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A Context Vision

THE PM10 POLLUTANT AND IMPACT ON HEALTH IN THE LOCALITY OF TUNJUELITO

EL CONTAMINANTE PM10 Y EL IMPACTO EN LA SALUD EN LA LOCALIDAD DE TUNJUELITO

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Abstract: This article reflection, arises from the need to frame the concept quality of life with environmental improvements due to growth and economic boom, where the capital faces a high population density and the sharp increase in the vehicle fleet, thus increasing levels emission of air pollutants. analyzing the effects of urban pollution on human health obtaining real-time data, network monitoring air quality in Bogota (RMCAB) of the TUNAL station was performed and the relationship between pollution was established by particles PM10 road traffic and respiratory and cardiovascular diseases, of the inhabitants of the town, comparing the data with records subaddress Public Health Surveillance ERA, the Hospital El Tunal, achieving arguments that air pollution of PM10 causes respiratory problems and cardiovascular diseases, which in effect constitutes a public health problem for Bogota

Key words: Air, Air pollution, environmental impact, environment, health Policy.

Resumen: El presente artículo de reflexión, surge de la necesidad de enmarcar el concepto calidad de vida con mejoras ambientales debido al crecimiento y auge económico en donde la capital del país afronta una alta densidad poblacional y el aumento desmedido del parque

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automotor, acrecentando así los niveles de emisión de contaminantes atmosféricos. Se realizó el análisis a los efectos de la contaminación urbana sobre la salud humana obteniendo datos en tiempo real de la red de monitoreo de la calidad del aire para Bogotá – Colombia (RMCAB) de la estación TUNAL (Bogotá) y se estableció la relación entre contaminación por partículas de PM10 del tráfico rodado y las enfermedades respiratorias y cardiovasculares de los habitantes de la localidad, contrastando los datos obtenidos con registros de la subdirección de Vigilancia en Salud Pública “enfermedad respiratoria aguda’’ ERA del Hospital El Tunal, logrando argumentar que la contaminación del aire por material particulado PM10 genera problemas respiratorios y cardiovasculares, que en efecto, constituye un problema de salud pública para Bogotá.

Palabras clave: Aire, contaminación atmosférica, impacto ambiental, medio ambiente, política de la salud.

1. **Introduction:**

The atmosphere, understood as the gas layer that surrounds our planet, cannot be interpreted as a passive entity of the phenomenon of atmospheric pollution, because all the meteorological variables play a great role in the evolution and dispersion of the pollutants in the air; for example, the wind, the humidity, the thermal inversion and the precipitations determine that at a certain moment the decrease or the increase of contamination. The wind usually favors the diffusion of pollutants, whereas the humidity does not favor it because it produces accumulation of fumes and dust existing in the air. The RMCAB analyzes in real time suspended particles of different sizes (PM10, PST, PM2.5), pollutant gases (SO2, NO2, CO, O3) and meteorological variables such as precipitation, wind speed and direction, temperature, solar radiation, relative humidity and barometric pressure, aware of the interaction of these components in the atmosphere and the effects that pollution brings to

human health. This reflective paper focuses its attention on PM10 particulate matter. The particulate material is presented as solid or liquid particles capable of infiltrating the airways and causing significant respiratory and cardiovascular damage[1] (The size of these particles, oscillate with a diameter of 2.5 to 10 μm, where one micron is one thousandth of a millimeter). The particles studied for this case are those of diameter less than or equal to 10 microns; the PM10 is also called respirable particulate material because it is able to enter the respiratory system of the human being.

The Colombian capital is currently part of the Decennial Atmospheric Decontamination Plan for Bogotá (PDDAB) to evidence and justify the problem of air pollution in the city. The Percentage Exceedence Index is used, where this index was proposed for the development and monitoring of it (IPE – see Gaitán et. al., 2007). This is a indicator (see Equation 1) that compares data network monitoring air quality available for Bogota (RMCAB) with the national air quality standard and quantifies the level of non-compliance.

$$IPE = \sum_{1} \left(\frac{N_E}{N_D} \right) * 100$$

Equation 1. Percentage of Exceedances Index (IPE)

Where N_E is the number of times air quality data (eg, hourly averages, daily averages) exceeds the standard used for reference (eg, annual standard, daily standard), and N_D is the total number of data available for each of the stations (i) of the network.

Taking as reference this indicator for the entire city of Bogotá, we analyze the main pollutants criterion: CO, O3, NO2, SO2, PM10 [2] and based on data from the RMCAB from 1997 to 2008, and it has shown that the main pollution problem facing the city has to do with particulate matter [3], reporting a level of non-compliance of 40%, which is why it is the

pollutant with greater non-compliance with the air quality standard, and therefore the most relevant. [4] [5].

The problem of transport in the town Tunjuelito has several variables that affect pollution [6]: such as the types of fuels, the age of motor vehicles that intrinsically includes the technology being used, driving behaviors, the number of vehicles passing at a particular road, the population density of the vehicle, environmental factors, as well as the vulnerability of these to be altered, among others. Each of these components must be taken into account for any decision regarding the environment and the health of the population, taking into account that the high concentrations of particulate matter and tropospheric ozone (O3) [7], which exceed air quality standards, are associated with an excess of mortality and morbidity of the population due to respiratory and cardiovascular diseases [8].

According to the records of the District Health Office for Bogotá (SDS), respiratory disease is the main cause of infant mortality in the city; it is known that in the Colombian capital there are concentrations of particulate matter that surpass the recommendations given by the World Health Organization [9] [10].

Question and Justification:

Environmental health is directly related to the performance and interaction of the human being, with the set of diverse constituents that are presented in the environment, the Indicators that allow the construction of the Environmental Performance Index (EPI) for Colombia in 2012 are mainly the components:

- Enviromental health
- Effects of air pollution

- Effects of water pollution
- Burden of disease associated with the environment
- Ecosystem vitality [11]

Being that the item effects of air pollution the most relevant for the environmental health issue, altering the timely condition of favorable environmental conditions.

In order to guarantee the conditions of health and clean air for the citizens, is governed through the political constitution of the Republic of Colombia Article 79 [12] Where it states that "All people have the right to enjoy a healthy environment", the main physiological need to breathe necessarily involves an acceptable air quality; the greatest concern is to establish reliable and measurable standards of air pollution, which will undoubtedly be more strongly positioned in future times, owing to the significant increase in the limits of the permissible concentration of pollutants likely to cause variations at the systemic level; the adoption of policies to reduce emissions of potentially harmful pollutants is focused and made structural through the integration and characterization of appropriate cleaner technologies such as fuel switching, control of emission reduction through the control of emissions of gases emitted to the atmosphere [13], control of mobile and fixed sources, the application of “pico y placa” measurements and environmental for public transport and freight vehicles, and compliance with the Bogotá air quality pact signed with Ecopetrol, thanks to which obtained a sulfur content in diesel below 50 parts per million (ppm) and further states that the responsibility should go beyond compliance with existing environmental standards, ie it is proposed to include guidelines social responsibility, because air pollution represents a significant environmental risk to the health of the local population, and it is essential to reduce the levels of air pollution, in order to contribute to the quality of life of the inhabitants [14]

For the network of hospitals in the city of Bogotá, an entity attached to the district health office of the mayoralty of Bogotá, in the case of Tunjuelito mayoralty promotes the "District Environmental Health Policy for Bogotá [15], 2011 -2023 " given in Decree 596 of 2011, which has as its fundamental objective the implementation of guidelines of the same in the relevant conditions of environmental health to enjoy a healthy environment and prevention of potential diseases.

The incidence of the PM10 pollutant in the environmental health of the population under study is attributed to transportation and mobility, generated by the locality and its complexity [16], several of the environmental and health risks facing the population close to the Tunal station. Daily in a local context and studied under a prudent and uniform period of time, with the purpose of generating significant arguments that allow the population to present different levels of vulnerability in terms of PM10 exposure [17], it should be noted that in general, for emissions to have adverse effects on health, they must comply with a process line in which the PM10 has a life span in the environment and directly and indirectly affects the health of the community, this includes the following items:

1. Concentration of pollutant (mass per time) [18]
2. Inhaled fraction (inhaled mass per emitted mass) [19]
3. Toxicity (impact on health by inhaled mass) [20]

The justification that can be established of the intrinsic relation between quantity of emissions and effects to health is shown through figure 1.

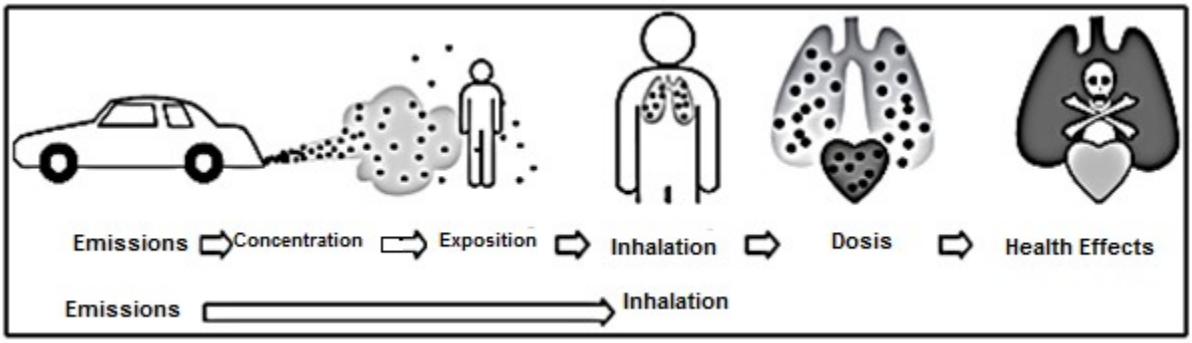

Figure 1. Relationship between air pollution and health effects of emissions [21].

The most frequent illnesses found in the Tunal hospital, in Bogotá's third level, are respiratory diseases such as Acute Respiratory Infection (ARI) which presents a specific symptomatology, such as: Frequent cough, phlegm, shortness of breath, and are the reasons why most of the population visit the hospital on a daily basis. It also increases the probability of premature death in any age group; the development of frequent illnesses in each medical health center exacerbates their numbers: asthma, bronchitis, emphysema, pneumonia are the group of diseases that face 7,878,783 inhabitants of the city of Bogotá [22] and more specifically the 201,230 [23] inhabitants of the sixth locality of Tunjuelito. [24]

The breathing rate is the indicator of lung function, which normally ranges from 10 to 12 breaths per minute in resting state for adults [25], the main influence on the same is the PM10. Particles with a diameter of 10 microns are the most dangerous, and represent the greatest vulnerability to health because when they inhaled they accumulate in their respiratory system causing severe injury or damage to the basic and vital functioning of the human being; the distribution of these particles within the lungs is given according to the size of the lung, allowing direct and deep incidence in the lung alveoli, the patient presents strong permanent damage as well as reduction of respiratory capacity [26].

Among the diseases of major environmental importance, are directly related to previous exposure to a contaminated environment, which can be detrimental to the development of human health [27]. According to epidemiological studies carried out by the District Health Secretariat of Bogotá, the exposure of age groups of children under 5 years of age, which are more directly exposed to places where PM10 concentration levels have high pollution levels.

79.6% of children show greater complications, becoming more aggravating pulmonary diseases. The main effects on lung function are the reduction of the normal flow in the passage of air, the narrowing of the airways, the inflammation and subsequent infection of the airways, due to various particles that infiltrate the respiratory system, increase of mucus production, liquid and swelling of the edema, cause the loss and death of diverse cells that line the airways [28], due to direct exposure to contaminated air and increasing the likelihood of abysmal respiratory infection [29].

This paper is structured in a summary of this, a previous introduction with a focus on the PM10 as pollutant and the impact on health and environmental impacts, is composed of: study methods with their three respective stages and phases of each one. The interpretation and work in the section results and discussion of the compilation of the data obtained quantified and qualified according to the population sampled and the conclusions obtained in the following item are developed. In the history of research on studies carried out in the city of Bogotá similar to the same theme is the "relationship between PM10 and acute respiratory infection in children aged 0 to 5 years in the locality of Kennedy Bogotá D.C in 2008" developed by University of Environmental Applied Sciences of the faculty of Health Sciences as well as “relation between PM2.5 y PM10 in the city of Bogotá” whose authors are Néstor Rojas and Boris Galvis of the University of Los Andes. Punctually we identify that the radical article differentially to the two mentioned above in the methodology used and the results

obtained as well as the variables analyzed and their applicability to the technological field and implementation of measures in the set of items studied, as well as the analysis of the type of socio-environmental impact in the locality that presents higher pollution levels of PM10.

2. Implemented methods

Mainly, the issue of air quality is addressed under a scholarly approach to the predominance of environmental health; was determined that the area of direct influence is framed in the locality of Tunjuelito, Altitude: 2,502 msnm, Latitude: 04º 34 '00 "N, Longitude: 074º 07' 59" W of the city of Bogota and the various aids such as the modern air quality monitoring network (RMCAB) [30], which is in charge of monitoring the concentrations of the different pollutants in real time, so the information provided by this monitoring network was used to establish the pollution trends in the city and to understand the variables that determine those trends, which Are part of the integrality of the set of tools for the conformation of the same.

It resides within three investigative stages that start from two phases each, which allowed a joint or general scope, emphasizing the results obtained in a precise way in each of them:

2.1 STAGE OF REVIEW OF DOCUMENTATION: The first stage was responsible for the collection of the data generated and in which an exhaustive search of the information was carried out in different governmental entities, which provided the different requirements for all requested information such as the hospital network, network of air quality monitoring, secretary of mobility, 50 commercial establishments, minor mayoralty in the town of Tunjuelito, ministry of environment and sustainable development, community bordering the Tunal station.

Within this point stage we took into account the different propitious values for the selection of information composed of two phases:

• Quantitative phase: in which it was inquired about the existence of different data and statistics provided by the daily RMCAB, and the influence in particular of the statistics consulted in the Tunal hospital according to the indicators of the presence of respiratory diseases in the Locality of Tunjuelito [31].

• Qualitative Phase: it was defined within the framework of the collection of the information given by the different entities, afterwards a comprehensive analysis of the information obtained was done, concisely relating the degree of affinity between the same, for our object of study, as well as previous visits To several sectors of the locality, mainly 100 meters around the Tunal station of the RMCAB, conducting a survey with objective questions to the surrounding population easily understood with a sample size of 200 people randomly chosen.

2.2 ***FOLLOW-UP AND MONITORING STAGE***: This stage consisted in the development of the modeling of the data obtained previously, according to the determined evaluation period which was two months; in this stage the control of the documentation was carried out and it is composed of two phases:

• Systematic control phase: Systematic control of the database provided by the air quality monitoring network was studied daily in order to have the relevant numbers, since it was possible to verify the inconsistency of the data in a 60 days period: From Sunday to Sunday period between October 20, 2015 to December 20, 2015.

• Phase of impact analysis of PM10 pollutant: this being the pollutant that affects in greater proportion to the locality of Tunjuelito, more exactly in the specific location of the Tunal station. PM10 was found in small solid or liquid particles of dust, ash, soot, metal particles, cement or pollen [32], these are dispersed in the atmosphere and are mainly

composed of inorganic compounds such as silicates and aluminates, heavy metals among others and organic material associated with carbon particles (soot). Given this, PM10 is a major cause of different impacts on human health, as well as influence on environmental factors [33].

2.3 STAGE OF INTEGRALITY AND ANALYTICAL-SCIENTIFIC PRODUCTION OF RESULTS: The final result of the analysis and the research work of the database is the approach of this paper and given the current and global situation of air pollution in the sixth Tunjuelito locality, where the economic resources are low, the pollution indices are high; the influence of environmental impacts of different sources is notorious and in which different nodes of environmental agents are evidenced that intensifies daily, the concentration of pollutants as it is the PM10. This stage was carried out in two phases: Phase of feasibility and Phase of results. [34].

- Feasibility phase: the statistical analysis of each of the age groups was performed, specifying the time of day determined, followed by the validation of the data obtained for the time period of interest (60 days). Analysis of the same with the variables obtained in the consolidation of the data.

- Phase of results: The technical production of the included and previously analyzed results was realized; it was executed and interacted in a technical and scientific way at local and global level the reflection of the key aspects presented here.

3. Results and discussion

For the generation of results, we analyzed the three months in which periodic changes had been more noticeable during the year; in addition, we analyzed every day of each of these months: October, November and December, in order to further filter the results and obtain

results with greater precision, in which we find a specific day within the month that presented the maximum concentration values of pollutant related to the magnitude of the time, hour by hour during the 24 hours of the day. In this way we analyze the change of the pollutant according to the variation of the time that is in a determined period [35].

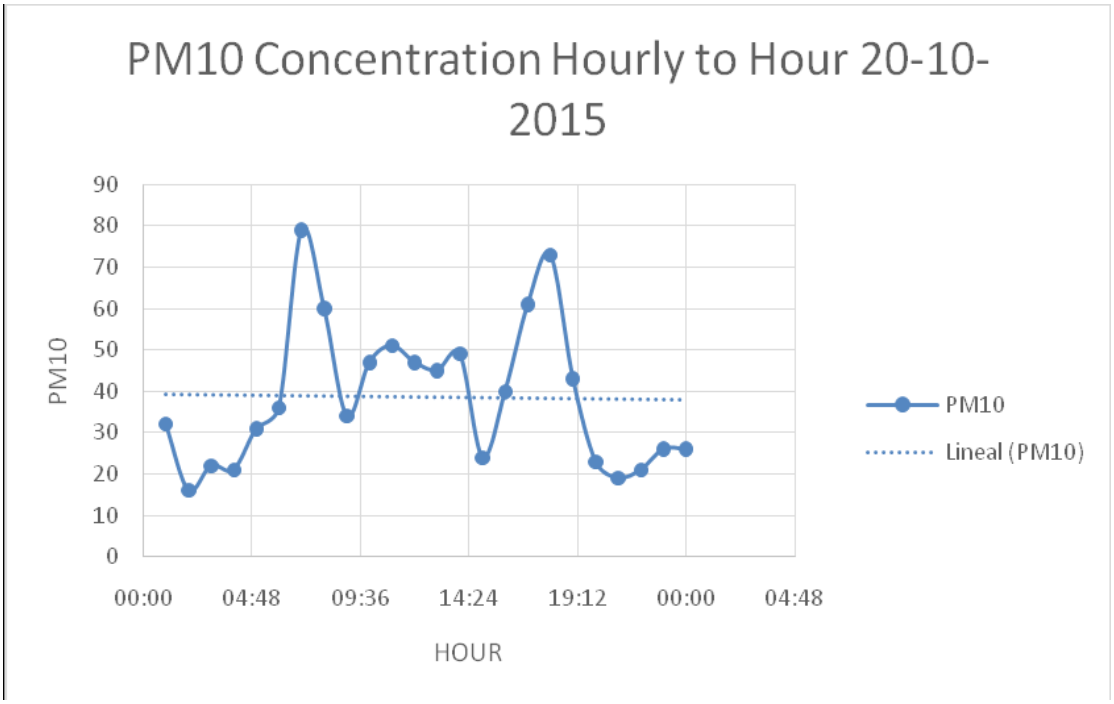

Figure 2. PM10 concentration, STUDY MONTH OCTOBER. **Source**: own.

The values recorded in the figure 2 [36] obtained from the RMCAB, show the concentration of PM10 hour by hour for Tuesday, October 10, 2015, which presents the maximum peak at 7:00 am, with a value Of 79 µg / m3, from which we can conclude that this value is recorded at one hour in the morning in which there is high mobility of all types of vehicle and that is within the range of the denominated “peak hour”. On the other hand, the minimum value recorded for this day was at 2:00 pm, when the flow of vehicles is lower and is within the range of the so-called "valley hour". We conclude that the number of vehicles that move through Boyacá Avenue and Villavicencio Avenue is a factor clearly related to the air quality of the locality and, in turn, the respiratory health of the locality [37].

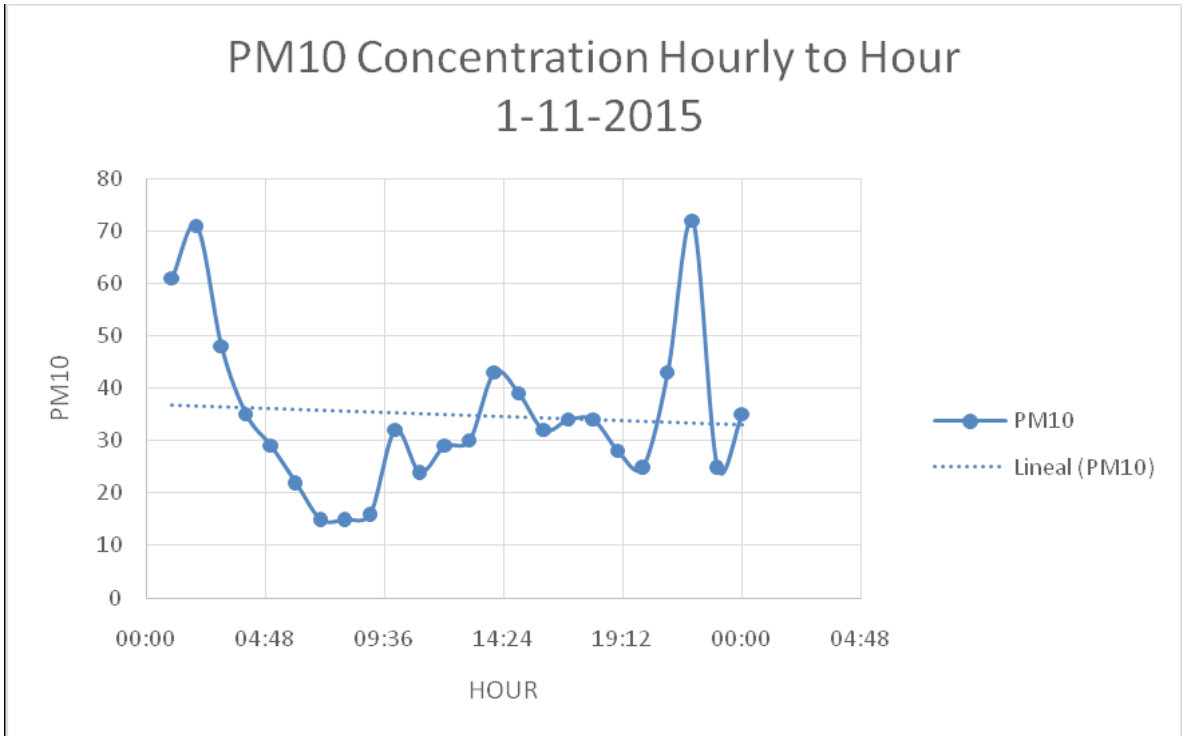

Figure 3. PM10 concentration, STUDY MONTH NOVEMBER. **Source**: own

The values recorded in the figure 3 are obtained from the RMCAB and evidence the concentration of PM10 hour by hour for Sunday, November 1, 2015 [38], which presents the maximum peak at 10:00 pm with a value Of 72 µg / m3, exceeding the monthly average by 51%, from which we can conclude that it is due in the first instance to the mobile sources that transit the two main avenues of the locality: Villavicencio Avenue and Boyacá Avenue, that present high flow at that time due to the high mobility of the transit through these ways for the entrance to the city [39]. In addition to the factor of the mobile sources, which for this study works consistently, it takes into account the viability of contamination of the fixed sources, for example the industries located in the sector, more specifically to the presence of tanneries of which Generate emissions at that time [40].

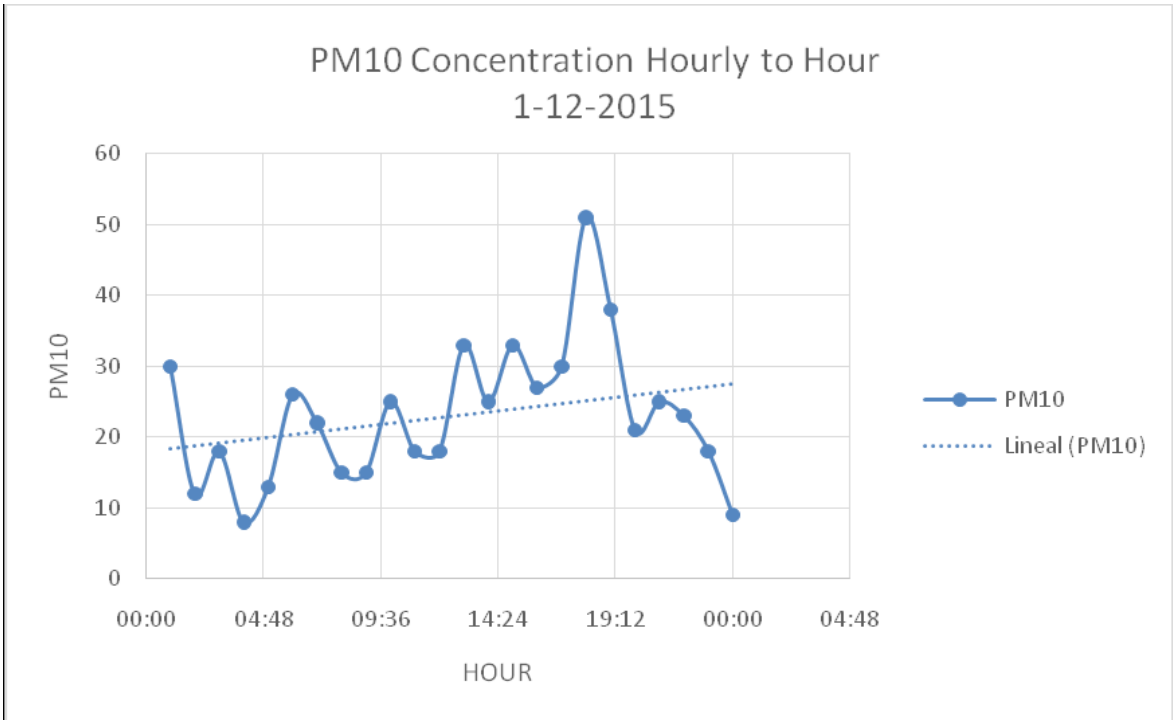

Figure 4. PM10 concentration, STUDY MONTH DECEMBER. Source:own.

The values recorded in the figure 4 are obtained from the RMCAB and show the concentration of PM10 hour by hour for Tuesday, December 1, 2015, which presents the maximum peak at 6:00 pm with a value of 51 µg / m3, which effectively indicates the high mobility of vehicles at the so-called peak time [41], causing it to increase substantially by 20 µg / m3 with respect to the previous hour, on the contrary it is evident that the minimum value is obtained at 4:00 am at 8 µg / m3, when mobile sources are not as steep as in peak time.

40% of the population of Tunjuelito that corresponds to 201,230 Inhabitants and more specifically the inhabitants located to 100 meters of the station of tunal monitoring, that are 328 inhabitants, who present complications in respiratory level 26% and cardiovascular level 14% According to Tunjuelito Hospital II Level of Attention State Social Enterprise (ESE). For the study of the UPZ Tunjuelito and UPZ Venecia, the latter being the densest at the population level, presents a substantial increase in the number of cases of pulmonary

diseases presented in various age groups, has shown a tendency to increase, becoming higher in the years 2012 and 2014 [42].

During the course of 2015 two cases of pneumonia mortality in children under 5 years old with residence in the Isla del Sol neighborhood of UPZ Venecia are presented, which shows an increase in the rate to 12.9 per 100,000 children under five years [43]. Tunjuelito had 2.9 deaths from pneumonia per 100,000 children younger than five years of age than Bogotá, corresponding to 27.5% more [44]. When comparing this indicator in the locality with others, it has a rate equal to that of Bosa, 26% less than Chapinero, which is the locality with the highest mortality rate due to pneumonia in children under five years [45], [46].

This leads to the implementation of programs and subprograms at the locative level, in order to reduce the rate of mortality and recidivism of the disease, in any age group more specifically in children under 5 years [47], [48]. By contrasting the impact with the adoption of health campaigns or brigades in which the punctual effect of the contaminant and its prevention with vaccines is explained, the first one is called anti-pneumococcal conjugate vaccine (PCV) [49]. An anti-pneumococcal polysaccharide (PPSV) vaccine is recommended for all children under 5 years of age, and is recommended for children 2 years of age or older who are at increased risk for pneumonia (such as children with weakened immune systems) and for adults who have risk factors for pneumonia [50].

The clearly identified environmental impacts and direct effect to single vectors of PM10 promoted contamination in air [51], soil and water; in this case these are the most notorious means of propagation that cause short, medium or long term effects of direct and indirect environmental impact and the just relation of the whole man environment, in the same, that is to say the human being is the first implicated in the alteration of the conditions of the environment when we speak in terms of air pollution [52], bringing with it serious changes in

the level of life quality, life level and way of life of the population for this specific case in health [53].

We refer to the main current legal regulations on atmospheric emissions applicable to the sixth locality of Tunjuelito and the Capital District decree 02 of 1982, law 99 of 1993, resolution 898 of 1995, decree 948 of 1995, decree 2107 of 195, resolution 005 of 1996, resolution 0160 of 1996, resolution 0909 of 1996, resolution 619 of 1997, decree 1697 of 1997, resolution 415 of 1998, resolution 623 of 1998, resolution 1048 of 1999, resolution 318 of 2000, resolution 775 of 2000, resolution 068 of 2001, resolution 391 of 2001, established the normative base as fundamental axis to identify the values and the characteristics of the quality of the air in the present locality.

It was observed that, according to the variability of the figures presented in the results, the level of contamination emitted by mobile sources is directly proportional to the level received by the population and the number of significant vectors as diseases in the same [54]. The PM10 contaminant analysis and the identification of the environmental impact on the health of the 6th Tunjuelito locality, is observed punctually specified in the obtained figures, confirming the contamination of the highest index is that from mobile sources [55].

In addition to mobile sources, the locality focuses on the main economic activity, according to the classification of the establishments visited, We have that first is the processing of leather, secondly the metalworking industry and thirdly the manufacture of furniture; Now, if the classification is made by a fixed source type, we find that first boilers are located, secondly the extractors and thirdly the furnaces, which are predominant activities in the locality that generate daily emissions and contribute to local air pollution. A condition to be noted is that the local wind regime has a predominance of 74% for the South-North direction, which would also have an impact on the Kennedy locality; the predominant

atmospheric stability category shows an average wind speed between 0 and 2 m / s, which makes it possible to establish that in most of the time stable conditions are observed in the sector. Sectors with the highest emissions from fixed sources are Venecia , Rincón de Venecia and San Benito (Place of high presence of tanneries) due to combustion processes that use coal, fuel oil and natural gas.

4. Conclusions

According to the results of this analysis and according to the records obtained from the air quality monitoring network, it was observed that 40% of the analyzed time period exceeded the limits established by the environmental regulations of the city of Bogotá for PM10.

Air pollution from particulate matter is a significant environmental problem, given its toxicity and exposure, a problem that has risen sharply in recent years, which is directly related to the notable economic growth, the purchasing power of cars and cars in general, and the high traffic of freight vehicles in the study area.

To effectively regulate the proper functioning of the Bogotá city car park through rigorous controls that allow the measurement and quantification of the emissions that these vehicles emit into the atmosphere and that affect the quality of the air that is breathed not only at the local level But for the whole city, since air being a vital element is of general and irreplaceable concern.

The contribution by mobile sources or vehicles is represented by Boyacá Avenue, Gaitan Cortés, Mariscal Sucre, Usme Avenue and Autopista del Sur avenues, due to the large number of cars that transit through them, since the roads cover a large part of the city, providing concentrations permanently, its contribution to the air quality of the sector is much higher than that of fixed sources, which affect smaller areas.

The gasoline vehicles generate a greater contribution, because the percentage that transits by the locality is much greater than the one that works with diesel or other fuels.

The total distribution for the values of PM10 indicates that in sectors adjacent to the aforementioned routes they present concentration values very close to the permissible limits and in some cases exceed the regulations for Bogota D.C.

The pollutant evaluation period, which was analyzed between October 20 2015 and December 20 2015, shows that the month with the highest concentration of PM10 was October, the 20th of the same month in the hours of the morning more exactly 7:00 am on Tuesday, with which we can conclude that it was the month in which the entrance of SITP buses increased as well as the circulation of public transport buses by the area of influence of the Tunal station.

In addition, the impact caused by the landslide of the landfill of Doña Juana, and the impact it had on the areas surrounding the landfill, led to the gradual increase of the PM10 concentration, which had a standard average of 38 µg / m3, and increased to 79 µg / m3, causing various effects on human health, especially in the age group of less than 5 years in local children.

It is important to take into account that the air quality of the locality is not only affected by the sources located within it, but also by sources located in other localities, whose dispersion is deposited in Tunjuelito.

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