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Environmental quality study of the San Rafael Park in Guadalajara, Jalisco, Mexico

Estudio de calidad ambiental del parque San Rafael en Guadalajara, Jalisco, México

VILLASEÑOR-ACEVES, Jessica Teresa†, OROZCO-MEDINA, Martha Georgina*, FIGUEROA-MONTAÑO, Arturo and DAVYDOVA-BELITSKAYA, Valentina

Universidad de Guadalajara. Centro Universitario de Ciencias Biológicas y Agropecuarias, Mexico.

ID 1st Author: *Jessica Teresa, Villaseñor-Aceves* / **ORC ID:** 0000-0002-1578-6822

ID 1er Co-author: *Martha Georgina, Orozco-Medina* / **ORC ID:** 0000-0002-2619-3408, **Researcher ID Thomson:** T-4562-2018, CVU CONACYT ID: 25755

ID 2nd Co-author: *Arturo, Figueroa-Montaño* / **ORC ID:** 0000-0001-7442-6301, **Researcher ID Thomson:** T-6241-2018, **CVU CONACYT ID:** 76655

ID 3er Co-author: *Valentina, Davydova-Belitskaya* / **ORC ID:** 0000-0001-8224-3150, **Researcher ID Thomson:** X-6164-2019, **CVU CONACYT ID:** 20417

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Abstract

An evaluation of environmental conditions in terms of air and noise pollution was performed in San Rafael Park and completed by a perception survey of how visitors value the park´s environmental state suitable for sport and recreational activities. The park is in the Municipality of Guadalajara, Jalisco, Mexico. CO pollution levels were assessed by data from Tlaquepaque monitoring station from the Atmospheric Monitoring System of Jalisco´s State (AMSJ). CO mean concentration was 1.99 ppm which it is referred as a low health risk (NOM-172-SEMARNAT-2019). Noise levels were evaluated using a CESVA SC 160 noise integrating equipment. At recreational facilities, noise levels were recorded in the range of 49.3-93.2 dB A which were far from specified level of 55 dB A at such facilities (NOM-081-SEMARNAT-1994). Survey results highlighted poor environmental conditions to perform sports and recreational activities (90%) and 77% of responders showed a good intention to continue visiting the park even its environmental state. Reported health effects were: Eye irritation (72%), dry eye (46%), sneezing (33%), allergies (15%) and offending odor (9%). Findings of the study put forward the relationship between the state of the environment and health of a community and the decision users must make to visit parks to get health, social and recreational benefits even the poor environmental conditions within the park´s facilities.

Environmental pollution, Environmental health, Recreational parks, Cities, Guadalajara

Resumen

Se analizaron las condiciones de calidad ambiental y percepción social al interior del Parque San Rafael ubicado en el municipio de Guadalajara, Jalisco. Se estimó la percepción que tienen los usuarios al realizar sus actividades físicas y/o recreativas. El propósito de esta investigación consiste en estimar niveles de monóxido de carbono (CO), y el nivel de ruido al que están expuestos los usuarios y percepción acerca de la calidad ambiental del parque. Para ello se hizo un reconocimiento del área de estudio, se aplicaron un total de 100 encuestas y se integró en una matriz de Leopold, en donde el 90% de los visitantes afirma que la calidad del aire es mala en la zona metropolitana de Guadalajara (ZMG), el 77% muestra interés por acudir al parque a realizar ejercicio o actividades recreativas al haber una mejor calidad de aire, las principales molestias de los visitantes son: irritación de ojos (72%), resequedad (46%), estornudos (33%), alergias (15%), lagrimeo (12%) e inclusive malos olores (9%). Se accedió a la base de datos de la estación de Tlaquepaque del Sistema de monitoreo atmosférico de Jalisco (SIMAJ) mostrando 1.99 ppm como lectura promedio de CO durante el muestreo equivalente a un nivel de riesgo bajo (NOM-172-SEMARNAT-2019). Se seleccionaron y caracterizaron 22 puntos de muestreo para las mediciones de ruido con un sonómetro integrador de precisión CESVA SC 160. La NOM-081-SEMARNAT-1994, establece el límite máximo de 55 dB A en áreas exteriores de recreación. En el monitoreo se registraron niveles de 49.3 hasta los 93.2 dB A. La calidad ambiental es clave en la salud y bienestar de la población.

Contaminación ambiental, Salud ambiental, Parques recreativos, Ciudades, Guadalajara

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* Correspondence of the Author (E-mail: martha.orozco@academicos.udg.mx)
† Researcher contributing first author.

Introduction

Green areas and open spaces play a set of essential roles in the well-being and quality of life of the inhabitants of urban centers. These places can be conceived, from an environmental point of view, as elements that directly influence the urban environment and, from a social point of view, as generators of direct impacts and benefits in the community (Martínez Soto, J., Montero and López Lena, M., De la Roca Chiapas, J.M., 2016).

According to Spathelf and Nutto, the United Nations World Health Organization recommends a minimum of 12 m2 of green areas per inhabitant in urban areas and a city, in the ideal, should have a coverage of 20% of trees within its territory. (Spathelf, & Nutto, 2004).

The importance of green areas in cities lies in the positive effects they have on the resident population, effects that can be manifested in physical and mental health, in environmental or ecological awareness, in the process of community empowerment, in the feeling of security, among others. Green and recreational areas can be made up of the following components:

Vegetation component: trees (preferably native species), shrubs, garden plants and lawns.

Pedestrian circulation spaces: accesses and paths, among others.

Street furniture: benches, seats, trash cans, tables, lighting components, sculptures or ornamental elements, information panels, bicycle parking and covered seating areas, among others.

Children's play infrastructure: swings, slides, seesaw, hammocks, handrails, rings and sandboxes, among others.

Sports infrastructure: soccer, basketball, five-a-side soccer, and multipurpose sports courts; areas for practicing urban and/or alternative sports such as skate parks, outdoor gyms, among others (Wilson, 2006).

Vegetation in the city, in addition to its ornamental function, has a regulating role: it retains atmospheric water, contributes to evapotranspiration, constitutes a filter against pollution and represents an excellent regulator of air, heat and humidity exchange with the urban environment; it has an important role as a perceptual-landscape element; since ancient times there has been talk of the psychological need of city dwellers to get closer to nature, the therapeutic effects of which are well known: The WHO and many other authors have highlighted the therapeutic effects of nature in reducing stress, fatigue and so many other aspects (Gómez, 2005). (Gómez, 2005).

Guadalajara, the second city in economic importance in Mexico, is distinguished from the rest of the country by the extension of its metropolitan area, as well as by the characteristics of its nearby municipalities, stands out for its cultural, artistic, touristic, food production and state-of-the-art technology leadership; However, in terms of noise pollution control, more elements are required to advance in the diagnosis and control, with this proposal it is possible to document the noise problem, to have a theoretical basis to closely support initiatives that aim to influence the problem and thus provide better welfare conditions to the population (Orozco, 2021).

Perception: It is defined as a learning process that produces knowledge or experience about the environment (Durand, 2008). Health risks are perceived differently by the different groups that make up the social group, depending on their culture, experiences and beliefs; the perception of risks influences people differently according to their condition, gender, experience with health care, and the way they perceive it.

According to their condition, gender, experience in relation to the hazard, and also schooling, socioeconomic level and proximity to the threat (Gran, 2018; Rangel and Hernández, 2018 in Orozco et al 2018; Noriega, 2018). To study the environmental quality of recreational spaces in order to characterize the environmental conditions that influence the wellbeing of users to optimize the quality of life, and to expose aspects that highlight the importance of San Rafael Park, which will allow generating environmental and socio-cultural information about the park.

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Air: CO and health effects

The characterization of recreational spaces may include the analysis of CO in air quality, as well as the perception of environmental and health problems of the exposed population. For the purposes of this study, technical, scientific and regulatory criteria will also be considered, as well as recommendations of guidelines for the characterization of environmental conditions. All this with the purpose of generating information about recreational spaces through a particular study of San Rafael Park in Guadalajara.

Atmospheric pollutants, normally measured in the urban atmosphere, come from mobile sources (vehicles) and fixed combustion sources (industries, residential uses-air conditioning, and waste disposal processes). A distinction is made between primary and secondary pollutants. Primary pollutants are those that come directly from the emission source. Secondary pollutants are produced as a consequence of the chemical and physical transformations and reactions that primary pollutants undergo in the atmosphere, distinguishing, above all, photochemical pollution and acidification of the environment (Ballester, 2005). (Ballester, 2005).

CO is a gas formed in nature through the oxidation of methane (CH4), the anthropogenic source of CO is the incomplete burning of fuels (gasoline, gas, coal, wood and fuel oil). In this sense, in order to have less CO emissions, it is necessary to have more complete combustion processes, which requires an adequate amount of oxygen; when this is insufficient, CO is formed. The ZMG contributes a significant amount of emissions of this pollutant to the atmosphere, due to the number of automobile trips and the age of the vehicle fleet in circulation (NOM-021-SSA1-1993).

The main health effects of CO air pollution range from alterations in lung function, cardiac problems, other symptoms and discomfort to an increase in the number of deaths, hospital admissions and emergency room visits, especially for respiratory and cardiovascular causes. The main potential harmful effect of this pollutant is its affinity to combine with hemoglobin, resulting in a high formation of carboxyhemoglobin and, as a consequence, a decrease in the amount of oxyhemoglobin and, therefore, in the delivery of oxygen to the tissues (NOM-021-SSA1-1993).

Guadalajara became the municipality that generates the greatest impacts to public health due to health indices of environmental pollution in the last decade, concluded a study conducted by the Colectivo Ecologista de Jalisco (CEJ), which released this information (Meléndez, 2012).

Air quality standards, CO

Air quality standards establish the maximum concentrations of pollutants in the environment that should not be exceeded with a certain frequency, in order to guarantee the protection of the population's health, including that of the most susceptible groups such as children, the elderly and people with chronic respiratory diseases, among others. For the development of this work, emphasis was placed on the guidelines for obtaining and communicating the Air Quality and Health Risk Index (NOM-172-SEMARNAT-2019). In addition to the criteria for evaluating ambient air quality with respect to CO (NOM-021-SSA1-1993).

The concentration of CO, as an atmospheric pollutant, must not exceed the permissible value of 11.00 ppm in an eight-hour moving average once a year, as protection to the health of the susceptible population (NOM-172-SEMARNAT-2019).

Air quality	Level of risk associated	Limits ppm
Good	Under	≤8.75
Acceptable	Moderate	≥8.75 <11.00
Mala	High	≥11.00<13.30
Very Bad	Very High	≥13.30<15.50
Extremely Bad	Extremely High	>15.50

Table 1 Reference table, "Air and health index" for CO. NOM-172-SEMARNAT-2019

Noise pollution and health effects

To talk about noise pollution it is necessary to refer to the concept of noise and all its implications, which are so complex and varied depending on the context in which it is produced and the conditions of the receivers (Orozco, 2021). The noise level in cities is an indicator of critical conditions of traffic, concentration of activities and roads, its potential as an indicator in a diagnosis of environmental quality is highly significant. Noise as a pollutant is one of the main environmental stressors affecting the quality of life and health of the exposed population (Orozco, 2008).

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Sound is considered a pollutant when it has negative effects on health or decreases the quality of life. Noise is understood as a sound that is undesirable for the person who hears it and, in general, has one or more of the following characteristics:

- It is long-lasting
- Loud intensity
- Strong intensity
- High frequency
- Caotic

Urban noise (also called environmental noise, residential noise or domestic noise) is defined as the noise emitted by all sources except industrial areas. The main sources of urban noise are automobile, rail and air traffic, construction and public works, and the neighborhood. The main sources of indoor noise are ventilation systems, office machines, household appliances and neighbors (Berglund, 1999).

Noise emission causes various damages on the environment, such as:

- Adversely affect wildlife
- Produce nuisances of greater or lesser intensity to third parties.
- To diminish the quality of the natural environment
- Degrade the quality of life.

The effects of noise exposure on human health are physiological and psychological. The first and most obvious physiological effect of continuous exposure to noise is hearing loss, which in most cases is irreversible.

The sound waves coming from the outside pass through the outer ear and collide with the eardrum, which begins to vibrate, transmitting these vibrations to the chain of ossicles (hammer, anvil and stirrup), which also move and vibrate. The vibration passes to the inner ear, where the snail is located, which has a liquid inside it.

The fluid moves and bathes a set of hair cells that constitute the organ of Corti, which is the real organ of hearing. These cells have a sensitive nerve structure and each group of cells responds to a different tone. They are linked to nerves that go to the upper surface of the brain where sounds are perceived. Excessive noise can cause damage to the hair cells, either due to disappearance of the cilia or degeneration of the transmitter cells.

Some of the main effects caused by noise, unlike deafness, may disappear some time after cessation of exposure:

- Blood pressure
- Change in heart rate
- Change in respiratory rate
- Change in blood pressure
- Change in skin resistance
- Change in visual acuity

Psychological effects of noise:

- Communication problems, with the consequent social problems.
- Alterations in sleep, modification of your sleeping habits
- Decreased work performance and efficiency at work
- Annoyance, or feeling of displeasure. (Lombardero J.L, 2008).

Noise regulations

Urban, environmental, residential or domestic noise is emitted by all sources except industrial ones. Since 1980 the World Health Organization (WHO) has addressed the problem of urban noise and has advanced in different initiatives and one of the most successful was the elaboration of Guidelines for urban noise, which was developed by a group of experts in 1999 in London, United Kingdom.

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The guidelines provided by the WHO have been used in different countries of the world to establish the normative parameters through which the different tours should be adjusted to avoid exposures that endanger the health of people and as far as possible aspire to reduce noise pollution. (Orozco, 2021).

For Mexico there are Official Mexican Standards (NOM's), in relation to this study was based on the following noise pollution standard issued by SEMARNAT, mentioned below:

NOM-081-SEMARNAT-1994.
Establishes the maximum permissible noise emission limits for fixed sources and their measurement method.

ZONE	SCHEDULE	MAXIMUM LIMIT PERMISSIBLE dB A
Residential (outdoor)	6:00 a 22:00 22:00 a 6:00	55 50
Industrial and commercial	6:00 a 22:00 22:00 a 6:00	68 65
Schools (outdoor playgrounds)	During the game	55
Ceremonies, festivals and entertainment events.	4 hours	100

Table 2 Permissible noise limits (dB A). NOM-081-SEMARNAT-1994

Description of the Study Area

San Rafael Park is a recreational space of green areas and sports facilities located in the east of the ZMG, at the following coordinates 103° 17' 54.99" W, 20° 39' 11.37" N. The study area was delimited by the following perimeter streets of San Rafael Park: Manuel M. Ponce, Mariano Azuela, J.R Benítez, San Jacinto Av., and Federico Medrano (Figure 1).

Figure 1 Location of the study area, San Rafael Park. Google earth

Methodology

The specific methods were applied to estimate each of the parameters of interest with a CESVA SC 160 precision integrating sound level meter for noise recording (dB A), for CO (ppm) data from the SIMAJ report (2015) were used. (SEMADET, 2015).

Noise measurement. For the estimation of sound pressure levels, the methodology described by Orozco M., in Curiel, 2008 will be used. Twenty-two sampling points were selected within the San Rafael Park (Figure 2), taking into account as critical points, areas where users carry out their activities within the park, but at the same time that are close to establishments, public, health, religious institutions and avenues perimeter to the Park. A CESVA SC160 precision integrating sound level meter was used at a height of 1.30-1.40 m and at 60 cm separation from the body, in an area clear of trees, with a duration at each point of 5 min (Orozco, et al., 2014).

Figure 2 Location of sampling points inside San Rafael Park. Google Earth

CO ppm parameters. CO information was obtained from SIMAJ (SEMADET, 2015), corresponding to 2015 from the station closest to San Rafael Park. Tlaquepaque station located on the intersection of Boulevard General Marcelino García Barragán and Avenida Niños Héroes, inside the dry stack.

Perception. 100 surveys were applied to visitors and neighbors adjacent to the park, to identify the main causes and annoyances generated by noise, its importance and how it affects the health of the population.

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Using multiple-choice and open-ended questions, the survey was conducted at each sampling site to obtain the perception at different points, from the opinion of neighbors and passers-by (Hernández C., 2018).

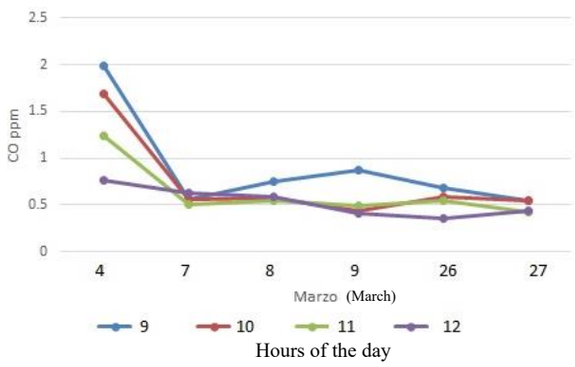
This type of technique is used to collect data based on oral questioning of respondents individually or in groups (Rangel and Hernandez, 2018).

Results

To evaluate the environmental quality, in the points to be studied, the busiest streets were chosen, Av. San Jacinto, C. Federico Medrano, C. Manuel María Ponce, Mariano Azuela, José R. Benítez. Some were adjusted to allow data collection in attention to a greater number of people exposed or to an evidently more limited or critical environmental situation (Hernández C., 2018).

Carbon monoxide

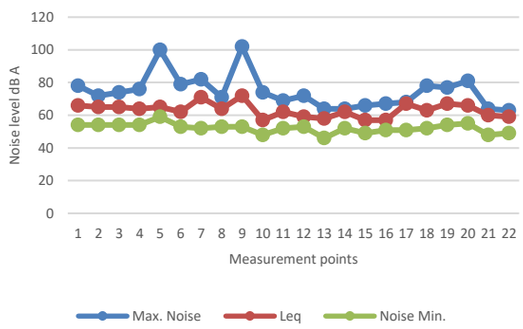
SEMADET records were evaluated. In a schedule from 9:00 am to 12:00 pm yielding values within the permissible limits, being the highest value 1.99 ppm corresponding to a good air quality (Table 1, Graph 1).



Graphic 1 Distribution of CO ppm by hours and days analyzed

Noise

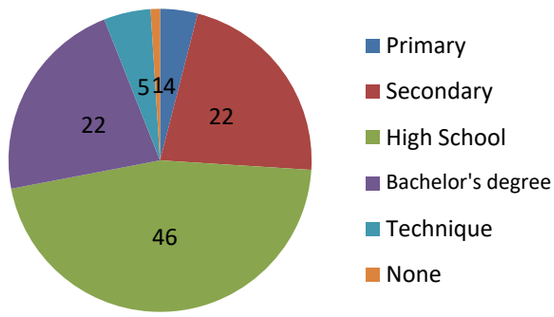
In order to evaluate the noise impact on the park's visitors and neighboring residents, measurement points were strategically selected. The results recorded values above the standard value of 55 dB A according to NOM-081-SEMARNAT-1994 (Table 2, Graph 2).



Graphic 2 Noise levels dB(A) inside San Rafael Park.

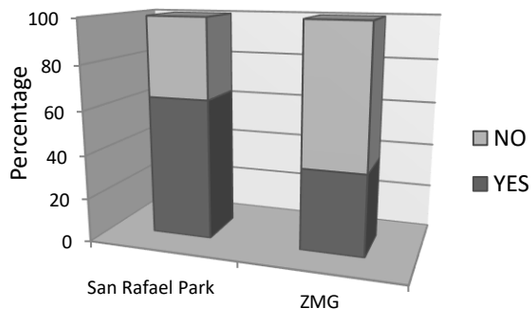
Perception

A total of 100 surveys were administered to visitors and residents around the park, 52% were women and 48% men, 4% had primary education, 22% secondary education, 46% high school, 22% bachelor's degree, 5% technical, and 1% no education (Graph 3).



Graphic 3 Proportion of respondents' level of education in San Rafael park

In terms of air quality, 64% of the visitors reported good air quality as a result of the positive impact of the green areas inside the park, while only 37% mentioned that the air quality in the rest of the ZMG is bad due to the excessive growth of the city and the lack of adequate management of natural resources (Graphic 4).



Graphic 4 Proportion of opinions regarding air quality

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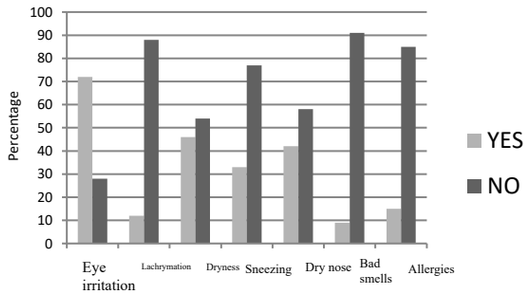
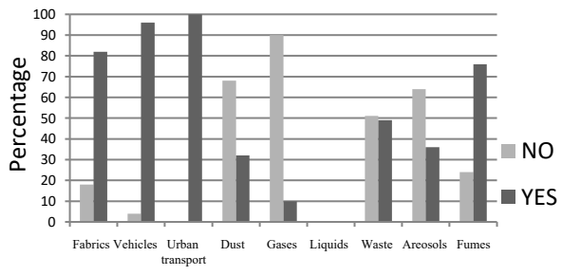
In terms of reported discomfort, 72% had irritated eyes, 46% had dry eyes, 33% had sneezing, 15% had allergies, 12% had watering eyes, and 9% had bad odors coming from outside the park (Graphic 5).



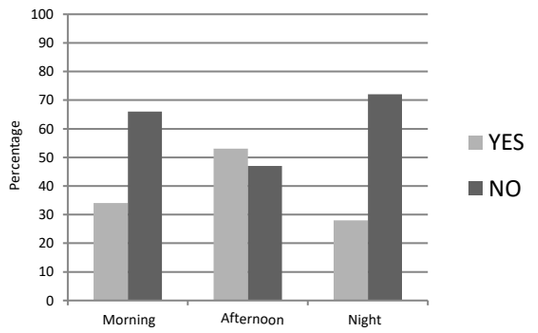
Graphic 5 Proportion of symptoms reported by visitors to San Rafael Park.

They also identified public transportation (100%) and vehicles (96%), industry (82%), smoke emissions from various sources (76%), waste management and handling (49%), aerosols (36%), dust (32%) and gases (10%) as the main causes of poor air quality (Graphic 6).



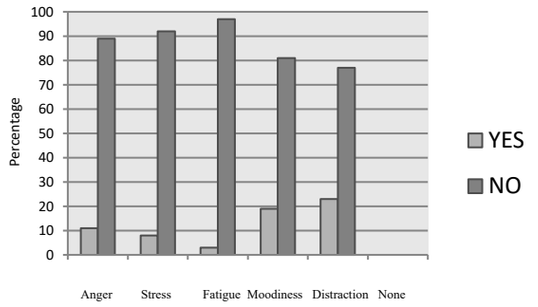
Graphic 6 Agents responsible for poor air quality

Regarding the times that noise affects visitors the most, 40% mentioned that it is annoying at any time, 32% were more annoying at night, 30% during the morning and 22% in the afternoon (Graphic 7).

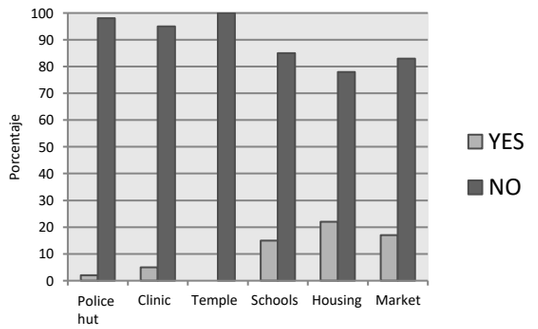


Graphic 7 Proportion in which time of the day noise bothers the most

Regarding the impact of noise on emotions, 23% consider it a distraction, 19% feel bad, 11% feel angry, 8% feel stressful and 3% feel tired (Graphic 8). Noise generated by the settlements around the park 22% comes from homes, 17% from the market, 15% from schools, 5% from the clinic and 2% from the police station, and in general no one is bothered by the noise generated by the church (Graphic 9).



Graphic 8 Emotions most affected by noise to visitors of San Rafael Park.



Graphic 9 Main sources of noise around San Rafael Park

Some park visitors and neighbors report bad odors from sewage and lack of waste collection (35%), while 8% perceive bad odors inside the park (Graph 10), with a higher prevalence during the afternoon.

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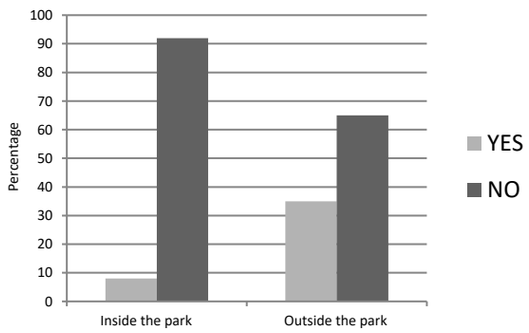

Graphic 10 Proportion of people who perceive bad odors in San Rafael Park

Discussion

Carbon monoxide CO

The AMG, contributes a significant amount of emissions of this pollutant to the atmosphere, derived from the number of automobile trips and the age of the vehicle fleet in circulation (Ruiz, M., 2015).

Poor air quality is currently classified as a cause of cancer by the WHO. That is why it is imperative to implement actions to reduce and reverse these effects, in order to ensure the health of the population (Ruiz, M., 2015).

Recreational Park

It is important the existence of recreational spaces in society, especially in the ZMG that has had an accelerated growth, today there are few spaces that are destined for this use, they are places where people take part of their time to perform some activity going to them, because it generates better feeling to be surrounded by nature, since thanks to these places it influences the physical activity of the population, talking about green areas, open spaces a natural environment motivates people.

Having these green and wooded areas has a contribution for environmental health, decreases air pollution, these wooded areas favor the capture of particles found in the air, in this case carbon monoxide, and of course among other pollutants that affect human health.

It is worth noting that the San Rafael park, despite being located around avenues with heavy vehicular traffic, of course helps us to reduce dangerous particles emitted by the combustion of cars, so it really achieves the objective of the San Rafael park both to improve the quality of life of users who attend by obtaining better air quality and for the environmental impact.

Noise

Noise is an important factor for people who come to the park for recreational activities, since this other factor can influence the health of visitors, deteriorating the quality of life, which is why it is important to choose the place where the recreational activity or coexistence is intended to take place. If the interest is to exercise, it is useless to go to a place where the conditions are not favorable, and this can be reflected in both physiological and psychological aspects, which generate health problems, or discomfort such as headaches, mood swings, among others.

Based on the results obtained during the monitoring inside San Rafael Park, it was found that from point 1 to point 5, corresponding to the perimeter facing San Jacinto Avenue and adjacent to the IMSS UMF 78 clinic, police station and stores, the minimum level was 54.13 dB A and the maximum recorded was 100.2 dB A, with a considerable range of variation that tends to exceed permissible limits (Graph 2).

From point 6 to point 9 corresponding to the boundary of the park with Federico Medrano Avenue, which borders the San Rafael del Parque Parish and businesses, the minimum level recorded was 51.7 dB A and the maximum recorded was 102.15 dB A, the latter is the boundary of the baseball field that borders the "Osos Chatos" Market, a construction materials store (Graph 2).

At points 10, 11 and 12, they are adjacent to one end of the baseball field, SIAPA Coexistence Center, the Baseball All-Star Field, the Guadalajara BMX Track, the latter is located behind the Mixed Secondary School #58 "Victor Cadena Aguayo". In this transect the readings ranged from 48.53 dB A and the maximum of 73.98 dB A, generating an environment with acoustic conditions not so severe in terms of hearing impairment, and it is worth mentioning that the Guadalajara BMX Track was not in use, it is only used in certain seasons (Graph 2).

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From point 13 to 15 from the Guadalajara BMX Track and covering José R. Benítez Street and the intersection of Mariano Azuela, which is a residential area, the levels remained at a satisfactory threshold, registering a minimum of 46.33 dB A and reaching a maximum of 65.98 dB A (Graph 2).

Points 16 to 22 are located in the center of the park in strategic areas between the different courts, the multipurpose gymnasium, the dome for outdoor classes, and the jogging track, and the levels are recorded as a minimum within the permissible limits of 47.81 dB A and with a maximum over the permissible limits of 80.85 dB A outside the Pan American gymnasium, the jogging track, and an area with weightlifting equipment (Graph 2).

In terms of critical points for visitors during recreational activities, the areas with the most noise generated by vehicular traffic are the jogging track adjacent to San Jacinto Avenue and Federico Medrano Street. Inside the park, the noise level tends to decrease a little, and the noise captured is merely from the people themselves or music coming from the terrace where aerobics classes are held.

Carbon monoxide CO

CO, is one of the major pollutants in the atmosphere and that the main sources of emission are motor vehicles with the highest percentage of affectation since every time the vehicle fleet in the ZMG grows irrationally just in 2015 there was a total of 3,268,321 motor vehicles in circulation in Jalisco, which use fuel such as gasoline or diesel and not least the industrial processes that use carbon compounds also causing great affectation to the environment. (IIEG,2020)

Carbon monoxide is a colorless and odorless gas formed by the incomplete combustion of organic material in the presence of oxygen deficiency. It is considered one of the major pollutants in the Earth's atmosphere and one of the major environmental problems in Latin America (Téllez J., Rodríguez Alba, Fajardo A., 2006).

According to SEMADET results, during the sampling days and the time span of 9:00-12:00 hrs, the highest value was 1.99 ppm, corresponding to good air quality (NOM-081-SEMARNAT-1994).

Conclusions

Green Areas (Recreational). The municipality of Guadalajara has an evident deficit of green areas. According to the Population and Housing Census in 2015, the ZMG had a population of 1,460,148 inhabitants (INEGI, 2015), following WHO recommendations, of at least 1.6 m2 of green areas per inhabitant to guarantee their well-being (CONANP, 2018).

Therefore, the municipality should have about 23,362,368 m². It is of utmost importance to generate more green spaces, wooded areas, recreational spaces with favorable conditions both to generate a better environmental quality in the ZMG, giving a positive impact to the population, motivation, awareness, environmental health, a better quality of life. And not to continue reducing these spaces to make way for buildings, industries that lead to poor management of natural resources.

Noise. Noise is a very important factor, simply before a physical, recreational or social activity, people go with an objective idealizing that it is a space to be in contact with nature, to obtain better health benefits and apparently within the social perception shows us that the population when exposed to noise levels of up to 102. 15 dB A only presents emotion with 19% bad mood and 23% distraction, could it be that the population is generating a resistance to live in a chaotic city, because it seems normal to them the noise around San Rafael Park, because it should be mentioned that the park is delimited by facilities such as the IMSS clinic UMF 78, Parish San Rafael del Parque, Mercado de los Osos Chatos, Mixed Secondary School 58 "Victor Cadena Aguayo", Primary School Manuel Alatorre, Elementary School Manuel Alatorre, Elementary School Manuel Alatorre, School of the "Victor Cadena Aguayo", Another benefit of these spaces is that we do not perceive noise pollution as such, since the vegetation plays the role of absorbing acoustic energy, dispersing noise and we perceive more the sounds of nature and fresh air.

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Carbon monoxide. Atmospheric monitoring data from the Tlaquepaque station, near San Rafael Park, with a coverage radius of approximately two kilometers, was used. It is clear that topographic and urban characteristics and factors such as wind direction and speed affect the transport and dispersion of pollutants, which causes particular behaviors at points where the station has no influence, which is why the pollutant dispersion models are useful. Regarding the readings taken during the sampling days, it was determined that the air quality for CO was good with a maximum value of 1.99 ppm.

Surveys. Regarding the social perception of air quality, 37% believe that the air quality in the ZMG is good, in contrast to the 64% who identify air quality in the same category inside the park. This demonstrates the environmental services that the population obtains from these ecosystems, such as scenic beauty, tranquility, air purification, microclimate, and shade, among others.

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