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Escuela Académico Profesional de Ingeniería Ambiental

Tesis

Analysis of Dispersion of the Pollutant PM2.5 by the La Leña Poultry Shop with the Langrangian Model in the Province of Huancayo, 2020

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Para optar el Título Profesional de
Ingeniero Ambiental

Huancayo, 2024

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Analysis of dispersion of the pollutant PM 2.5 by the "La Leña" poultry shop with the Langrangian model in the province of Huancayo 2020

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Abstract. In the present work we seek to analyze the dispersion of the PM 2.5 pollutant by the "La Leña" poultry shop with the Langrangian model in the province of Huancayo in the year 2020, for this the dispersion of the PM2.5 pollutant was simulated with the Lagrangian Method and the GRAL model This is a model developed by the Technological University of Graz Switzerland that simulates atmospheric pollutants emitted by fixed sources, it was elaborated using meteorological data that were pre-processed according to the requirements of the GRAL program, the mathematical calculations of the estimation of the emission, exit velocity and volumetric flow, the minimum PM2.5 concentration was determined with 0.14523 µg/m3 of concentration in the same emission source, this is due to the speed and direction of the wind that disperses this pollutant from the same source, in the same way the highest concentration was registered, which was 0.82253 µg/m3 located in the Plaza Constitución. Likewise, it is concluded that according to the direction of the wind and therefore where there is more concentration is in the West Northwest zone of the fixed source of emission.

Keywords: PM2.5, concentration, pollutant, emission, dispersion, GRAL model.

1 Introduction

Air pollution is a global problem, one of which is particulate matter pollutants (PM 2.5), which is present in different cities around the world, characterized by being small particles reaching a size of 2.5 micrometers, produced as a result of combustion processes and industrial activities. As time passes to the present, in the field of atmospheric particulate matter research, the adverse effects of this pollutant are being identified, both on the ecosystem and on health (1).

The rapid development of industries and urbanization has become an environmental problem by polluting the air, particles such as PM 2.5 suspended in the air of the atmosphere contain organic and inorganic pollutants including heavy metals; PM 2.5

has a chemical composition that is generally dependent on an emission source (2). Particulate matter is a very complex mixture of solid and liquid particles, these two present in the air plus the mixture of the chemical composition represents an even greater complexity (3).

In the city of Huancayo in recent years the population growth has been considerable and for this reason many businesses such as restaurants have been established in the center of the city, one of these businesses are chicken shops with artisanal ovens, due to this in the province In Huancayo, it has been observed that the population prefers charcoal-roasted chicken, a reason that prompted the increase in poultry shops, which have a high demand for sale and accessibility in restaurant markets. This gastronomy activity leads to contamination by particulate matter, because many times these poultry houses use coal to roast the chickens, which, when it combusts when burning the coal, generates emissions and is then expelled through chimneys causing different pollutants such as PM2.5, PM10, NOx , CO which, according to studies carried out on some of their compounds, showed that some of these can cause cancer.

The present work includes the issue of PM2.5 particle emission by the "La Leña" poultry shop in the province of Huancayo; PM2.5 concentrations are "The main agents that alter a radiation balance, visibility reduction and regional haze pollution are aerosols comprising more than 50%" we can mention that particulate matter has effects on human health ; since it is very harmful, it causes respiratory diseases (4). Likewise, the study seeks to measure the emissions of a certain pollutant, such as particulate matter 2.5, using the GRAL model to simulate air pollutants emitted by specific sources, compare the results obtained with the Environmental Quality Standard in Air, the study carried out will reveal the concentration of PM2.5 emissions and their dispersion.

Also in the work he seeks to understand the concentration of pollutants in the surroundings of the "La Leña" chicken shop. For which we will address in the first part the geographical description, emission of the place of study, the meteorology, the use of the GRAL model and the Langragian model, for this, pre-processed meteorological variables will also be used. The second part covers the analysis of the results obtained through the data obtained by the methodology used. Finally, the presentation of the discussions and conclusions.

2 Methodology

2.1 Description of the place of study

The place of study was carried out in the province of Huancayo, at the UTM coordinates: Abscissa 477211.00 m E and North 8665911.00 m S, it is located at an average altitude of 3249 m asl, with a population of 845,615 inhabitants, it is located in the Mantaro Valley 419.41 km. Huancayo is located in the middle of the valley between the central and western cordillera, being the largest valley in the entire country, Huancayo with its temperate sub-humid climate, the temperature varying between 28 degrees Celsius during the day and -5 degrees Celsius at night, the seasons lowest are recorded in the month of June to August. Having a maximum temperature of 16.9

degrees Celsius per year and temperatures min. Of 6.3 degrees Celsius, the total precipitation was 936.1 millimeters per year.

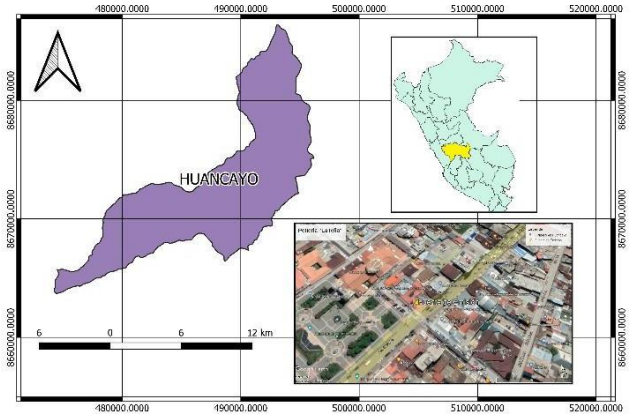

Fig. 1. Location of the fixed emission source "Pollería La Leña"
Source: Self made

2.2 Poultry issue description

In the study that was carried out on the poultry shop called "La Leña" it was necessary to collect information on the characteristics of pollutants that it generates daily, the research was carried out in an urban environment, for this information is needed on the characteristics of the source of emission, which in this case is poultry, said this, the height of the chimney, the diameter of the chimney, outlet temperature and velocity of pollutant outlet are needed, likewise it is necessary to collect information on the concentration of PM $_{2.5}$ (the unit of the activity, emission factor and emission).

2.3 Description of the weather

Information from the meteorological station of the Continental University called "Portable UC" was used, which is located 478354.35 to the East and 8668231.34 to the North. The samples were taken on February 14, 2020, from the hours that the facility operates, which is from 11:00 a.m. to 10:00 p.m., the variables of the weather station that were used for the investigation were: the day, the time, wind direction, wind speed and radiation.

2.4 Stability

For atmospheric stability that can be associated with the temperature gradient, compared to the ambient temperature gradient is the adiabatic dry temperature gradient. Under adiabatic conditions, a warm volume of rising air behaves like a balloon. It will expand until its density matches that of the surrounding air (5)and for this investigation we will pull data from the “Portable UC” weather station.

2.5 GRAL model description

The GRAL model (Lagrangian Model) is a model developed by the Technological University of Graz Switzerland, it simulates air pollutants emitted by fixed sources, air source and mobile source by providing a certain concentration, the pollutants released into the atmosphere, according to the standards of environmental air quality in reference to those established by environmental laws, have environmental impacts that can affect human health such as respiratory diseases and alter air quality. This model allows input of weather data so you can measure the profile of pollutants. To carry out the PM2.5 modeling, the chimney data was entered (chimney height, chimney diameter, outlet temperature, gas outlet speed) and the meteorological data that are: wind direction, wind speed and stability. (6)

2.6 Normativity

It is important to take into account the parameters established by the Ministry of the Environment of the Environmental Quality Standards for air; In order to analyze the contamination of the stationary emission source, see Table 1.

Table 1. ECA air

Pollutant	Chemical formula	Value (ug /m3)	Period
Nitrogen dioxide	NO2	200	average in 1 hours
		100	annual arithmetic mean
Particulate material with a diameter less than 10 microns	PM2.5	fifty	Arithmetic mean in 24 hours
		25	annual arithmetic mean
Carbon monoxide	CO	30000	average in 1 hour
		10000	average in 8 hours
Sulfur dioxide	SO2	250	Arithmetic mean in 24 hours

Ozone	o3	100	average in 8 hours

Source: RMCA. Environmental Law No. 1333.

2.7 Process

In the first place, the information was organized and collected, in this case from the fixed emission source "Pollería La Leña", data such as the height of the chimney, the diameter of the chimney and the temperature, then the pre-processing of the meteorological data obtained from the "UC" station to find the stability, once we had all the necessary data we fed the data at the source and finally generated the dispersion model of PM2.5 particulate matter.

Activity unit. The activity unit is the number of kilos of meat produced from the time it starts operating until the establishment closes.
To obtain this information on how much it produces per day or how many kilos per day the poultry farm generates, it was necessary to go to the source and collect the information, likewise it was necessary to produce 300 chickens per day and each one has a weight of 1 .85 kg which, when multiplied, gives us that they produce 555 kilos for the 11 hours of operation

Emission Factor (EF). For the emission factor, we also had to resort to bibliographic data from studies carried out worldwide, which when we investigated we found in an article entitled "EMISSIONS FROM CHARBROILING AND GRILLING OF CHICKEN AND BEEF", see table 2.

Table 2. Emission factor

EMISSION FACTOR		
APPLIANCE AND MEAT	(g/kg of meat)	Font
Grill-25% Fat Burger	15.0	Current study
Grill-25% Fat Burger	32.7	Norbeck et al.
Grill-25% Fat Burger	40.0	Hildemann et al.
Grill-25% Fat Burger Auto	18.0	Schauer et al.
Grill-21% Hamburger Fat Auto	4.5	Current study
Grill-21% Fat Burger	7.4	Norbeck et al.
Grill-21% Fat Burger	7.1	Hildemann et al.
Grilled-chicken with skin	7.2	Current study

Grilled chicken with skin	10.4	Norbeck et al.

Font: Emissions from charbroiling and Grilling of Chicken and Beef

The emission factor is a very important tool that is used to estimate emissions from the source. In this case, we are considering 10.4 g/kg of meat for poultry.

Emission estimate. Taking into account the values of unit of activity and emission factor, we can now find the emission of the pollutant, for this we have the following formula:

$$E = A(FE) \quad (1)$$

$$E = 555\ \frac{kg}{11}\ x\ 10.4\ \frac{g}{kg}$$

$$E = 5772\ \frac{g}{11}$$

$$E = 524.74\ \frac{g}{Kg}$$

$$E = 0.52474\ \frac{h}{}$$

Output speed. To determine the outlet speed of the source through the chimney, it was necessary to look for data on the volumetric flow, for which reason in the article " Emissions from Charbroiling and Grilling of Chicken and Beef" information, it was found that the volumetric flow is 40 m^3 /min. Likewise, the measurement of the diameter of the chimney was made, which is 0.60 m.

With these data obtained, it was replaced in the following equation to obtain the output speed, which must be represented in meters per second (m/s)

$$v = \frac{Volumetric\ flow}{\frac{\pi\ x\ (Diameter\ of\ Chimney)^2}{4}} \quad (2)$$

$$v = \frac{40m^3/min}{\frac{\pi\ x\ (0.60m)^2}{4}}$$

$$v = 141.47\ \frac{m}{min}$$

$$v = 2.358\ \frac{m}{s}$$

Execution of the GRAL Model. To start the GRAL Model program, the information already collected previously must be established, see table 3, all this information will be entered in the configuration of the point source.

Table 3. General data

PM2.5 emission	**0.5247kg/h**
chimney height	10m
output speed	2.4m/s
outlet temperature	550
chimney diameter	0.60m
source location	477268.9 8665956

Source: Self made

Likewise, a satellite image is needed to simulate the dispersion of the pollutant around the fixed source and it is necessary to georeference with two points to have the exact location, see figure 3.

Figure 2: Georeferencing of the emission source.
Source: Google Earth

The meteorological data must have a structure designed to be processed by the program, the template must be in an xlsx file. Table 4 shows you how it should be structured.

Table 4. Structuring of meteorological data.

Day.month.year	Hour	speed _ m/s	Dir.	Stability

14.2.2020	11:30 a.m.	1.9	354	4
14.2.2020	11:40	7.9	327	4

Source: Self made

The meteorological data have an interval of 10 minutes from the beginning of the operation of the establishment, which is at 11:00 am. Until 10 o'clock p.m.

3 Results

Figure 3 shows the results in the analysis of the speed and direction of the wind in the wind rose for the emission source.

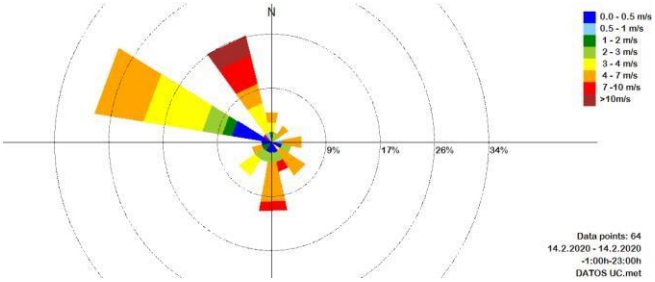

Figure 3: Wind rose
Source: Self made

Table 5 and Figure 4 indicate that the most constant speed is 4 - 7 m/s with a value of 31.3% and the least constant speed is > 10 m/s with a value of 3.1%.

Table 5. Wind speed

WIND SPEED	
0 – 0.5m/s (%)	14.2
0.5 – 1m/s (%)	3.2
1 – 2 m/s (%)	6.4
2 – 3 m/s (%)	12.7

3 – 4 m/s (%)	20.4
4 – 7 m/s (%)	31.3
7 – 10 m/s (%)	9.5
> 10 m/s (%)	3.1
ADDITION (%)	100

Source: Self made

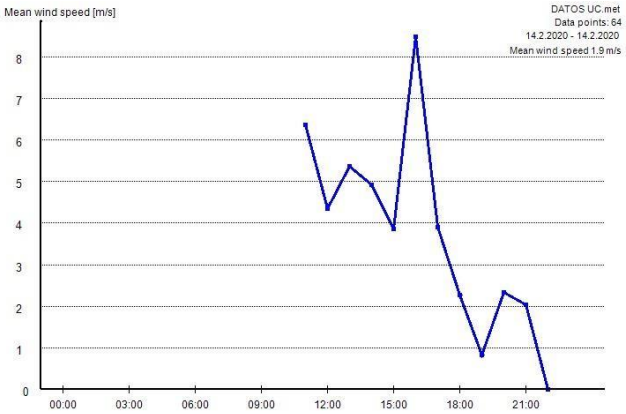

Figure 4: Average wind speed
Source: Self made

Likewise, in the direction of the wind there are the following values, see table 6, and in figure 5 it indicates the direction of the wind, likewise it is observed that for the WNW it has more consistency with 28.1% and for the SSE and the ENE is with 0%.

Table 6. Wind direction

DIRECTION OF THE WIND	
N	4.7
NNE	1.6
NE	3.1
ENE	0
E	4.7
ESE	1.6
SE	3.1

SSE	0
S	4.7
SSW	3.1
SW	6.2
WSW	3.1
W	1.6
WNW	28.1
NW	1.6
NNW	17.2
ADDITION (%)	100

Source: Self made

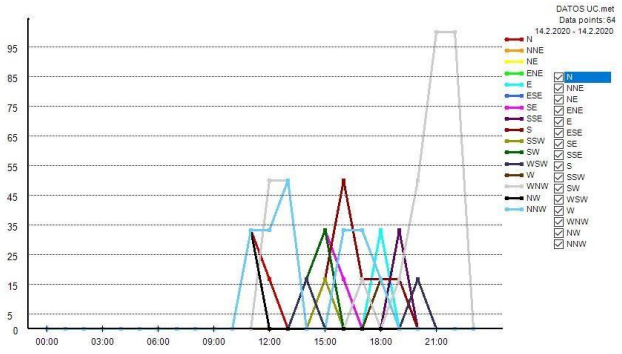

Figure 5: Wind direction
Source: Self made

Figure 6 shows us the dispersion modeling in the GRAL, it gave as results that it covers a large part of the center of the district of Huancayo has an exposure of 11 hours, where in the same emission source it has a concentration of PM 2.5 with 0.14523 µg/m ^{3} , analyzing the places frequented by the citizens of Huancayo such as the Constitución Park, the dispersion of the pollutant reaches a concentration of 0.82253 µg/m ^{3} , likewise there is an educational institution close to the emission source, the concentration of the contaminant to this institution called "Rosario" is 0.20805 µg/m ^{3} , as there is also the El Carmen hospital, it is minimal and its exposure to this contaminant since it reaches a concentration of 0.07027 µg/m ^{3} , the model market is close to the emission source which is considerably the place where the concentration of people is more where this said place has a contaminant value of 0.6947 µg/m ^{3} , likewise the main stadium of the city of Huancayo reaches a pollutant concentration of 0.51186 µg/m ^{3} , in the southern zone as well as in the northern zone, about 3 blocks from the emission source, they have

the highest concentration of pollutant, which is 0.34407 μg/m ^{3} and 0.32578 μg/m ^{3} respectively.

4 Conclusions and discussions

It was possible to develop a simulation modeling of the dispersion of the PM2.5 pollutant from a fixed emission source called "Pollerías La Leña" located in the center of the city of Huancayo, using the Langrangian method and the GRAL model, for which it was necessary to processing of the variables of the meteorological data collected from the "portable UC" station.

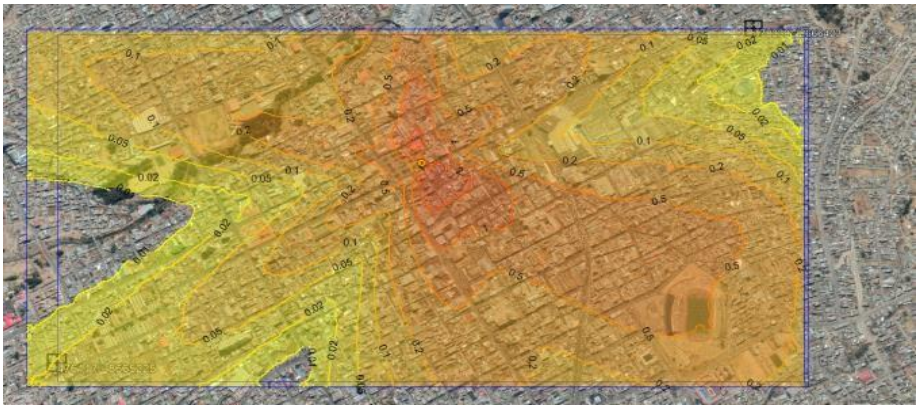

Figure 6. Modeling the dispersion of the PM2.5 pollutant
Source: Self made

The direction of the wind was determined and therefore where there is more concentration is in the West Northwest zone of the fixed emission source.
The concentrations of PM2.5 were determined in the same emission source 0.14523 μg/m3, in the Plaza Constitución 0.82253 μg/m3, in the nearest educational center the "Rosario" school 0.20805 μg/m3, in the Regional Maternal Teaching Hospital Children 0.07027 μg/m3, in the Mercado Modelo 0.6947 μg/m3, in the Huancayo Stadium 0.51186 μg/m3, in the South zone and North zone about 3 blocks from the emission source 0.34407 μg/m3 and 0.32578 μg/m3 respectively.
It should be noted that the minimum concentration of PM2.5 was 0.14523 μg/m3 in the same emission source, we can deduce that it is due to the speed and direction of the wind that disperses this pollutant from the same source, in the same way the highest concentration that was 0.82253 μg/m3 located in the Plaza Constitución.
Taking into account that the emission is only from a fixed source that is La Pollería La Leña, we conclude that it does not exceed the ECA of the air for the PM2.5 pollutant, since according to Table 1 the maximum concentration in one day is 50 ug/m3 and according to the results of the simulation obtained, the highest concentration at a point close to the source was 0.82253 ug/m3, then we can also conclude that if the investigation had been from various sources, the results of the concentration of the PM2.5 pollutant in the simulation would have exceeded the ECA of the air, but if it had been much higher than our result.

Making a comparison with an article written by Irving Jesus Lizarraga Isla in the city of Huancayo, we used a single source of data reception, which is the UCI Meteorological Station, however, in the article by the aforementioned author, 3 different stations were used, located in different parts of the city of Huancayo, in which without a doubt they obtained different results for a single source, then we can say that our station provides true data and therefore a simulation closer to reality since it is located only 3.4 km away, compared to the other investigation where the closest station to its source is 7.3 km away.

Reviewing the Langrangian model that we applied and the AERMOD model that was used in other investigations, both give us a simulation of the transport and distribution of pollutants emitted by emission sources, however, the Langrangian model proved to be more efficient in giving us the results and also be more accessible because less information is needed to process in the program compared to the AERMOD model than if it requires it.

In comparison with investigations carried out in Huancayo, it is observed that the activity of the operation of artisan ovens, the emission of PM 2.5 from the poultry houses has a value of 7,236 kg for the year 2017 and in the calculations of our investigation the emission of pollutant per hour of operation is 5.77 kg for the year 2020 these aforementioned emissions are concentrations where it can affect human health in the long term, affecting the respiratory system, likewise this can be deduced that it depends on the speed of the wind and the direction of these pollutant will expand or distribute throughout the environment of the emission source with great difference to 2020, due to climate changes the speed and direction of the wind are directly affected, so it makes it have a more distant reach where this emission can affect the population who lives or transits through the area of the source.

References

1. Levels, composition and origin of atmospheric particulate matter in the North and East sectors of the Iberian Peninsula and the Canary Islands. Rodríguez, María del Mar Viana. Barcelona : CSIC, 2003.
2. Heavy metals and their source identification in particulate matter (PM2.5) in Isfahan City, Iran. Mohsen, Soleimani, Nasibeh, Amini y Babak, Sadeghian. Irán, China : ELSEVIER - Journal of Environmental Sciences, 2018.
3. Chemical characterization of atmospheric particulate matter in the urban center of Huancayo, Peru. Suarez Salas, Luis, y otros. Huancayo : Revista de la Sociedad Química del Perú, 2017.
4. Dispersion of particulate material 2.5 emitted by roasted chicken restaurants using the AERMOD model in Huancayo, Perú. Lizarraga Isla, Irvin Jesus, y otros. 211, Huancayo : DYNA, 2019, Vol. 86.
5. Evaluation of Atmospheric Stability in Physical and Weather Conditions. Haro Velastegui, Arquímides Xavier, y otros. Ecuador : Brazilian Magazine of Meteorology, 2018.
6. GRAL Model Dispersion. K, Markus, R., Raphael y Github. s.l. : Free Software Foundation, 2007.
7. Emissions from Charbroiling and Grilling of Chicken and Beef. McDonald , Jacob D., y otros. Nevada : Journal of the Air & Waste Management Association, 2012.