag inside a refrigerator at a temperature of 4ºC, to maintain its viability until the time of planting (Beisner, 1989).



a) Corsage of seeds b) Seed shelling

c) Embryo in central position 10x d) Substrate sterilization.

Figure 1 Preparation of germplasm
Source: This research

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The substrates were previously sterilized in an autoclave at a temperature of 254 ºF and a pressure of 1.2kg / cm2 for 40 minutes (Figure1d), according to the methodology described by Jiménez and Guevara, 1996; Mesén 1996) the seeds were treated with the fungicide Ridomil (Mancozeb + Cimoxanil) in a dose of 1 gr / liter, sprayed at the time of sowing.

Preparation of substrates

Paper towel: Three layers were placed directly on the bottom of each petri dish to ensure moisture retention. The seeds were pressed gently on the paper to increase contact (Figure 2a).

Sand + Earth: In each petri box, 9 grams of sand and 9 grams of soil were placed, passed through a 0.8 mm sieve, leveling the substrate (Figure 2b); the seeds were gently pressed to level with the substrate and increase its contact.

Peat: 4 grams were placed in each Petri dish, then the substrate was leveled and the seeds were deposited at the level of the peat, for which it was necessary to apply pressure gently on the plant material.

a) Paper towel substrate

b) Sand + earth

Figure 2 Substrate preparation
Source: This research

Parameter Evaluation

Germination percentage (PG): To determine this, daily observations were made from day 10 after sowing, at which time the plumule emerged from the seeds was observed. Its calculation was obtained by the coefficient of germinated seeds within 30 days after sowing, based on the total number of seeds tested, expressed as a percentage, according to the methodology proposed by Oyola et al., (2008).

Germination speed (VG): the germination was registered daily for 30 days after sowing, considering the seeds germinated when the radicles emerge. Its calculation was obtained by the ratio of germinated seeds with germination time, and were calculated according to the proposed formula Oyola et al. (2008).

Statistic analysis

The statistical tests were performed using the Infostat statistical package. V.2018, under the 2x2 factorial arrangement, the LSD alpha = 0.05 means purchase test was used.

Results

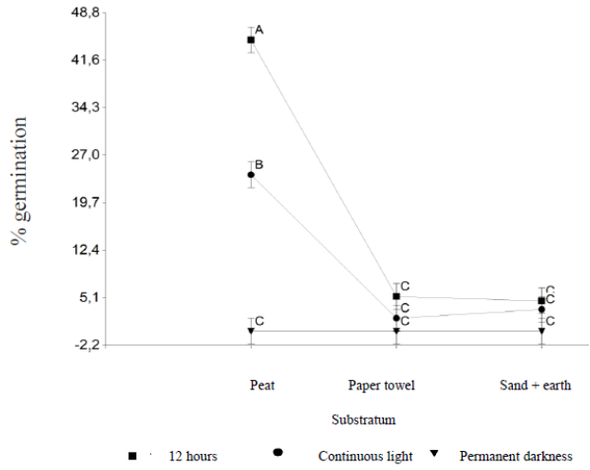
Germination

The assumptions of homoceasticity and normality in the fixed factors (substrates and periods of light) were not validated, a correction of the variance was made by the *Varldent* corrective for the -substrate- factor, allowing to continue with the following tests.

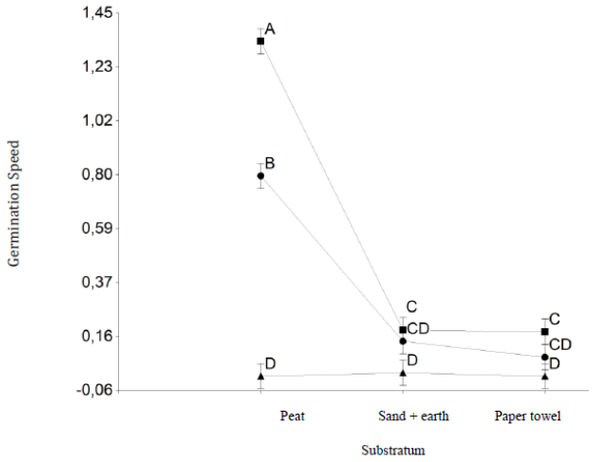
The variance analysis of the germination variable indicated significant differences (P≤0,05) for each of the substrates, as well as in the periods of light, as well as the interaction of these (Table 1).

Germinative parameters.	12 light hours			Continuous light			Permanent Darkness		
	Peat	Sand + Earth	Paper towel.	Peat	Sand + Earth	Paper towel.	Peat	Sand + Earth	Paper towel
% germination	44,67 ± 1,98a	4,67 ± 1,98c	5,33 ± 1,98c	24± 1,98b	3,33 ± 1,98c	2 ± 1,98c	0 ± 1,98c	0 ± 1,98c	0 ± 1,98c
Germination speed	1,34 ± 0,05a	0,18 ± 0,05c	0,18 ± 0,05c	0,8 ± 0,05b	0,14 ± 0,05cd	0,08 ± 0,05cd	0 ± 0,05d	0,01 ± 0,05d	0 ± 0,05d

Table 1 Percentage and speed of germination in seeds of capirona, in three levels of light periods and three substrates. The results show the means ± (E.E). Values with different letters indicate significant differences between light periods and substrates. (post-hoc LSD, Fisher LSD, p <0.05)
Source: This research



Grphic 1 Germination percentage in seeds of capirona, The results show the means ± (E.E). Values with different letters indicate significant differences between light periods and substrates. (post-hoc LSD, Fisher LSD, p <0.05)
Source: This research



Graphic 2 Germination speed in capirona seeds. The results show the means ± (E.E). Values with different letters indicate significant differences between light periods and substrates. (post-hoc LSD, Fisher LSD, p <0.05)
Source: This research.

The test of comparison of means of LSD - Fisher (P≤0.05), in the interaction of the factors indicated that Turba * 12 light hours presented significantly higher values of% of germination, with respect to the other periods of light and substrates, (44.67 ± 1.98a) (Graphic 1).

Germination speed

The variance analysis carried out for the variable Germination speed, showed significant statistical differences (P≤0.05), indicating that, Turba * 12 light hours, the highest germination velocity values were presented (1.34 ± 0.05a), being statistically superior to other periods of light and substrates. (Graphic, 2).

Discussion

The behavior of germination% and the germination rate in peat substrate can be explained since the seeds of species that live in aquatic or flooded environments, where oxygen is scarce, germinate better if the concentration of this gas is low (between 5 and 10%), when considering the capirona a species adapted to temporarily floodable soils and riparian zones (Reynel et al., 2003), the effect tends to be more marked in the more humid substrate since it probably activates with greater intensity physiological response mechanisms of the seed, on the contrary, the paper towel and the mixture of sand + earth with low humidity retentions have an environment that probably decreases the physiological respondents, degún Pérez and Martínez, (1994), the increase of the amount of water available to the seed allows the activation of metabolic processes (Rodríguez and Nieto, 1999), and decreases the amount of oxygen that reaches the embryo (Pérez y Martínez, 1994).

Likewise, the results can be explained as mentioned by Triviño, (2008), indicating that according to the need for light for each species in its germination is regulated by its requirements for its development in the natural state; where tropical low-lying species are generally heliophytes or semiheliophytes, and have high light demands, according to Reynel et al. (2003), capirona is a heliophyte species and therefore explains the increase in% germination and the germination speed obtained in the photoperiod 12 hours, with differences in photoperiod with lower light intensity.

Although for Beisner, (1989), light is not essential for the germination of seeds at rest, but its effect through phytochrome, can break the lethargy by accelerating the germination period. Also, light can promote the increase in the concentration of germination promoting substances or decrease the concentration of inhibitors, or the combination of these two effects (Araya et al., 2000). Tests carried out by Oyola et al., (2008) concluded once the seed has the adequate conditions of humidity, temperature and aeration, the exchange of gases between the substrate and the embryo accelerates the emergence, while lower values in different treatments are associated with the effects of a possible physiological response of defense of the seed when not having an ideal substrate for its germination.

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Conclusions

The best results regarding the percentage and average speed of germination were obtained with the interaction of peat substrate with the period of 12 light hours, exerting one (44.67% ± 1.98a) and (1.34 ± 0.05a) seeds / day.

Significant differences in substrates and light periods on the percentage and average speed of germination of the capirona species, reaffirms the need to use substrates and specific light periods to achieve an optimum in the propagation of the species.

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Implementation of the use of condensed water from air conditioners in the development of chemical laboratory practices at the Instituto Tecnologico de Cancún as an alternative in the consumption of distilled water

Implementación del uso de agua condensada de los aires acondicionados en el desarrollo de las prácticas de laboratorio de química del Instituto Tecnológico de Cancún como una alternativa en el consumo de agua destilada

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Abstract

Use and collection of condensed water from air conditioners in the ITCancún laboratories that generate a large amount of this water. The ITCancún chemistry laboratory generates more than 15 liters per day of its air conditioners and the same amount is produced by the Electromechanical Engineering workshop. These impressive amounts can be attributed to the climatic conditions of the state due to the high humidity index. The purpose of this Article is to use the water collected from the air conditioning systems of the ITCancún laboratories, in the cleaning of the chemistry laboratory material and in the preparation of solutions for the development of the chemistry practices of the careers of the institute's engineering. The collection of water represents a significant economic saving in the acquisition of distilled water. The results obtained from the physicochemical parameters of the water collected from the air conditioning are pH 8.3, Alkalinity of 2.8 mg / L, conductivity 16μS, and 22μS, these parameters being water quality. Said water by condensation can be reused in cleaning floors, bathrooms. Having a comprehensive and sustainable project friendly with water care

Sustainable, Integral, Reused, Condensed Water

Resumen

Aprovechamiento y recolección del agua condensada de los aires acondicionados en los laboratorios del ITCancún que generan una gran cantidad de dicha agua. El laboratorio de química del ITCancún genera más de 15 litros cada día de sus aires acondicionados y la misma cantidad produce el taller de Ingeniería Electromecánica. Estas cantidades impresionantes se pueden atribuir a las condiciones climáticas del estado por el alto índice de humedad. En este Artículo se tiene como objetivo darle uso al agua captada proveniente de los sistemas de aire acondicionado de los laboratorios del ITCancún, en la limpieza del material del laboratorio de química y de la preparación de soluciones para el desarrollo de las prácticas de química de las carreras de las ingenierías del instituto. La recolección del agua representa un ahorro económico significativo en la adquisición de agua destilada. Los resultados obtenidos a las pruebas físico químicas del agua recolectada del aire acondicionado, son pH 8.3, Alcalinidad de 2,8 mg/L, conductividad 16μS, y 22μS, siendo estos parámetros de calidad del agua. Dicha agua por condensación la podemos reutilizar en limpieza de pisos, baños. Teniendo un proyecto integral y sostenible amigable con el cuidado del agua.

Sostenible, Reusó, Agua Condensada

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Introduction

We know that a domestic air conditioner can produce up to 25 liters per day of condensed water, however, the water produced is often discarded. This amount of water collected can represent a great saving for institutions that use distilled water for commercial use in the performance of laboratory practices. The water collected is of sufficient quality to be used in all types of activities that require water: for example, cleaning, for the consumption of the building itself, being a sustainable building in the reuse of water for cleaning the bathrooms, floors of the halls and laboratories. In these places, the best thing about air conditioning condensate recovery is that water is produced as a natural product without cost being friendly to the environment in the care of drinking water. During periods of high heat and high humidity, when it is most necessary to justify having condensate capture systems. The relative humidity in Cancun remains at around 60% to 90% during the summer months.

The air conditioning system allows water to be produced by extracting moisture from the air through a condensation process, condensation is the change in matter from a substance to a denser phase, such as from gas to liquid. Condensation usually occurs when a vapor cools, but it can also occur if the water vapor in the air that condenses naturally on cold surfaces is called dew. Water vapor will only condense on another surface when it is colder than the temperature of water vapor, or when the balance of water vapor in the air, that is, the saturation humidity, has been exceeded is compressed.

The principle of distillation is very simple, but the realization of the process on a large scale presents many problems, for example, as water is distilled from a container with brackish water, the salts become more concentrated and end up precipitating or forming large calcic crusts and consumption of large amounts of energy. We are increasingly aware that we must create a sustainable society; that is, one whose processes are in equilibrium with the natural processes of the planet, not releasing toxic materials into the environment and satisfying their needs with renewable resources.

As man increases the production of environmental pollutants, we find that large amounts of money and resources are being invested to guarantee the supply of fresh water. This is one of the reasons why we choose to use the condensed water from the air conditioners being a sustainable chemistry laboratory.

The ecological environment has become a global concern, because pollution of the environment is becoming more serious. Rapid industrialization has caused many serious problems, such as depletion of natural resources, degradation of major ecosystems (Zheng-Xia He, 2016). Given the environmental conditions and problems and the depletion of water supplies, we resort to the process of using the distilled water generated by the air conditioners in a sustainable way in saving the consumption of 80 liters of distilled water, which is consumed in a semester in the development of chemistry laboratory practices.

Finally, all this must be achieved with a minimum possible expenditure in the consumption of distilled water, in the performance of laboratory experiments. The raw materials of the chemical processes must be renewable and economically viable resources, especially if a total of 180 students are attended per semester distributed in a total of twelve teams per group.

Distilled water and its importance

It is one that like all types of water is composed of two hydrogen atoms and one oxygen, whose molecule is represented chemically by the formula H2O and through the process of distillation have been removed impurities and ions.

Distillation is used to purify water for a long time, in this process dissolved pollutants such as dissolved salts remain in the tank where the water boils, while the impurities free water vapor rises out.

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The process to distill the water is based on the elimination of the various components that are in the water, for it is necessary to submit to water, to various processes that include condensation and vaporization, to be able to carry out said procedure, it is need to have a distiller at hand, this tool is not so easy to obtain, since it is not a very common article without mentioning the fact that its cost is quite high, however there are much simpler and cheaper alternatives to achieve debugging water, although these methods do not guarantee 100% purity.(Brown LeMay Burnsten. 2014)

Types of distilled water as Chemical reagent It is the water used in laboratories to prepare solutions, mixtures, patterns, etc.

- Deionized water-deionized
- Bidistilled water
- Water chemically pure reactive grade
- Tri-distilled water

The natural process of the water cycle creates by itself distilled water when it is condensed in the atmosphere the rainwater is much softer than others in its natural state. Currently there are several ways to obtain it through renewable energy following the culture of saving the consumption of electricity, as is the case of the use of solar energy for distillation of water these devices are known as solar distillers and use the sun as energy for water evaporation. (Ecured 2018)

Distilled water

Distilled water is free of minerals, metals, poisons, etc. As it carries absolutely nothing, it has a very large mineral absorption capacity.

Condensed water air conditioners

The air conditioners, when they are working, generate a large amount of water due to the condensation effect. Instead of discarding this water, one option is to reuse it for different uses and thus, make the most of this type of condensate.

Water has become a scarce resource in some parts of the country and the world, it is important that we are aware not to waste or throw large quantities of this vital liquid.

But, you have to suggest how you can collect this water, put a hose or pipe the valve by which the device throws the excess liquid put a container underneath where we will accumulate a large amount of water for use in the chemistry laboratory, another of our water suppliers is the electromechanical engineering workshop.

How an air conditioner works

An air conditioning system does not generate cold air, but extracts the heat from the air of the room that you want to air condition, how a refrigeration circuit works to extract heat from the air of a home or a classroom, laboratory, shopping center, etc.

Components that form an air conditioning system

Evaporator

The evaporator, where the process of extracting the hot air occurs, which gives its heat to the refrigerant gas, a fan distributes the flow of refrigerated air to the room. The Split system has temperature sensors connected to the thermostat.

Expansion valve

The expansion valve releases the refrigerant gas from the pressure, which passes through it from the liquid to the gaseous state when it passes through.

Condenser

The condenser and the compressor where the refrigerant gas passes from gas to liquid, in unit the hot air (from the heat it has absorbed) is expelled from the inside to the outside.

Compressor

It generates a force by compressing the gas that comes from the evaporator in a gaseous state. This pressure increases the temperature of the gas that returns to its liquid state and heats up. The compressor is one of the most important parts of the cycle and the one that consumes the most energy. The working speed of the compressor will depend on the signal sent by the temperature sensor.

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Refrigerant gas

Synthetics: halocarbonated fluids such as CFC, HCFC and HFC

Non-synthetic: hydrocarbons, carbon dioxide, ammonia, water, air (also called natural refrigerants).

The refrigeration cycle uses a refrigerant gas to which the excess temperature is transferred, when circulating it at a temperature lower than that of the refrigerated space. The refrigerant gases contain Hydrofluorocarbons HFC refrigerants consist of hydrogen, fluorine and carbon that can be contaminants to the atmosphere, although today there are refrigerant gases with a very low level of PCA or "polluting power". CFCs and HCFCs do not contain chlorine, and therefore do not harm the ozone layer. However, due to their long period of life, they are ecologically acceptable refrigerants but with a high GWP (Global Warming Potential) value.

While the refrigerant is circulating inside the evaporator, the hot air inside the house is passing through the evaporator because of the work done by the fans. The refrigerant absorbs at this point the heat of the air, which leaves the Split much colder.

Yunus Cengel, Michael Boles (...) in this process, the refrigerant, now already in gaseous state and warmer (it has absorbed the heat from the air), goes back to the compressor where the cycle will be fulfilled again.

While this process is working, the temperature inside the house, although the relative humidity increases until reaching the dew point in which the water vapor becomes liquid that is accumulated in the base of the evaporator. That is why the Split must have a drain to expel these condensed droplets or vapors.

In air conditioning systems they condense approximately seven liters of water every day; Potentially potable water that is wasted. (www.acrlatinoamerica.com). Approximately 10 to 20 liters of water are generated daily from condensed air in the chemistry laboratory, generated daily (see figure 1), which remain on all day and the reagents need a suitable climate so that humidity does not affect its quality.

Figure 1 Water collection system of the chemistry laboratory
Source: Own Elaboration

This type water that is not susceptible to human consumption, but can be used for domestic chores, the PH is very acidic 5. 8, the use has already been mentioned that it can be given to the water is for housework such as grooming, washing, water the plants, but it can not be ingested, because it contains bacteria, but it is not harmful since the relative unit of the air when hitting the coil causes the water vapor to lower its temperature and condense.

One of the first things that air conditioners do with the air they take is to extract moisture through evaporation coils, which attract water vapor to condense inside the device. The moisture is then evacuated by means of drainage pipes. If the condensation appears on the outside of the appliance, it is probably due to the large temperature difference between some of its components.

Water quality parameters

In the process of characterization of the quality of a water sample, the parameters such as acidity, alkalinity, and hardness are of utmost relevance, since they allow to know possible characteristics of the origin of that sample, as well as the possible contamination by diverse ions that are aggregates in excess to the bodies of water where the sample has been taken.

Hardness: It is called water hardness to the concentration of mineral compounds in a certain amount of water, in particular magnesium and calcium salts. Water commonly referred to as "hard" has a high concentration of these salts and "soft" water contains them in very small quantities.

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Water hardness is normally expressed as an equivalent amount of calcium carbonate (although this salt itself is not found in water) and is calculated, generically, from the sum of the existing calcium and magnesium concentrations (milligrams) per each liter of water; which can be expressed in $CaCO_3$ concentration.

Acidity: Acidity is the quality of an acid. Acid solutions may have characteristics such as sour taste, hydrogen release, or pH less than 7 (at 25ºC).

Alkalinity: The basicity or alkalinity is the neutralizing acid capacity of a chemical in aqueous solution. This alkalinity of a substance is expressed in base equivalents per liter or its equivalent of calcium carbonate.

pH: The electrometric method is based on the measurement of the electromotive force of an electrochemical cell, which consists of the sample, a glass electrode and a reference electrode. A standard deviation of $\Delta pH = 0.05$ or less can be obtained by this method. If the sample is low in ionic strength, ie less than 5 mS / m electrolytic conductivity, special analysis equipment and procedures are necessary.

Conductivity: The electrolytic conductivity is a numerical expression of the capacity of a solution to transport an electric current. This capacity depends on the presence of ions, their total concentration, their mobility, valence and relative concentrations, as well as the temperature.

The determination of conductivity is of great importance because it gives an idea of the degree of mineralization of natural, potable, residual water, treated waste, process or water to be used in the laboratory in routine analysis or for research. The conductivity value is a parameter regulated by maximum permissible limits in discharges of wastewater to the sewage system or to receiving bodies, it is also a parameter of water quality for agricultural uses and activities, for primary contact and for human consumption.

Temperature: so it is necessary to measure the temperature as an indicator of the presence of compounds and contaminants, through the test method established in this Mexican regulation.

The temperature value is a criterion of water quality for the protection of aquatic life and for sources of drinking water supply, it is also a parameter established as the maximum limit allowed in wastewater discharges and a specification of importance in the calculations of energy and heat balance of industrial processes. For the application of this Mexican standard it is essential to have a measuring instrument with demonstrable traceability to the international system of units.

Nitrates: Nitrate is an essential nutrient for many photosynthetic autotrophs, and in some cases has been identified as the determinant of the growth of these.

A high concentration of nitrates is a sign of a greater stage of mineralization of nitrogen compounds. In the waters of some wells, appreciable amounts of nitrates are usually found, which is objectionable from the sanitary point of view.

For C. Zetina-Moguel (2018) the cost of distilled water from air conditioning equipment is an externality that derives from the comfort acquired by decreasing temperature and humidity in indoor environments. If we take advantage of the quantity of byproduct, it will not allow us to not have to buy large quantities of distilled water, which would only be acquired where more rigorous experimental tests are carried out and of a research nature. At the same time, the use of air conditioners inside the houses and enclosures increased; replacing the fans in some homes by excessive heat. Although the costs of this artificial comfort are high and are not accessible to the majority of the population, offices and public buildings as well as hospitals and schools, squares have been mostly equipped with artificial cooling equipment.

The classrooms of the educational establishments in the different levels have not been alien to this tendency and at present ventilators and air conditioning equipment are used in almost all the closed spaces of the Technological Institute. The air conditioning equipment are environmental cooling systems that mostly produce condensation of water from the environment. Virtually this by-product of waste disposal of the spaces is not used and is poured outside the rooms causing the walls to be stained by runoff, producing fungi and visual pollution, it can be used to keep the grass moist although it is a water lack of nutrients.

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Methodology

Description of the method

The sampling of the conditioned air of the air conditioning was carried out in the chemistry laboratory and the Electromechanical Engineering Workshop, water sampling of the keys of the tables, comparisons with the samples, drinking water that was taken from the chemical and water laboratory. Characterization of physical and some chemical parameters of the water that drain from the air conditioners of the laboratories, and of the distilled water that is acquired from the supplier of chemical substances. The analytical methodology used included the techniques of:

SAMPLING

The sampling is carried out in accordance with the NMX-AA-3 "Wastewater-Sampling" and NMX-AA-14 "Receptor Bodies. Sampling", as the case may be. Physical characterization of the water quality of the samples was made from the organoleptic parameters, temperature, electrical conductivity, salinity, total dissolved solids, pH. A sample was taken in the water outlet pipe of the air conditioning of the chemistry laboratory, Workshop of Electromechanics of the IT Cancún, it was classified as indicated below in table No. 1

Sample	Place	Milliliters	Observations
A	Water from the air conditioning condensate collected inside the chemistry laboratory	1000 ml	Taken from the existing drainage drum by simple transfer.
B	Water from the air conditioning condensate collected outside the chemistry laboratory	1000 ml	Water collected during a period of approximately one day
C	Water from the condensate of the electromechanical laboratory; collected from the key connected to a storage tank.	1000 ml	Water taken directly from the outlet valve of the tank or tank that collects the condensed water from the cooling system of the electromechanical laboratory
D	Water coming from the basin tap of the water chemistry laboratory	1000 ml	Water from the key of the chemistry lab tables. For water comparison with respect to condensate water

Table 1 Description of the samples
Source: Own Elaboration

In each semester the careers of Electromechanical Engineering, Computational Systems, Civil, Mechatronics, are made a total of 6 laboratory practices according to the chemistry program, serving a total of students per career of 57 students, each group is very peculiar form teams between 10 and 14. The assembly of each practice is the preparation of solutions at different concentrations and volumes, as indicated in table number 2.

Engineering Careers	No. of Students	No. Practices	No. of equipment	Milliliters of water used in washing laboratory equipment approximately per equipment	Shift	Milliliters used for each practice at different molar concentrations
Electromechanics	60	5	10	5000 ml.	morning	5000 ml
Electromechanics	50	5	10	5000 ml.	evening	5000 ml
Mechatronics	59	5	12	5000 ml.	morning	5000ml
Civil	60	5	14	5000 ml	morning	5000 ml
Computer systems	49	5	10	5000 ml	morning	5000ml

Table 2 Assembly of Experiments period August december 2017
Source: Own Elaboration

According to the previous table, an approximate of 65 to 100 liters of water per semester is consumed, including other subjects that will be carried out in the laboratory, as well as the practices of the students of the Master of Environmental Sciences.

The collection of condensate water from air conditioners per day is approximately 15 to 20 liters depending on the humidity conditions in the environment. (See figure 2 and 3)

Figure 2 condensate water collection systems air conditioning chemical laboratory
Source: Own Elaboration

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Figure 3 condensate water collection systems air conditioning electromechanical workshop
Source: Own Elaboration

It seems that we see it normal to have to have a gutter falling from our air conditioning to the ground and under it a bottle that we have to change every time it is filling.

Physical Parameters

The measurement and analysis of the physical parameters, the methodologies established in the standards and the equipment in existence in the laboratory were used.

A OAKTON Brand conductivity and pH meter, PC 700 (pH / mV / Conductivity / ºC / ºF) Bench Meter - Eutech Instruments was used. With the same equipment the reading of total dissolved solids and salinity was taken.

The meter, for the moment of the practice, had two electrodes, one for conductivity and another for pH with a temperature sensor. The methodology for each parameter was followed according to Mexican water standards.

NMX-AA-008-SCFI-2011 - Determination of pH - test method

NMX-AA-093-SCFI-2000- Determination of electrolytic conductivity - test method

NMX-AA-007-SCFI-2013 - Measurement of temperature in natural, residual and treated wastewater - test method.

Chemical Parameter

Determination of hardness, total alkalinity and total acidity in water samples according to the Procedure that marks these standards for water samples from air conditioner condensates.

Nitrate in water by UV Mexican Standard NMX-AA-82-1986. Water pollution_ Nitrate nitrogen determination_ Ultraviolet spectrophotometric method. DOF. 1992. A spectrophotometer of the Shimadzu brand was used, Model UV-1800.

Condensed water flows were estimated using field gauges (water measurement NMX-AA-072-SCFI-2001, which establishes the test method for the determination of total hardness in natural, treated residuals and residual waters, Mexican Standard NMX-AA -036-SCFI-2001. Water analysis Determination of acidity and alkalinity in Natural, Residual and Wastewater treated. Test method we follow the same by flask and stopwatch) in volume / time. The readings were made in the mornings before starting activities and at the end of the daily routine of work, during a continuous period of 4 months, it was also used in the rinsing of the laboratory material used to prepare analytical solutions, (see figure 4)

Figure 4 sample taking of condensed water from air conditioning
Source: Own Elaboration

Preparation of solutions for chemistry experiments

Table No. 3 indicates the solutions prepared per experiment, and the number of equipment per group and the distilled water that is used in addition to the preparation of solutions and solutions.

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Name of the practice	Solutions	Required milliliters	Average number of teams per group
Chemical reactions	NaCl (table salt) lead nitrate II, 0.05M Concentrated sulfuric acid, 2M HCl Vinegar, acetic acid: CH3COOH Magnesium tape: Mg 0.5M potassium iodide sodium bicarbonate: NaHCO3 **Distilled water**	**Approximately 5 liters per group** **5 liters**	
Electrochemistry	Granulated Zn 5% NaOH solution $ZnSO_4$ solution KCl solution $CuSO_4$ Copper Sulfate Solution $AgNO_3$ Silver Nitrate Solution **Distilled water**	Approximately 5 liters per group Approximately 5 liters per group	**10**
Periodic Properties	Distilled water Sodium hydroxide 6M Hydrochloric acid 1: 1 Universal indicator Li, Na, K, Ma, Ca, P, S Dry ice Oxides of chromium (III), zinc, copper (II), iron (III), silicon, nickel and aluminum **Distilled water**	**Approximately 5 liters per group** **5 liters**	**10**
Volumetry and gravimetry	**Hardness Alkalinity Acidity Nitrates**	**15 liters**	

Table 3 laboratory practices consumption of distilled water
Source: Own Elaboration

The air conditioners produce a continuous supply of water when they are in operation, the devices have the capacity to drain the water, which is used in the chemistry laboratory as an economical and sustainable saving in the experimental development proposed in the practices laboratory of the subject of chemistry for engineering careers taught by the Technological Institute of Cancun. (See figure 5)

Figure 5 standard preparations for determination of NO3 and Cobalt by the UV method
Source: Own Elaboration

Results

The results of the analysis of the physical parameters of the samples are presented.

Sample	Temperature °C	CE (µS)	pH (ua)
A (interior of the chemistry laboratory)	19.7	10.83	8.52
B (outside of the chemistry lab)	19.7	22.3	8.3
C (from the electromechanical laboratory)	19.7	16.32	8.07
D (lavabo del laboratorio de química del agua)	19.7	766	7.53

Table 4 Results of the measurement of physical parameters
Source: Own Elaboration

Determination of Acidity and Alkalinity

Initially the titration of the titrants was carried out, considering the real grams titrated in a 10 ml aliquot, in order to perform the calculations of the concentration in units of equivalents per liter, we considered the grams titrated in the 10 ml aliquot, correcting in this sense any error that may exist in terms of weighing and / or preparation of solutions. Thus, the equations described below were used:

For the acid: considering 53 grams per equivalent of sodium carbonate (Na_2CO_3):

$$N_{HCl} = \frac{gr Na_2CO_3 \; x \; 1000}{ml.\, HCl \; tilizado \; x \; 53}$$

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For the base: considering 204.2 grams per equivalent of potassium hydrogen biphthalate ($C_8H_5O_4K$):

$$N_{NaOH} = \frac{grC_8H_5O_4K\ x\ 1000}{ml.NaOH\ tilizado\ x\ 204.2}$$

The results obtained from solutions prepared with water from air conditioning.

Title Solution	Normality (N)	Titled	Titled mass (g±0.0001)	Vol titulante (ml±0.1)	Titled titling concentration (N)
Hydrochloric acid	0.020	Sodium carbonate	0.0006	4.1	0.003
Hydroxide Sodium	0.02	Potassium bicarbonate acid	0.0042	10.1	0.002

Table 5 Calculation of the normality of the titulants to be used in determining acidity and alkalinity
Source: Own Elaboration

Results of concentration of acidity and alkalinity obtained for the different sample of water a practice of volumetry and gravimetry.

SAMPLE VOL.	Sample (ml)	Total Alkalinity mg/L CaCO3	HCl (ml±0.1)
A	10	3.26	0.2
B	10	2.80	0.2
C	10	2.80	0.2
D	10	26.09	1.9

Table 6 sample preparation for alkalinity determination
Source: Own Elaboration

Results of acidity and alkalinity concentration obtained for the different samples (see figure 6)

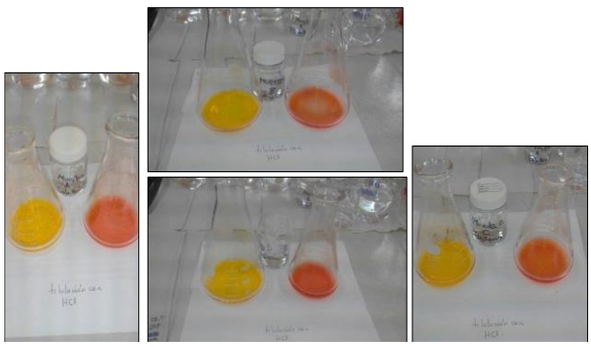

Figure 6 Methyl orange turn alkalinity determination
Source: Own Elaboration

From the results obtained, it is generally observed that the samples are more alkaline than acidic, mainly the sample D coming from the basin of the water chemistry laboratory, this result being consistent with the values of hardness obtained, where the sample D is definitely more hard, that is to say it contains more salts, and these salts are those that possibly contribute grade of alkalinity to the sample.

Acid base titration was tested for the determination of acidity, using different indicators, it is worth mentioning that the use of the indicator is important to locate the end point with greater or lesser precision, besides that the volumes in this case were small, resulting in more advisable the indicator of range of turn, ends that is to say, phenolphthalein that turns from acid to base and not inside ph acids like the orange of methyl. (See figure 7)

Figure 7 preparations of solutions with condensate water from air conditioners
Source: Own Elaboration

Determination of hardness

Calcium carbonate was evaluated, using the EDTA solution, to obtain the F factor from the following equation:

$$F = \frac{mg\ de\ solución\ de\ CaCO3}{2ml\ de\ EDTA\ utilzados}$$

We proceeded to titrate 25 milliliters of each sample, with the volume of EDTA used and the factor discussed in the previous point we proceeded to perform the calculation of total hardness with the equation shown below:

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$$Dureza\ Total \frac{mg}{L} CaCO3 = \frac{Vol.EDTA * F * 1000}{Vol.Muestra}$$

Where F is the factor that represents the equivalent in mg of CaCO3 per ml of EDTA. The results obtained are shown in figure 7 and table 7.

Sample Vol.	Sample (ml)	NaOH (ml±0.1)	total acidity mg/L CaCO3
A	10	0.3	3.4
B	10	0.1	1.0
C	10	0.1	1.3
D	15	0.0	0.0

Table 7 Preparation of the sample for the determination of the Acidity test With phenolphthalein (from colorless to red wine)
Source: Own Elaboration

Figure 7 hardness determinations
Source: Own Elaboration

As expected, the condensate samples from the air conditioners did not have high hardness values, the variations of the data fall within the margin of error since, when propagating these, the error occurs in the order of ± 0.01 mg / L in terms of CaCO3, so you could say that the water in these samples are not hard.

In the case of water from the basin of the water chemistry laboratory (sample D), a value of 0.90 ± 0.01 is obtained in terms of mg / L of CaCO3, thus noting that this water is harder than the others, due, possibly at the origin by virtue of the different salts contained in the well from which it is extracted or dragged through tanks and or pipes. A spectrophotometer of the brand Shimadzu, Mod elo UV-1800 was used (see figure 8).

Figure 8 Shimadu UV-183 spectrophotometer
Source: Own Elaboration

Determination of nitrate nitrate in water simples

Based on the provisions of standard NOM-AA-082-1986, solutions were prepared as shown in table 8, for the calibration curve, and measurement at 220 nm.

ID	Pattern	concentration concentration ppm	Concentration (M) 0 Mother Solution	Concentration µg N-NO3/cm3
Solution to fix HCl	4.15ml HCl concentrated in 50ml distilled water	-------	IN	-----
Mother KNO3 solution	192.1mg in 250m	768.4		1061
KNO 3 Standard Solution 0	50ml of mother in 500ml	76.8	0.01	0.6
		76.8	0.006	0.6
Pattern 1 of KNO3 Pattern 2 of KNO3	0.5ml mother in 25ml	1.5 0. 2	0	0.21 2
	1.5 ml mother in 25ml			
	3.5 ml mother in 25ml	14.6	0.00005	0.64
Patrón 3 de KNO_3	5ml mother in 25ml	10.76	0.0001	1.49
Patrón 4 de KNO_3	.5ml mother in 25ml	15.37	0.0002	2.13 5
Patrón 5 de KNO3 Patrón 6 de KNO_3	10ml mother in 25ml	723.05	0.0002	3.196
		30.74	0.0003	4.26

Table 8 preparation of standards for NO3 by the UV method
Source: Own Elaboration

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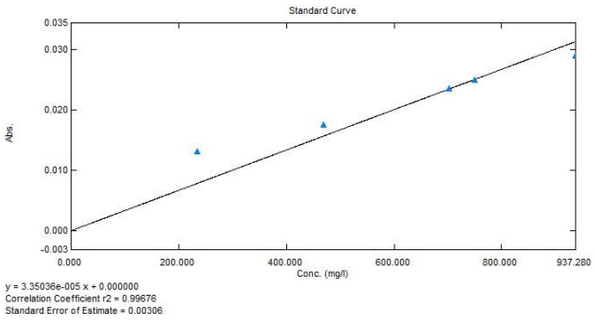
The absorbance reading of each of the standard solutions was performed, and with the software of the equipment a calibration curve was obtained with intercession adjusted to zero on the abscissa axis. In graph 1, the calibration curve obtained at 220 nm is shown



Graphic 1 *Calibration curve of NO_3 standards*
Source: Own Elaboration

Results of concentration of N-NO3 in µg / cm3 in samples at 220 nm

Sample Table

	Sample ID	Type	Ex	Conc	WL220.0
1	A	Unknown		0.051	0.016
2	B	Unknown		-0.014	-0.004
3	C	Unknown		0.318	0.099
4	D (tuberia lab procesos)	Unknown		1.047	0.327

Table 8 Results obtained from the N-NO_3 readings, at 220 nm the samples by the UV method
Source: Own Elaboration

It was expected that the condensate samples from the air conditioners do not present a nitrogen-nitrate concentration, however three of the three samples present nitrates, this is possible if the water drains salts and / or minerals present in the pipes through the which is downloaded. In the case of sample B, which is condensed water from the air conditioning taken outside the laboratory, at the outlet of the pipe where this sample was taken (see figure 9), presence of algae was observed, in this sense it is even possible that the nitrate of having been used as a nutrient by the plants present.

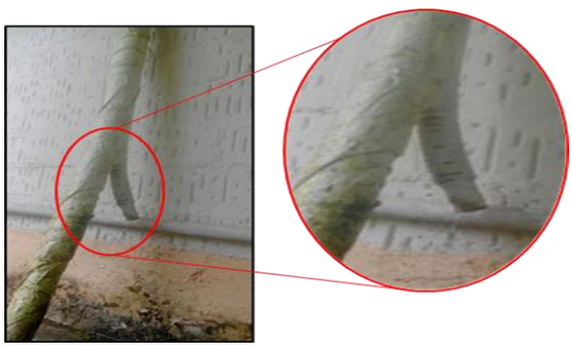


Figure 9 probable contamination of the sample
Source: Own Elaboration

In the case of sample D, a concentration was obtained that was much higher than the 0 value, which was expected considering that the sample was taken from a pipeline, from which it is presumed that the sample is usually stored for a time, as well as water possibly coming from well, which usually contains salts such as nitrates.

From the practices of chemical periodicity, chemical reactions, oxidation-reduction reactions, electrochemistry, silvery electroplating of an object, there was no interference that altered the process, (see figure 10).

Figure 10 Electro plated silver nitrate solution
Source: Own Elaboration

Acknowledgement

The TECNM / Technological Institute of Cancún is thanked for the support with the for the realization of this investigation in the facilities of the Chemistry Laboratory. In the same way the attentions and the facilities given to the Electromechanical Workshop are appreciated.

Conclusions

The degree of alkalinity, acidity and / or hardness of a water sample can allow us to establish coherence with the origin of this, and even possibility of contamination by external elements that should not be present and that affect these characteristics in the samples.

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Therefore, knowing the standards - methods that govern the determination of these parameters is very useful in the environmental analysis of water samples, and with it the appropriate assessment of the substances used to eliminate possible systematic errors committed in the weighing or other, as well as the selection of indicators on which we can rely with confidence to locate the end point of the degrees involved.

Sampling is a determining phase in the process of environmental analysis of a sample, so special care must be taken in following the appropriate protocols for that purpose. All sample taming must be designed prior to the analysis in order to have clarity of the study objectives and the ways of conservation of the sample.

From the samples of water taken, it was expected to have pH towards the acidity and low conductivities for the samples of the air conditioners, this by virtue of being practically distilled water, nevertheless the obtained basic pH could be due to salts and / or ions dragged from the pipes of such equipment; In this regard, it is expected that as long as the equipment receives periodic maintenance services and replaces hoses and / or pipes, the water could have characteristics closer to that of the distilled water.

In the case of sample D, water from a sink, it is definitely observed through the electrical conductivity, which has a higher quantity of dissolved ions, either by treatments subsequent to the well extraction process or by the intrinsic characteristics of the well water.

UV-Visible spectroscopy is a very useful technique for the characterization of water, which is directly dependent on the objective of a research and the elements or chromophores that are to be detected.

The condensate water from air conditioners is possibly contaminated with nitrates during the passage through the pipes.

When the silver nitrate solution is prepared and the water does not have the required properties, the solution acquires a whitish hue indicating that the water contained minerals or the presence of chlorides. Turning black, interfering with the reactions.

The use of condensed water from air conditioners is a type of water suitable for use in academic laboratories that do not require a 99.999% purity quality, to perform the experiments, it is also free and does not generate an additional cost to perform the tests chemistry lab practices, the cost of a 20-liter jug has a cost of 210 pesos, the Tri-distilled water used in special analyzes 20-liter drum has a cost of $ 235. (see table No. 9)

Type of water	Water generated	Water costs	Amount of water in ml consumed Per semester	Savings in distilled water consumption.
Distilled	We do not have a distiller	215 x 20 liter jug	100 liters	100%
Condensate of the air	Water generated per day 20 liters	Free of charge	Water generated contributes the necessary amount for the supply of water	

Table 9 reduction of costs in the consumption of distilled water
Source: Own Elaboration

The uses that are given to the condensed water of the air conditioners are washing floors, bathrooms, water for the plates, the engineers of the electromechanical laboratory, use it in the radiator of their car. The environmental impact would be in saving the consumption of distilled water and energy when the institution has a distillation system, in addition to having an impact on the educational environment, which could be used in basic and basic education laboratories.

The characterization of the physical parameters was based on some chemical parameters according to the Mexican water standards, some of them are from 1986, 1991, they are still valid, for the analysis of water quality according to the official newspaper of the federation there have been modifications to those standards.

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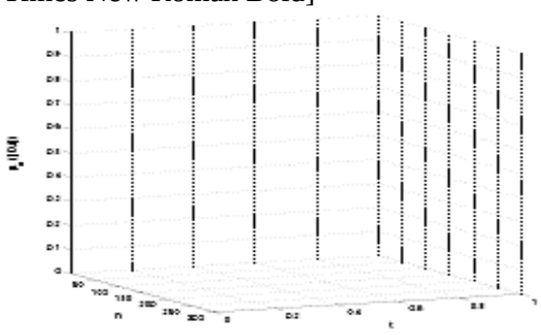

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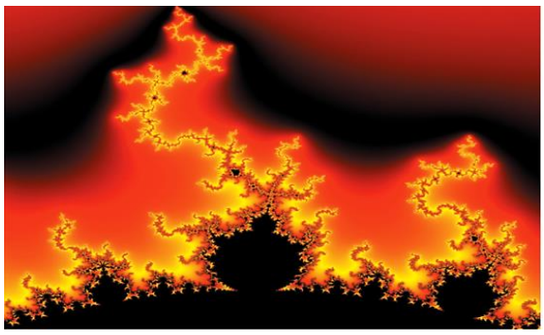

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